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Journal of Hearing Science®

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Dear Colleagues,

This third issue of the *Journal of Hearing Science* in 2025 brings together papers that show how deeply hearing and balance disorders are embedded in people's bodies, identities, social worlds, and health systems. From chronic rhinosinusitis and nasal polyps, through pediatric cochlear implantation and adult speech in noise testing, to music perception in cochlear implant users and the lived experience of tinnitus in veterans, the contributions span the path from pathology and surgical outcomes to everyday communication and participation.

An important contribution is the qualitative study on the lived experience of tinnitus in UK military veterans. Tinnitus is more prevalent among them than in the general population, and this study gives voice to those who live with ongoing internal sound. Veterans describe tinnitus as a constant presence that strains mental health, disrupts sleep, complicates communication, and sometimes leads to withdrawal. While some find ways to cope – such as through sound therapy, routines, and peer support – many still struggle to access effective help. More broadly, tinnitus is one of the most common and complex symptoms in audiology and otology. Its impact ranges from a mild background noise to a dominating experience that shapes mood and attention, all of which means that good care must combine audiological assessment with attention to mental health, effective coping strategies, and the whole context of a person's life.

The issue concludes with a report from the 17th Congress of the European Federation of Audiology Societies (EFAS), held from 14 to 17 May 2025 in Vienna, Austria. EFAS meetings help connect researchers, clinicians, and policy makers across Europe and beyond. The report offers a concise overview of new evidence, current debates, and emerging directions in diagnostics, intervention strategies, hearing care delivery, and professional education.

We hope this issue of the *Journal of Hearing Science* will support your clinical work and research and encourage collaboration across disciplines and borders in the service of people living with hearing and balance disorders.

With kind regards and greetings,

Prof. Henryk Skarzynski, M.D., Ph.D., Dr. h.c. multi

Review papers

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RISK FACTORS FOR RECURRENCE OF NASAL POLYPS IN CASES OF CHRONIC RHINOSINUSITIS AFTER ENDOSCOPIC SINUS SURGERY: A NARRATIVE REVIEW

Contributions:
A Study design/planning
B Data collection/entry
C Data analysis/statistics
D Data interpretation
E Preparation of manuscript
F Literature analysis/search
G Funds collection

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Abstract

Introduction: Chronic rhinosinusitis (CRS) is a persistent inflammatory disease of the nasal mucosa and paranasal sinuses, classified into phenotypes with (CRSwNP) and without (CRSsNP) nasal polyps. A key limitation of endoscopic sinus surgery (ESS) for CRSwNP is the frequent recurrence of polyps. This narrative review aims to summarize current evidence on risk factors for polyp recurrence after ESS.

Material and methods: All relevant publications published from 2019 to 2024 were retrieved from PubMed based on the keywords *chronic rhinosinusitis*, *endoscopic sinus surgery*, and *nasal polyps*. Exactly 47 papers were identified.

Results: A number of risk factors for polyp recurrence in CRSwNP patients following prior ESS were identified. Most highlight the significant number of relapses in patients with asthma, allergic rhinitis, eosinophilia, aspirin hypersensitivity, smoking, non-compliance with post-procedure recommendations, prior sinus surgery, and elevated levels of inflammatory factors (interleukins: IL-5, IL-10, and IL-6).

Conclusions: Recognition of these risk factors and incorporation of biomarker assessment may improve patient stratification and enable tailored postoperative management. Further studies are needed to validate these predictors and develop effective strategies to reduce recurrence rates in CRSwNP patients.

Keywords: nasal polyps • chronic rhinosinusitis • endoscopic sinus surgery

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CZYNNIKI RYZYKA NAWROTU POLIPÓW NOSA U OSÓB Z PRZEWLEKŁYM ZAPALENIEM ZATOK PRZYNOSOWYCH PO ENDOSKOPOWEJ OPERACJI ZATOK – PRZEGLĄD NARRACYJNY

Streszczenie

Wprowadzenie: Przewlekłe zapalenie zatok przynosowych (CRS) to przewlekła choroba zapalna błony śluzowej nosa i zatok przynosowych, klasyfikowana jako fenotyp z polipami nosa (CRSwNP) oraz bez polipów nosa (CRSsNP). Podstawowym ograniczeniem endoskopowej chirurgii zatok przynosowych (ESS) w przypadku CRSwNP jest częsty pooperacyjny nawrót polipów. Niniejszy przegląd narracyjny ma na celu podsumowanie aktualnych dowodów naukowych dotyczących czynników ryzyka nawrotu polipów po ESS.

Materiał i metody: Wszystkie istotne publikacje opublikowane w latach 2019–2024 zostały wyszukane w bazie PubMed na podstawie słów kluczowych: *chronic rhinosinusitis*, *endoscopic sinus surgery*, *nasal polyps*. Wybrano dokładnie 47 artykułów.

Wyniki: Naukowcy zidentyfikowali wiele czynników ryzyka nawrotu polipów u pacjentów z CRSwNP po wcześniejszej ESS. Nawroty polipów większość autorów zaobserwowała u pacjentów: z astmą, alergicznym nieżytem nosa, eozynofilią, nadwrażliwością na ASA, palących tytoń, nieprzestrzegających zaleceń pooperacyjnych, z wcześniejszą endoskopową chirurgią zatok przynosowych oraz podwyższonym poziomem czynników zapalnych – zwłaszcza interleukin: IL-5, IL-10 i IL-6.

Wnioski: Rozpoznanie tych czynników ryzyka i włączenie oceny biomarkerów może poprawić stratyfikację pacjentów i umożliwić dostosowane postępowanie pooperacyjne. Konieczne są dalsze badania w celu walidacji tych czynników predykcyjnych i opracowania skutecznych strategii zmniejszania częstości nawrotów u pacjentów z CRSwNP.

Słowa kluczowe: przewlekłe zapalenie zatok przynosowych • endoskopowa chirurgia zatok przynosowych • polipy nosa

Key to abbreviations	
AAO-HNS	American Academy of Otolaryngology – Head and Neck Surgery
AERD	aspirin-exacerbated respiratory disease
ALCAM	activated leukocyte cell adhesion molecule
ASA	acetylsalicylic acid
BAFF	B cell-activating factor
BMI	Body Mass Index
CLCs	Charcot–Leyden crystals
CRS	chronic rhinosinusitis
CRSwNP	chronic rhinosinusitis *with* nasal polyps
CRSsNP	chronic rhinosinusitis *sans* nasal polyps
ECP	eosinophil cationic protein
EPOS	European Position Paper on Rhinosinusitis and Nasal Polyps
ESS	endoscopic sinus surgery
IgE	Immunoglobulin E
IL	interleukin
MLK	modified Lund–Kennedy
MLM	modified Lund–Mackay
MMP	matrix metalloproteinases
MUC	mucin
NOS	nitric oxide synthase
NSAID	non-steroidal anti-inflammatory drug allergy
sIgE	specific Immunoglobulin E
sST2	soluble ST2
TIMP	tissue inhibitors of metalloproteinases
Treg	regulatory T
TSLP	thymic stromal lymphopoietin
TSLPR	thymic stromal lymphopoietin receptor

Introduction

Chronic rhinosinusitis (CRS) is characterized by persistent inflammation of the nasal mucosa and paranasal sinuses [1]. Based on the presence of nasal polyps, CRS is classified into two phenotypes: chronic rhinosinusitis *with* nasal polyps (CRSwNP, accounting for approximately 20% of CRS cases) and chronic rhinosinusitis *without* (*sans*) nasal polyps (CRSsNP) [2,3]. The 2020 European Position Paper on Rhinosinusitis and Nasal Polyps (EPOS) [4] further categorizes CRS into primary and secondary forms, and within these, into localized (unilateral) and diffuse (bilateral) types based on polyp location. Additionally, CRS is endotyped into predominant type 2 inflammation and non-type 2 inflammation (absence of type 2 markers), with CRSwNP generally classified as diffuse and driven by type 2 inflammation [4]. CRSwNP occurs more frequently in men, although the disease tends to follow a more severe course in women. CRS is characterized by a high rate of recurrence and a heterogeneous clinical course [2,3].

Common symptoms of rhinosinusitis include nasal obstruction, persistent rhinorrhea, nasal swelling and congestion, hyposmia, sinus pressure, facial pain, headaches, and fatigue. Secondary complications such as nasal polyps can exacerbate symptoms and complicate treatment [5–8]. In pediatric populations, symptoms may differ and often include cough, irritability, fatigue, halitosis, periorbital swelling and redness, as well as thick yellow-green nasal or postnasal discharge. Children are also at increased risk for progression from acute to chronic rhinosinusitis [5–7].

Beyond physical symptoms, CRS significantly impacts mental health, contributing to reduced concentration, sadness, anxiety, sleep disturbances, and social discomfort. This adversely affects daily functioning, self-esteem, and parental well-being in affected children [2,6]. Patients, especially those with anosmia, face a higher risk of depression [2].

Diagnostic criteria established by the American Academy of Otolaryngology–Head and Neck Surgery (AAO-HNS) in 2015 (**Table 1**) require the presence of two or more cardinal symptoms (facial pain/pressure/fullness, hyposmia/anosmia, nasal obstruction, and mucopurulent nasal drainage) persisting for at least 12 weeks, alongside objective evidence of inflammation (such as purulent mucus or edema in the middle meatus or anterior ethmoid

Table 1. Diagnostic criteria for chronic rhinosinusitis (CRS) as established by the American Academy of Otolaryngology – Head and Neck Surgery [9,10]

Criterion	Details
Symptoms (≥2 of the 4 listed for ≥12 weeks)	Facial pain/pressure/fullness Hyposmia/anosmia (reduced sense of smell) Nasal obstruction Anterior or posterior mucopurulent nasal drainage
Documented inflammation (at least 1 of the 3 listed)	Purulent mucus or edema in the middle meatus or anterior ethmoid region Presence of nasal polyps in the nasal cavity or middle meatus Evidence of inflammation on radiographic imaging (e.g., CT scan)

region, presence of nasal polyps, or radiographic signs of inflammation) [9,10].

The inflammatory profile of CRS varies across geographic regions. Type 2 inflammation, characterized by local eosinophil infiltration and elevated IgE and cytokines (IL-4, IL-5, IL-13), predominates in Western populations and is frequently associated with asthma. In contrast, Asian populations more commonly exhibit type 1 and type 3 inflammation, with lower eosinophil counts but elevated TNF-α and IL-17 levels [3,11,12].

Endoscopic sinus surgery (ESS) remains the cornerstone treatment for patients unresponsive to pharmacological therapy, including intranasal and systemic corticosteroids. ESS is widely performed regardless of immune response type. However, nasal polyp recurrence after surgery is common and poses a significant clinical challenge. Identifying factors that contribute to polyp recurrence is critical for optimizing treatment and improving long-term outcomes [2,13,14].

This narrative review summarizes current knowledge regarding risk factors associated with nasal polyp recurrence following ESS, emphasizing the potential clinical and pathological predictors.

Material and methods

The aim of this review was to identify and summarize potential risk factors for nasal polyp recurrence following endoscopic sinus surgery in patients diagnosed with chronic rhinosinusitis with nasal polyps.

Eligibility criteria

We included studies published within the last 5 years, focusing on CRSwNP, its pathogenesis, and factors influencing nasal polyp recurrence after ESS. All types of observational studies were considered eligible for inclusion.

Search strategy

A comprehensive literature search was conducted using the PubMed database. The following keywords and their combinations were used: *chronic rhinosinusitis* (2,649 results), *endoscopic sinus surgery* (2,293 results), and *nasal polyps* (1,701 results). The final search and review of source texts was performed on 3 January 2025.

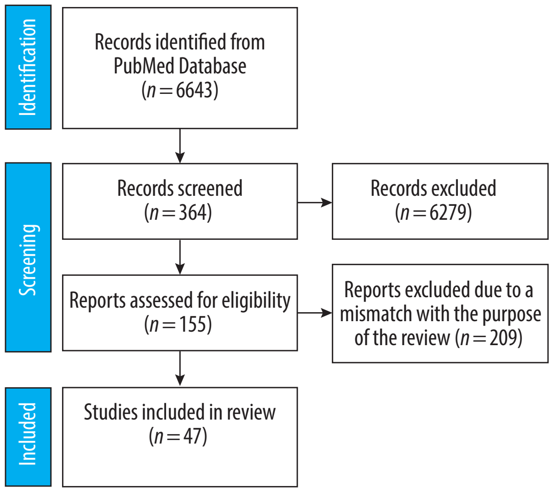

Figure 1. PRISMA flow diagram of the study selection process

Inclusion criteria were: publication within the last 5 years, availability of full text, English language, relevance to the topic, ethical approval (for original research), and high methodological quality. Exclusion criteria comprised older publications, animal studies, pharmacological models, non-English articles, and studies lacking ethical approval or deemed unreliable.

Data collection

Initially, titles and abstracts of retrieved papers were screened for relevance. A total of 6,643 articles were initially identified from the PubMed database between 2019 and 2024. After removing duplicates and screening based on title relevance, 364 articles remained. Abstract review further narrowed this to 155 studies assessed for methodological quality and relevance to the inclusion criteria. Subsequently, full-text articles were reviewed, resulting in the selection of 47 studies that were most pertinent to the review's focus.

Extracted data included diagnostic criteria for CRSwNP, insights into its pathogenesis, details on ESS, and reported risk factors for polyp recurrence following surgery.

The study selection process is summarized in **Figure 1**.

Results

Recurrence of nasal polyps following ESS in patients with chronic rhinosinusitis with CRSwNP occurs frequently. Multiple studies have investigated the clinical and biological factors influencing the risk of polyp recurrence.

Clinical risk factors

Several studies have identified key clinical predictors for polyp recurrence. Mohamed et al. [15] highlighted smoking, concomitant asthma, allergy, previous sinus surgery, aspirin sensitivity, and nasal anatomical variations as significant risk factors in their cohort of patients resistant to medical treatment. Similarly, Fageeh et al. [16] found asthma and smoking to be strongly associated with polyp recurrence, while factors such as septal deviation, age, gender, and BMI showed no correlation. Alqahtani et al. [5] reported that recurrent upper respiratory tract infections, nasal allergies, smoking, and impaired sinus ventilation (including turbinate hypertrophy, nasal polyps, and septal deviation) were significantly associated with CRSwNP recurrence. Correspondingly, Mamat Nasir et al. [8] identified smoking and nasal allergies as important contributors to relapse risk in their patient cohort and Mullol et al. [2] additionally highlighted bronchiectasis as a risk factor.

Calvanese et al. [17] found that asthma, hypersensitivity to acetylsalicylic acid (ASA), and eosinophilia level were significantly associated with polyp recurrence and involvement of multiple sinus sites, but there was no link to sex, age, or preoperative eosinophil count. Bouatay et al. [18] similarly emphasized asthma and ASA intolerance, as well as patient non-compliance with intranasal steroid therapy, as key factors influencing recurrence risk. Abuduruk et al. [19] additionally noted the effect of surgery extent, patient adherence to postoperative care, IL-5 expression, and T2 inflammatory profile on recurrence.

The impact of smoking on recurrence was further explored by Cavaliere et al. [20], who found higher rates of polyp recurrence in nonsmokers and former smokers than in current smokers, suggesting complex interactions between smoking status and disease progression.

Chen et al. [21] identified metabolic syndrome as an independent risk factor, with recurrence risk increasing with the number of metabolic components present. Yuan et al. [22] reported increased polyp recurrence in CRSwNP patients with rheumatoid arthritis, emphasizing the role of systemic inflammation.

Microbiome and inflammatory cytokines

Gan et al. [23] demonstrated that neutrophilic inflammation, characterized by elevated neutrophil and eosinophil counts and increased expression of IFN-γ, IL-17A, IL-17E, and IL-18, correlated with polyp recurrence and was linked to dysbiosis with increased *Staphylococci* and decreased *Corynebacterium* species in recurrent cases. Peng et al. [24] identified preoperative rectal carriage of *Staphylococcus aureus* as a significant risk factor, along with asthma, NSAID allergy, and prior ESS. Yu et al. [25] further underlined the role of neutrophil infiltration and elastase activity as markers of severe disease and recurrence.

Biomarkers predicting recurrence

Beyond clinical risk factors, numerous biomarkers have been examined for their predictive value in recurrence. Bai et al. [26] reported that elevated eosinophil cationic protein (ECP), interleukin-5 (IL-5) expression, higher modified Lund–Mackay (MLM) and modified Lund–Kennedy (MLK) scores, as well as anti-dsDNA IgG, were strongly associated with recurrence risk. These findings suggest that both radiologic and immunologic markers may help identify patients requiring intensified postoperative care.

Similarly, Viksne et al. [27] reported increased expression of IL-4, IL-6, IL-7, IL-10, and IL-12 in the subepithelial connective tissue of polyps from patients with recurrent CRSwNP, accompanied by decreased cytokine concentrations in the epithelium compared to controls. IL-6 showed a strong correlation with other cytokines and the proliferation marker Ki-67, suggesting its role as a predictor of polyp recurrence. Similarly, IL-4, IL-7, IL-10, and IL-12 correlated with Ki-67, indicating their potential involvement in polyp cell proliferation.

Lin et al. [28] also highlighted the prognostic significance of tissue and serum biomarkers in predicting polyp recurrence after ESS. Their study demonstrated that higher levels of tissue eosinophils, ECP, serum IgE, and interleukin-5 were associated with an increased risk of recurrence. Moreover, they pointed to the role of postoperative factors, such as infection and changes in the nasal cavity environment, in influencing surgical outcomes.

Wang et al. [29] found that B7-H4 mRNA expression levels were significantly elevated in CRSwNP patients, particularly in those with recurrent polyps, correlating with eosinophilia and suggesting B7-H4 as a potential marker for predicting postoperative recurrence. Deng et al. [30] demonstrated higher expression of SERPINB10 in recurrent CRSwNP tissues compared to primary cases and controls, with a positive correlation between SERPINB10 and eosinophilic inflammation, indicating its potential as a biomarker for polyp recurrence.

Niu et al. [31] identified increased serum levels of CSF1R and CDC42, and decreased DHRS9, in recurrent CRSwNP patients compared to non-recurrent cases. CSF1R expression was particularly linked to M2 macrophage polarization and cytokine production, which may contribute to recurrence risk. Deng et al. [32] reported elevated serum and tissue S100A8 concentrations in CRSwNP patients, especially in those with recurrence, correlating with eosinophil levels and suggesting its utility as a predictor of surgical outcomes.

Exosomal miRNAs have also been implicated in recurrence. Chen et al. [33] found that increased expression of miR-3174 and miR-192-3p was associated with higher recurrence risk, while Wang et al. [34] identified altered expression of miR-141-3p and miR-3679-5p in serum exosomes of CRSwNP patients, with greater changes observed in eosinophilic phenotypes.

Table 2. Summary of research findings [15–29,32,34–37,39,40,43,44]

Author, year	Detected risk factors	Recurrence rate in the study [%]	Follow-up period
Bai et al., 2022 [26]	Cationic eosinophil proteins, IL-5 expression, pre-ESS MLM, anti-dsDNA IgG, asthma	39.4	2–5 years
Bouatay et al., 2024 [18]	Asthma, ASA sensitivity, compliance with post-procedure recommendations, allergic rhinitis, Samter's triad	20.7	3 years (avg., min. 12 months)
Calvanese et al., 2024 [17]	Asthma, eosinophilia, ASA sensitivity	24.0	2 years
Chen et al., 2022 [43]	Increased CLCs expression	30.0	2 years
Chen et al., 2024 [21]	Metabolic syndrome	41.8	>2 years
Deng et al., 2024 [32]	S100A8 expression	23.3	no data
Fageeh et al., 2023 [16]	Asthma, smoking, bilateral polyps, average polyp grade, Lund Mackay score	51.5	2 years
Gan et al., 2021 [23]	Sinus microbiome composition, inflammatory cytokines, eosinophils and neutrophils concentration in polyp tissue	15.6	1 year
Gao et al., 2024 [44]	Increased sIgE, IL-6 and decreased Treg level	24.2	1 year
Guerra et al., 2021 [36]	MMP-2, MMP-7, MMP-9 and TIMP-1, TIMP-2 expression, asthma, non-allergic rhinitis	37.8	3 years
Kidoguchi et al., 2020 [39]	Increased NOS expression	25.7	no data
Lin et al., 2024 [27]	Preoperative tissue eosinophil percentage, ECP, IgE levels, IL-5 expression, postoperative nasal environment	19.5	6 months
Liu et al., 2020 [35]	MUC5AC, MUC5B, MUC2 expression	23.2	6 months – 1 year
Mohamed et al., 2023 [15]	Smoking, asthma, allergy, ASA sensitivity, septal deviation, prior sinus surgery, turbinate hypertrophy	15.0	6 months
Peng et al., 2023 [24]	Rectal S. aureus carriage, asthma, NSAID allergy, previous ESS	36.3	2 years
Viksne et al., 2022 [28]	IL-4, IL-6, IL-7, IL-10, IL-12, Ki-67 expression	no data	no data
Wang et al., 2022 [29]	mRNA B7-H4 expression	no data	no data
Wang et al., 2024 [37]	Upregulation of miR-141-3p and downregulation of miR-3679-5p	44.8	12–31.5 months
Yu et al., 2022 [25]	Human neutrophil elastase level, serum eosinophil count, IL-10 expression, younger age	25.7	1 year
Yuan et al., 2024 [22]	Rheumatoid arthritis	22.6	2 years
Zhang et al., 2022 [40]	Increased level of IL-33 and sST2	28.2	3 years
Zhang et al., 2022 [33]	Increased ALCAM expression	29.1	>2 years

Tissue remodeling and immune regulation

Alterations in tissue remodeling markers have a significant impact on the risk of polyp recurrence in patients with CRSwNP. Liu et al. [35] examined mucin expression (MUC2, MUC5AC, MUC5B) in nasal polyp tissues, finding that elevated mucin levels correlated with polyp recurrence, while downregulation was negatively associated with relapse rates. Guerra et al. [36] showed increased expression of matrix metalloproteinases (MMP-2, MMP-7, MMP-9) and decreased tissue inhibitors of metalloproteinases (TIMP-1, TIMP-2) in CRSwNP patients, especially in those with asthma and nonallergic rhinitis, which correlated with higher recurrence rates.

Zhang et al. [37] demonstrated that serum and tissue levels of activated leukocyte cell adhesion molecule (ALCAM) were significantly elevated in CRSwNP patients, particularly in eosinophilic phenotypes, and correlated positively with eosinophil counts and postoperative relapse risk. Soon after, Zhang et al. [38] also reported increased expression of B cell-activating factor (BAFF) in recurrent CRSwNP patients, which was associated with higher eosinophil percentages and polyp recurrence.

Table 3. Summary of research findings including the number of patients with recurrent or non-recurrent CRSwNP who completed the whole follow-up [30,31,33,37,41,42]

Author, year	Detected risk factors	Number of patients included
Chen et al., 2024 [33]	Upregulation of miR-3174 and downregulation of miR-192-3p	8 RG – 4 NRG – 4
Deng et al., 2022 [30]	SERPINB10 expression	140 (60 – CRSwNP; 40 – CRSsNP; 40 – HC) RG – 24 NRG – 36
Niu et al., 2024 [31]	CSF1R expression	Discovery cohort: 16 RG – 6 NRG – 10 Validation cohort: 75 RG – 24 NRG – 51
Wang et al., 2022 [42]	Increased eotaxin, G-CSF, IFN-α, IL-13, IL-17A, IL-5, MCP-1, and RANTES level	72 RG – 36 NRG – 36
Wen et al., 2021 [41]	Increased YKL-40 expression	160 (120 – CRSwNP; 40 – HC) RG – 40 NRG – 80
Zhang et al., 2022 [37]	Increased BAFF expression	160 (80 – CRSwNP; 40 – CRSsNP; 40 – HC) RG – 40 NRG – 40

Note: CRSwNP, chronic rhinosinusitis with nasal polyps; CRSsNP, chronic rhinosinusitis without nasal polyps; RG, recurrent group (CRSwNP); NRG, non-recurrent group (CRSwNP); HC, healthy controls

Table 4. Summary of other findings included in the review

Authors	Conclusion
Niu et al., 2023 [31] Zhu et al., 2022 [1]	M2 macrophages play a role in the development of CRSwNP by modulating immune responses and contributing to tissue remodeling
AlBloushi et al., 2024 [11] Barroso et al., 2023 [9] Fokkens et al., 2020 [4] Klingler et al., 2021 [3] Mullol et al., 2022 [2]	Chronic rhinosinusitis with nasal polyps and asthma frequently exhibit similar type 2 immunopathology, with epithelial barrier dysfunction observed in both conditions. Additionally, about 25% of individuals with CRSwNP also have asthma (compared to 5% in general population)
Laidlaw et al., 2021 [12]	Aspirin/nonsteroidal anti-inflammatory drug-exacerbated respiratory disease (AERD) is a well-established phenotype of CRSwNP that often coexists with asthma and is characterized by a severe clinical course
Martin-Jimenez et al., 2023 [13]	Surgical approaches involving extensive resection of the sinus bony structures (reboot surgery) and treatment of the mucosal lining of the nasal cavity (mucoplasty), along with improved surgical outcomes and reduced polyp recurrence, contribute to a better quality of life for patients
Barroso et al., 2023 [9] Miglani et al., 2023 [14]	Biological agents (including dupilumab, mepolizumab, and omalizumab) act as alternatives to ESS, but their effectiveness in reducing polyp size is significantly lower compared to ESS

Kidoguchi et al. [39] linked increased expression of nitric oxide synthase 2 (NOS2) and its gene polymorphisms with a higher risk of postoperative recurrence, particularly in eosinophilic CRSwNP. Zhang et al. [40] found elevated serum levels of IL-33 and soluble ST2 (sST2) in eosinophilic CRSwNP patients, which correlated with eosinophilia and recurrence risk, demonstrating their potential as predictive biomarkers.

Wen et al. [41] identified YKL-40 as a mediator associated with type 2 inflammation and polyp recurrence, showing higher levels in recurrent eosinophilic CRSwNP patients and correlation with eosinophil counts. Wang et al. [42] evaluated a panel of cytokines and found elevated serum levels of eotaxin, G-CSF, IFN-α, IL-13, IL-17A, IL-5, MCP-1, and RANTES in recurrent CRSwNP patients. Among these, eotaxin and RANTES showed strong predictive value for recurrence.

Table 5. Summary of the most common detected risk factors for polyp recurrence in CRSwNP patients

Authors	Detected factor
Abuduruk et al., 2024 [19] Alshehri et al., 2021 [7] Bai et al., 2022 [26] Bouatay et al., 2024 [18] Calvanese et al., 2024 [17] Cavaliere et al., 2024 [20] Fageeh et al., 2023 [16] Guerra et al., 2021 [36] Mohamed et al., 2023 [15] Moreno-Jimenez et al., 2025 [45] Mullol et al., 2022 [2] Peng et al., 2023 [24] Rizzi et al., 2023 [46]	Asthma
Abuduruk et al., 2024 [19] Alqahtani et al., 2023 [5] Alshehri et al., 2021 [7] Bai et al., 2022 [26] Bouatay et al., 2024 [18] Calvanese et al., 2024 [16] Ma et al., 2022 [47] Mamat et al., 2022 [8] Mohamed et al., 2023 [15]	Allergy (including allergic rhinitis, eosinophilia)
Abuduruk et al., 2024 [19] Bouatay et al., 2024 [18] Calvanese et al., 2024 [17] Mohamed et al., 2023 [15] Mullol et al., 2022 [2] Peng et al., 2023 [24]	ASA sensitivity
Alqahtani et al., 2023 [5] Fageeh et al., 2023 [16] Mamat et al., 2022 [8] Mohamed et al., 2023 [15]	Smoking
Abuduruk et al., 2024 [19] Bai et al., 2022 [26] Lin et al., 2024 [27] Wang et al., 2022 [42]	IL-5 expression
Viksne et al., 2022 [28] Yu et al., 2022 [25]	IL-10 expression
Gao et al., 2024 [44] Viksne et al., 2022 [28]	IL-6 expression
Mohamed et al., 2023 [15] Peng et al., 2023 [24]	Prior sinus surgery
Abuduruk et al., 2024 [19] Bouatay et al., 2024 [18]	Compliance with post-procedure recommendations

Chen et al. [43] examined Charcot–Leyden crystals (CLCs) in nasal secretions and found elevated levels in 85% of recurrent CRSwNP cases, with high sensitivity and specificity for predicting postoperative recurrence. Gao et al. [44] demonstrated that higher serum immunoglobulin E (sIgE) and IL-6 levels, alongside lower regulatory T cell (Treg) percentages, were associated with recurrence in eosinophilic CRSwNP patients, with combined marker analysis yielding high predictive accuracy.

Finally, Moreno-Jimenez et al. [45] showed increased expression of thymic stromal lymphopoietin (TSLP) in nasal polyps and elevated TSLP receptor (TSLPR) expression in peripheral blood of CRSwNP patients with low eosinophilia, suggesting these molecules as minimally invasive biomarkers and potential therapeutic targets.

Table 2, **Table 3**, and **Table 4** summarize the results of the studies included in the review.

Discussion

Recurrence of nasal polyps after endoscopic sinus surgery remains a significant challenge in the management of chronic rhinosinusitis with nasal polyps. It is estimated that approximately 20% of CRSwNP patients experience polyp recurrence within 5 years following ESS [46]. The studies included in this review reported an average recurrence rate of 28%, based on follow-up periods ranging from 6 to 69 months. Notably, the highest risk of relapse occurs within the first postoperative year, highlighting the need for close monitoring during this critical period [15–45].

Multiple risk factors for polyp recurrence have been consistently identified. Comorbid asthma, allergic rhinitis, and aspirin-exacerbated respiratory disease (AERD) are strongly associated with higher relapse rates [15–20,24–28,36,42,44]. Systemic eosinophilia and elevated levels of inflammatory cytokines, particularly IL-5, IL-6, and IL-10, further contribute to persistent disease and polyp regrowth [15–20,24–28,36,42,47]. Patient-related factors, such as smoking, poor adherence to postoperative care protocols, and a history of previous sinus surgeries, have also been implicated in increasing the risk of recurrence [15–45]. **Table 5** lists the most common risk factors found.

Recent molecular studies have provided new insights into the pathophysiological mechanisms underlying polyp recurrence. Biomarkers related to inflammation (e.g., NOS2, RANTES, ALCAM, BAFF, CSF1R, sST2, S100A8, SERPINB10, B7-H4, miR-3174, miR-192-3p) and tissue remodeling (e.g., MMP-2, MMP-7, MMP-9, and their inhibitors TIMP-1, TIMP-2) show promise as predictors of postoperative outcomes [29–43]. Charcot–Leyden crystals have also emerged as potential indicators of recurrence due to their association with eosinophilic inflammation [43]. However, these findings remain preliminary and require validation in larger, prospective studies before they can be integrated into routine clinical practice.

Importantly, the inflammatory phenotype of CRSwNP appears to influence recurrence patterns. Patients with eosinophilic CRSwNP consistently exhibit higher relapse rates than those with non-eosinophilic forms [34,37,40,41,44]. In contrast, the role of neutrophilic infiltration is less well defined, with conflicting evidence regarding its contribution to polyp regrowth [23,25,44].

While these insights represent significant progress, heterogeneity across studies – particularly in terms of follow-up duration, patient population, and biomarker assessment – limits direct comparisons and underscores the need for standardized methodologies. Future research should prioritize large-scale, longitudinal studies to validate promising biomarkers and explore targeted therapeutic strategies.

In clinical practice, incorporating established risk factors and emerging molecular markers into pre- and postoperative assessments may facilitate more personalized management strategies, ultimately improving long-term disease control and reducing recurrence rates.

Conclusions

Based on the reviewed evidence, the recurrence of nasal polyps after endoscopic sinus surgery in patients with CRSwNP is a multifactorial process involving complex immune and inflammatory pathways. Numerous studies have identified elevated levels of type 2 cytokines, eosinophil-associated markers, matrix metalloproteinases, and immune regulatory molecules as key contributors to polyp relapse. Biomarkers such as ALCAM, Charcot–Leyden crystals, mucins, and combined assessments of sIgE, IL-6, and regulatory T-cells show significant potential in predicting postoperative recurrence.

These insights underscore the importance of integrating biomarker evaluation into clinical practice to better stratify a patient's risk of recurrence, enabling personalized postoperative management. Continued research is essential to further validate these biomarkers and to develop targeted therapeutic strategies aimed at reducing polyp recurrence and improving long-term outcomes for patients.

Ultimately, improving the prediction and prevention of polyp recurrence has the potential to significantly enhance the quality of life for affected patients by reducing symptoms, decreasing the need for repeated surgeries, and minimizing the burden of chronic inflammation.

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SOCIAL AND ENVIRONMENTAL FACTORS AFFECTING COMMUNICATION HEALTH IN CHILDREN WITH COCHLEAR IMPLANTS: REPORT OF A PILOT STUDY

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Contributions:
A Study design/planning
B Data collection/entry
C Data analysis/statistics
D Data interpretation
E Preparation of manuscript
F Literature analysis/search
G Funds collection

Abstract

Introduction: This report summarises the pilot phase of a project, conducted at the World Hearing Center, Warsaw, Poland, on the role of social and environmental factors in the development of communication health in children with congenital deafness following cochlear implantation. This study validated the interview protocol, assessed the ICF-CY framework (International Classification of Functioning, Disability and Health, Children & Youth version), and identified preliminary social determinants.

Material and methods: The pilot study employed in-depth interviews (IDI) with 21 children with a CI and 20 of their parents. The interview framework was developed based on the ICF-CY framework. Qualitative analysis enabled the identification of key areas relevant to the development of communication health in children with a CI, including the school environment, social functioning, self-perception of disability, and parental involvement. The sample was selected using knowledge of the patient population attending the World Hearing Center, taking into account age at implantation, gender, and the absence of comorbid conditions.

Results: Development and validation of the research tool: an interview framework for children with a CI and their parents or caregivers is presented. Data indicate that the school environment, including peer relationships and teacher support, was the most frequently identified factor affecting the quality of the children's daily functioning. The children perceived their disability in varied ways, with most not identifying themselves as disabled, which highlights the need to reconsider traditional definitions of disability. Parental involvement and technical challenges related to the use of speech processors also emerged as important themes in user responses.

Conclusions: The pilot study confirms the value of using the ICF-CY as a framework for examining social factors that affect communication health in children with a CI. It also highlights the importance of an interdisciplinary approach and the need to incorporate psychosocial and environmental factors into the care of children with a CI. The findings point to the necessity of further research and the development of holistic support models tailored to this specific patient population.

Keywords: cochlear implant • interdisciplinary research • children with congenital deafness • ICF-CY • pilot study

ŚRODOWISKOWE CZYNNIKI SPOŁECZNE W KSZTAŁTOWANIU ZDROWIA KOMUNIKACYJNEGO U DZIECI Z IMPLANTAMI ŚLIMAKOWYMI: RAPORT Z BADANIA PILOTAŻOWEGO

Streszczenie

Wprowadzenie: Niniejszy raport podsumowuje wyniki pilotażowego etapu projektu „Rola społecznych i środowiskowych czynników w rozwoju zdrowia komunikacyjnego po wszczepieniu implantu ślimakowego u dzieci z wrodzoną głuchotą", realizowanego w Światowym Centrum Słuchu (WHC) w Warszawie/Kajetanach, na temat roli czynników społecznych i środowiskowych w kształtowaniu zdrowia komunikacyjnego u dzieci z wrodzoną głuchotą po wszczepieniu implantu ślimakowego (CI). Badanie pilotażowe służyło walidacji i dopracowaniu scenariusza wywiadu, ocenie przydatności koncepcji ICF-CY jako podstawy metodologicznej badania oraz uzyskaniu pierwszych wyników dotyczących czynników społecznych wpływających na zdrowie komunikacyjne dzieci z CI.

Materiał i metody: Wywiady przeprowadzono z 21 dziećmi i 20 rodzicami. W badaniu zastosowano pogłębione wywiady (IDI) z 21 dziećmi z CI i ich 20 rodzicami. Scenariusz wywiadów został opracowany w oparciu o koncepcję ICF-CY. Analiza jakościowa umożliwiła identyfikację kluczowych obszarów mających znaczenie w kształtowaniu zdrowia komunikacyjnego dzieci z CI, w tym środowiska szkolnego, funkcjonowania społecznego, samooceny niepełnosprawności i zaangażowania rodziców. Próbę do badania wybrano na podstawie wiedzy o populacji dzieci poddanych implantacji w Światowym Centrum Słuchu (WHC) z uwzględnieniem wieku w chwili implantacji, płci oraz braku współistniejących chorób i zaburzeń.

Wyniki: Dopracowanie i walidacja narzędzia badawczego: scenariusz wywiadu z dzieckiem z CI oraz jego rodzicem/opiekunem. Dane uzyskane podczas badania pilotażowego wskazują, że środowisko szkolne, w tym relacje z rówieśnikami i wsparcie nauczyciela, było najczęściej identyfikowanym czynnikiem wpływającym na jakość codziennego funkcjonowanie dzieci z CI. Dzieci w zróżnicowany sposób postrzegały swoją niepełnosprawność, a większość nie określała siebie jako osoby z niepełnosprawnością, podkreślając potrzebę redefinicji tradycyjnego rozumienia pojęcia niepełnosprawności. Z wypowiedzi użytkowników wynika, że istotnymi czynnikami są również zaangażowanie rodziców i wyzwania techniczne związane z wykorzystaniem procesorów mowy.

Wnioski: Pilotaż potwierdza użyteczność wykorzystania ICF-CY jako ramy w badaniach czynników społecznych wpływających na zdrowie komunikacyjne dzieci z CI. Podkreśla także znaczenie podejścia interdyscyplinarnego oraz potrzebę uwzględniania czynników psychospołecznych i środowiskowych w opiece nad dziećmi z CI. Wyniki wskazują na konieczność prowadzenia dalszych badań i opracowania holistycznych modeli wsparcia dostosowanych do tej populacji pacjentów.

Słowa kluczowe: implant ślimakowy • badania interdyscyplinarne • dzieci z wrodzoną głuchotą • ICF-CY • badania pilotażowe

Introduction

This report presents the results of the pilot phase of an interdisciplinary project "The Role of Social and Environmental Factors in the Development of Communicative Health after Cochlear Implantation in Children with Congenital Deafness," conducted at Poland's World Hearing Center (WHC) in Kajetany. The pilot study's aims were threefold: to test a new interview framework for children with cochlear implants (CIs) and their caregivers; to assess the applicability of the ICF-CY framework developed by the United Nations as the methodological foundation of the study, and to gather initial data on factors affecting the development of communication health in young CI users. Insights gained from the pilot will guide further refinement of the interview protocol and of an online questionnaire.

Our project combines audiological, medical, and sociological aspects to provide a multidimensional assessment of the communication health of children with CIs. Future phases will expand the study sample and analyse the impact of each dimension on long-term outcomes. In this way we aim to develop comprehensive guidelines for practitioners, schools, and families for maximising CI benefits and for developing communication health.

Project context

To better understand our approach, we first outline current knowledge regarding cochlear implantation in children. Research confirms that early implantation, especially before 3 years of age, significantly increases the likelihood of developing typical language, perception, and social interaction [1,2]. Children implanted early generally have better speech comprehension and production, and perform better in social settings compared to those implanted later [3,4].

However, even when children have similar medical profiles, there is considerable variability in outcomes, affected not only by technical and medical factors but also by psychosocial and environmental conditions [5]. Key influences include age at implantation, family environment, peer and school support, communication methods at home, and parental involvement. Recent studies highlight that social relationships – with parents, teachers, and peers – strongly affect language development and psychosocial well-being in children with a CI [6,7].

A holistic approach is increasingly recognised as essential, considering functional outcomes alongside psychosocial and environmental factors. The International Classification of Functioning, Disability and Health (ICF) [8] and its Children & Youth Version [9] offer valuable frameworks for assessing and planning rehabilitation of CI recipients [10]. Important determinants of CI outcomes include age at implantation, medical comorbidities, social determinants of health, and bilateral versus unilateral implantation [11]. Early implantation and bilateral hearing are associated with better results.

According to the ICF and ICF-CY, good functioning requires not only an intact auditory system but also activity and social participation, which are shaped by environmental factors such as social engagement and system-wide support [12]. Previous research on adults with CIs has used the assessment protocol based on the ICF model to gauge CI outcomes and has demonstrated that CIs improve auditory performance, communication, and well-being [10,13,14].

Communication health and the social environment

Following the American Speech-Language-Hearing Association (ASHA), which defines communication health as an individual's or a group's collective speech, language, and/or hearing health and well-being [15], we propose a related concept of communication health. In the ASHA definition, communication health is extended from the individual to the population level, going beyond discrete biological processes to include social and ecological factors, so that optimal communication health is achieved through preventing and mitigating communication disorders while promoting effective communication. Building on this framework, we define communication health to be the individual's ability to use speech, language, and hearing to participate fully in social life. Within a modern public health model, this construct sees communication as a key determinant of health and not merely a clinical deficit. Reflecting this view, a recent paper calls for integrating speech, language, and hearing sciences into a systems-based approach in order to overcome communication barriers and promote social participation [16].

Impaired development of communication in early childhood poses significant risks to a child's health and well-being, limiting their social and relational engagement [17]. In other words, a child's language and communication skills are closely linked to their psychological and social functioning. According to the ICF framework, communication involves not only auditory function but also activity and participation, so that it depends on personal and environmental factors. Thus, communication health will encompass sensory and linguistic proficiency as well as the ability to engage in family life, schooling, and social interactions.

Children with CIs

For children with a CI, communication health is a complex, multidimensional construct having audiological, social, and psychological components. Despite technological advances and generally positive outcomes, children with CIs can still face communication challenges and limitations in social participation [18,19]. Parents and professionals share the challenge of supporting a child to achieve its full personal, educational, and social potential [20,21]. All this underscores the need for flexible, individualised support and making use of comprehensive assessments that include audiological, environmental, and psychological factors [6]. However, prior research has mainly focused on audiological and medical factors, often neglecting the social and environmental aspects. To date, the ICF-based protocol has not been systematically used to assess outcomes in children with CIs.

Our project uses the ICF-CY framework to analyse the social and environmental factors that affect the outcomes of cochlear implantation in children with congenital deafness. Our study employs a 360-degree interdisciplinary approach, combining audiological, medical, and sociological data.

Key dimensions

Based on the ICF-CY framework in the context of communication health (see **Table 1**), we identified four key conceptual dimensions for the study. (1) *School environment* – analysis of educational conditions and the availability of specialised support revealed the significant impact of the school environment on children's communication skill and emotional development (in the ICF framework: environmental factors). (2) *Social functioning* – sociological studies have highlighted the role of a child's peer interactions and participation in extracurricular activities in shaping their sense of belonging and social competence (in the ICF framework: activity and participation). (3) *Perception of one's own disability* – conversations with children indicated that many young patients do not identify with the concept of "a person with a disability." This redefinition of self-identity is crucial for their self-esteem and motivation for further rehabilitation (in the ICF framework: personal factors). (4) *Parental involvement* – family support, both emotional and organisational, also emerged as a fundamental factor enhancing therapy effectiveness and overall satisfaction with implantation outcomes (again, in the ICF framework, these are environmental factors).

We hypothesise that social environmental variables – family and peer relationships, school and leisure functioning, and community engagement – significantly affect the benefits available from using a CI. Our 360-degree research strategy was to collect data from diverse respondents through in-depth interviews (IDI), focus groups, and computer-assisted web interviews.

Assumptions and expected outcomes

Our research was based on three core assumptions: (1) that social factors, such as support from family and friends, significantly affects CI outcomes over and above medical factors; (2) that active engagement in school and peer environments, combined with a positive self-identification, helps overcome limitations associated with deafness and hearing loss; and (3) that the ICF-CY framework provides an accurate and multidimensional assessment of functioning in children with CIs. We hope that our findings will contribute to the development of practical recommendations for families, educators, and professionals, while also promoting participatory approaches in pediatric research. Furthermore, adapting the ICF-CY tools to a

Table 1. Main conceptual dimensions and how they can be operationalised into a questionnaire

Dimension	ICF-CY concept	Details	Operationalised questions
Social activity and social functioning	Activity is a person's performance of a task or taking an action; activity limitations are the difficulties a person may have in acting	Includes verbal and nonverbal communication, coping with everyday life situations, and functioning at home, school, and within peer environments	• Communication patterns, the quality of communicating with others • The way free time is spent (alone or with others): e.g., watching movies, listening to music, sports • Dealing with usual and unusual situations • Functioning at home and outside the home (e.g., school, with peers) • Responsibilities at home and outside the home • Identifying what is easy, and what is difficult (when alone or with others), and why
Social participation	Participation is a person's involvement in certain life situations. Limitations to participation are problems that hinder a person. Engaging in life situations. Being included in a particular area of life, being accepted, or having access to needed resources	Involvement in family, school, and extracurricular events, participation in additional activities, as well as functioning in situations requiring increased auditory effort	• Involvement in family events • Involvement in school • Extra-curricular activities • Situations requiring auditory "effort"
Self-identification and identification by others	Two dimensions to understand the "if" and "why" disability is used in the way respondents describe themselves and how others describe them	Seeing oneself as a person with or without a disability. Perception by others from the perspective of disability	• Is a child with an implant a person with or without a disability? • What makes the child see/define themself this way? • How do others see the CI processor in the respondent? • What is a CI processor? (a body part or something artificial)

Polish context will help establish a common terminology for describing how children with CIs function, facilitating comparisons across centers and borders and improving support networks.

Ethical considerations

A full-scale research project "The Role of Social and Environmental Factors in the Development of Communicative Health after Cochlear Implantation in Children with Congenital Deafness," is scheduled for implementation at the World Hearing Centre between 2024 and 2027, and has received prior approval from its bioethics committee. Approval covers the study design, participant recruitment procedures, consent forms for parents/caregivers, and the data management protocol. Prior to each interview, parents or legal guardians provided written consent on behalf of both themselves and their child.

Material and methods

Study design

As part of the preparations for the full multi-year research project (2024–2027), an exploratory pilot study was conducted with the primary aim of developing, testing, and preliminarily validating an innovative research tool. This study, reported here, constitutes the first phase of the "360-degree" research strategy involving a comprehensive assessment of the functioning of children with CIs and incorporates perspectives from both patients and their parents.

This pilot was conducted at the World Hearing Center, a large clinical and scientific facility in Warsaw specialising in the diagnosis, treatment, and rehabilitation of hearing disorders. The pilot study took place from 2–5 September 2024 and involved a carefully selected group of 41 participants who met the inclusion criteria for the main project.

Special care was taken to create a welcoming and safe environment. Interviews were conducted in familiar spaces within the WHC. Children were given the option to participate in the interview either by themselves or in the company of their parent or caregiver.

The pilot involved several key stages:

(1) *Development of the research tool.* Based on a literature review and consultations with experts, the structure of in-depth interviews and questionnaires was developed. They were grounded in the ICF-CY guidelines and the latest trends in hearing rehabilitation research.

(2) *Tool testing in clinical settings.* Individual interviews were conducted with children and their parents, analysing the audiological, psychosocial, and environmental aspects of daily life.

(3) *Preliminary qualitative and quantitative analysis.* The collected data was analysed to identify the strengths and weaknesses of the tool, assess the clarity of questions, and detect potential difficulties in

interpretations as well as in reactions of interviewers with related questions.

(4) *Gathering feedback from participants and experts.* Following the initial work, consultations were held with participants and the research team, enabling improvements to be made to the tool before the main study is implemented.

The pilot study made it possible not only to verify the practical usability and validity of the research tool but also to identify key strengths, areas for improvement, as well as potential methodological barriers that might occur in the main project. The pilot results serve as a basis for optimising research procedures and ensuring the quality and reliability of data in the main project.

Participants

The pilot study involved 41 participants – 21 children with congenital hearing loss and 20 parents or legal guardians. The inclusion criteria for the children were congenital total deafness, age between 7 and 18 years, and at least 5 years of experience of using a CI. Additionally, to eliminate other factors that might affect the results, children with comorbid disabilities (such as neurological, intellectual, or motor disorders) were excluded. The children were divided into four groups, allowing for analysis that aims at understanding the functional development across stages of childhood and adolescence [22]: 7–9 years (children of early school age, at a stage of intensive development of basic language and social skills); 10–12 years (prepubescent period, characterised by increased independence and development of interpersonal skills); 13–14 years (early adolescence, a time of intense emotional and social changes); 15–18 years (late adolescence, preparation for adulthood and independence). **Table 2** shows the number of children in each age group.

Selection of participants was based on purposive criteria, using the patient database of the World Hearing Center, which ensured that the group was representative of children with congenital deafness who use CIs in Poland. We did not gather parents' ages; that will be gathered in the main study.

The range of ages allowed for a diverse range of experiences related to implantation and daily functioning to be captured, both in educational and social contexts. Parents and guardians involved in the study played a key role in providing information about the family environment, support, and observations of the child's development. They gave a complementary view of the child's situation and the factors impacting the effectiveness of implantation.

Research tools

To assess the functioning of children with CIs, an original structure for in-depth interviews was developed. It uses the methodological framework and guidelines of the International Classification of Functioning, Disability and Health – Children & Youth Version (ICF-CY). We focused on three key areas of functioning. The main conceptual dimensions are shown in **Table 1**, with examples of how these were operationalised into a questionnaire. Detailing the whole tool requires further work, which is being done; here we describe it in general using only high level terms.

Table 2. Gender balance of completed pilot study interviews

Age group [years]	Girls	Boys
7–9	2	3
10–12	2	3
13–14	2	3
15–18	3	3
All	9	12

The interview structure was designed to enable a multidimensional analysis of the experiences of both children and their parents, considering audiological, psychosocial, and environmental aspects. The in-depth interview consisted of six logically connected stages, allowing for a gradual introduction of the participant to the research topic and an open exploration of key areas of functioning: (1) *Warm-up* – introductory questions aimed at building an atmosphere of trust, learning about the child's interests, and reducing stress related to participating in the study; (2) *Free time* – exploration of preferred ways to spend time outside of school, including recreational, sports, and social activities, as well as barriers to and opportunities for social participation; (3) *School* – analysis of educational experiences, relationships with teachers and peers, identification of hearing challenges in the school environment, and strategies used to manage them; (4) *Hearing situations* – detailed discussion of everyday situations requiring auditory effort, such as conversations in noisy environments, participation in group activities, and use of assistive devices; (5) *Child's "relationship" with the implant* – questions about the child's subjective perception of the implant, its role in daily life, feelings about using it, and any technical challenges; (6) *Conclusion* – summary of the conversation, opportunity for open expression about personal experiences, and suggestions regarding support and needs.

The tool is designed to collect rich qualitative data, allowing for a multifaceted analysis of factors surrounding the effectiveness of cochlear implantation, as well as the identification of individual and environmental barriers and resources supporting the development of children with implants.

Data analysis

Data analysis used a qualitative approach, utilising a carefully developed codebook consisted of two layers:

(1) *Code categories (general topics)* – covering the main thematic areas emerging from the interviews, such as school functioning, peer relationships, leisure activities, social participation, perception of disability, technical challenges, and family support.

(2) *Analytical codes (detailed)* – precise identifiers relating to specific aspects of participants' statements,

e.g., coping strategies in noisy environments, preferred forms of activity, particular technical difficulties related to the implant, or ways the child perceives themselves.

The interview transcripts were systematically coded. This enabled the identification of recurring themes as well as the most frequently mentioned topics and the unique, individual experiences of the participants.

Since a mixed-method approach was in place, quantitative analysis was also possible. A frequency analysis was conducted to identify the occurrences of specific categories and analytical codes. This allowed most significant topics and themes to be identified and allowed comparisons to be made between different age groups and between children and parents.

Finally, the data analysis was enriched through triangulation – comparing results obtained from different sources (children vs parents) – which improved the reliability and validity of the interpretations. This approach allowed the main analytical categories to be identified as well as capturing relationships and contexts that may be help understand the factors influencing the outcomes of cochlear implantation in children.

Results

The pilot study enabled the development and preliminary testing of the interview framework specifically designed for children with CIs and their parents/caregivers. Assessment was also made of the applicability of the ICF-CY model as the appropriate methodological foundation. In this way, we were able to obtain valuable initial data on the social determinants of communication health in children with CIs, as follows.

Topics discussed

The content analysis of the in-depth interviews with children with CIs identified seven key topics that reflected the most important aspects of daily life and its challenges.

The most frequently mentioned topic was *school* (165 mentions). The children gave detailed descriptions of their experiences with learning, the relationships with teachers and peers, and strategies for coping with hearing difficulties at school. School-related topics encompassed both educational and social aspects, including their participation in lessons, school breaks, and extracurricular activities. Children mentioned classes they liked, such as: “I don’t like classes where you must write a lot, but computer science and P.E. are fine.” They mentioned issues they faced at school: “Sometimes I can’t hear well when the room is noisy, I have to concentrate more then.” Both were then subject to closer study among the research leaders to understand how it was possible to deepen understanding of how such answers can be used to increase the children’s quality of life (such as by increasing care).

The second most frequently discussed area was *leisure time* (63 mentions), during which children talked about their interests, favorite recreational and sports activities, as well as how the implants affect their ability to participate in social life outside school. They mentioned that some activities required auditory effort while others provided a break from acoustic stimuli. For example:

(a) “I’m putting together Lego, the latest set has 3000 parts. A couple of days it takes. Even when I went to a semi-college and ended at 5 p.m. It’s from 5 to 7 p.m. every day that’s how I put together for a week.”

(b) “Well, yes, paint something on a piece of paper, make something out of boxes, some structures. Now we made such a house that you can enter it from a cardboard box, only it has already crumbled.”

(c) “I […] dance – a lot of people now do that on TikTok and that’s how they dance all these dances – so I do the same: I prepare the choreography and perform it, record it, and post it on TikTok.”

(d) “Well a lot… I also train aerial acrobatics for example. I had my first class yesterday. But three years I’ve been training, only that the first classes sort of this year, from this school year. […] In acrobatics there are such hanging wheels and still such sashes, on them you hang… we learn various flips, star without hands and such things.”

As with the previously described cases, the answers were the subject of robust discussion to see how they could be used in the ongoing study as well as improving quality of life and raise awareness (e.g. in parents and doctors).

Further relevant topics occurring in interviews included:

- *The child’s “relationship” with the implant* (54 mentions). This covered subjective feelings about using the device, the level of acceptance, technical challenges, and the implant’s role in daily life.
- *Perception of disability* (46 mentions). Here, children shared reflections on their identity, sense of difference (or lack thereof), and how they were perceived by others.
- *Peer relationships* (46 mentions). This focused on interactions with friends, experiences of inclusion or exclusion, and support from peer groups.
- *Hearing situations* (45 mentions). Children described everyday challenges related to sound perception, understanding speech in noisy environments, navigating various acoustic settings, and adapting to changing auditory conditions.
- *Technical aspects related to CI usage* (16 mentions). Children addressed practical issues such as operating the speech processor, managing technical difficulties, charging batteries, and maintaining the device.
- *Family* (12 mentions). Children highlighted support from close relatives, the role of parents in the rehabilitation process, and the importance of the home environment for their development.

– *The future* (5 mentions). Children shared their dreams, plans, and concerns about their future lives with an implant.

Such a broad spectrum of topics highlighted the complexity that children with a CI experience and the multidimensional nature of the factors affecting their functioning. The collected data provided a rich source of insight for further analysis, making it possible to identify both universal and individual needs and challenges.

Functioning at school

Functioning in the school environment emerged as the most frequently discussed topic in interviews with children with CIs, highlighting the significant role of school in their daily lives and social development. Participants were especially eager to talk about their favorite subjects, most commonly mentioning mathematics, English, and computer science (a total of 27 mentions). The children related how they performed well in these subjects, and their satisfaction with learning contributed to a positive attitude toward school.

Nevertheless, a significant portion of their responses described the hearing difficulties encountered in the school setting (15 mentions). The children pointed to challenges related to understanding speech in noisy classrooms, during lessons held in large groups, and in activities that required quick information exchange. They noted the need to use various compensatory strategies, such as asking teachers to repeat instructions, choosing seats closer to the teacher, or using additional learning aids. Some said that openness and understanding from teachers and classmates played a crucial role in overcoming communication barriers and building a sense of acceptance.

Many respondents also pointed to physical activity, especially sports and physical education classes, as their most enjoyable school activities. Sports were seen as a space where they could demonstrate skills that were independent of hearing, build peer relationships, and develop self-confidence. The children said that participating in sports activities allowed them to integrate more fully with the group and give them a sense of equality with their peers.

In summary, school for children with a CI is, on the one hand, a source of joy and satisfaction, and on the other, an area where they must face hearing-related daily challenges. Coping strategies, support from teachers, and the openness of the school environment to their needs are crucial.

Leisure time and activities

Analysis of the children's statements showed that time outside of school is a significant aspect of their daily lives, promoting both personal development and the formation of social relationships. The most frequently mentioned leisure activity was playing computer games (19 mentions). The popularity of this activity can be explained by its visual appeal, the ability to adjust the difficulty level to the individual, and – particularly important for children with CIs – the reduced need for intensive auditory interaction. Computer games offer children an opportunity to engage in a virtual world where hearing barriers are less prominent, and success relies mainly on manual dexterity, reflexes, and logical thinking.

Among physical activities, soccer (12 mentions) was the most popular, as it not only supports motor development but also facilitates peer integration and the development of teamwork. Swimming (7 mentions) was another frequently chosen form of exercise, although some children pointed out technical limitations relating to non-waterproof processors, which sometimes hinder full participation.

Among activities that foster creativity and manual skills, children mentioned drawing and building with Lego bricks (6 mentions each). These activities allow for self-expression, the development of imagination, and spending time in a calm and relaxing way, regardless of hearing ability.

It is worth noting that the leisure activities chosen by children with CIs were quite similar to those preferred by their hearing peers, though they often consider specific needs and abilities related to their experience of deafness and implant use. These activities serve an important compensatory function, allowing children to develop in areas independent of hearing while also helping to build a sense of competence and belonging.

Perception of disability

One of the most important and surprising findings of the study was the significant diversity in how children with CIs perceive their own disability. Analysis of the statements revealed that the largest group of participants – eight children – did not identify themselves as individuals with a disability. These children said that, thanks to the CI, they could function in everyday life almost like their hearing peers, and that the differences resulting from their hearing loss are insignificant or even invisible to them. Their narratives included expressions indicating a sense of normality and full social integration, reflecting a high level of acceptance of their own health condition and technological support. For example, when asked "Do you see yourself as a person with a disability?" the children said: (a) "No. Because the people I've met don't even notice it in me. And most people forget about it. Teachers are the same, because they even forget that I have it, because I function in such a way that it's not visible." (b) "No, but I know that I am a disabled person because I have implants. So I don't consider myself to be an able-bodied person, but I know that I am disabled because I have implants. Well, I consider myself to be an able-bodied person."

A second group, consisting of six children, displayed an ambivalent attitude, expressed in responses such as "both yes and no." These children recognised certain limitations related to the implant and hearing loss but did not clearly define themselves as individuals with a disability. They often said their experiences were complex and context-dependent – in some situations, they felt "normal," while in others, they encountered barriers or difficulties that could be perceived as expressing a disability. For example:

(a) "Yes and no. That's not a very good answer. Because yes and no, maybe I'll start with no. No, because thanks to that, thanks to my parents, thanks to everything they've done for me, I feel like a normal person who just comes here every year. It's like the only sign, and I function normally like my peers, sometimes better than them, sometimes worse than them. It's like thanks to that I feel normal, in the sense that I don't see myself as that kind of person. But when it comes down to it, for example, if someone starts pointing it out during an argument or discussion, or if I simply see such a situation and find myself in a situation where I am unable to do something because of these processors or this defect, then yes, I see myself as such a person."

(b) "On the one hand, you could say yes, but on the other hand, I've learned a lot, so it's fifty-fifty. Well, for example, I can't do certain things, like swimming with the device, or I won't be able to hear, or… There's also the fact that some of my friends envy me because when I go to sleep, I can take off the device and go to sleep peacefully. Is that so cool? Sometimes my mom told me that it's dangerous because something could fall or start burning and I wouldn't hear it. But when my brother sleeps, I look at him and he sleeps like a log. But… You don't know if he would hear anything. Most of the time it's like that, but when I look at my parents, when I was little, I always shouted to my mom that I wanted to pee, or something else, or a drink, and my mom always got up. I often watch her, and she falls asleep, and is asleep in five seconds. I say, how do you do it, Mom? I don't know."

Only a small group – three children – unequivocally identified themselves as individuals with a disability. These children frequently pointed to specific challenges and limitations they experienced in daily life, both in terms of communication and social functioning. Their statements reflected an awareness of differences and difficulties that, despite technological support, continue to impact on their lives.

This diversity in how children perceive their own disability highlights the need to redefine traditional concepts of disability in the context of modern rehabilitative technologies such as CIs. It also underscores the necessity of an individual approach to psychosocial support that considers children's subjective experiences and self-identification, rather than relying solely on objective medical criteria. Understanding how children view their situation is crucial for effectively planning therapeutic and educational interventions that promote their development and social integration.

Technical challenges

Statements from the children clearly indicate that despite the significant benefits of using CIs, daily life with the device also involves several technical challenges. The most frequently reported issue was the lack of water resistance of the speech processors (16 mentions). This limitation effectively excludes children from many water-related activities, such as swimming, playing in the pool, or spontaneous play in the rain. For many young implant users, having to remove the processor before coming into contact with water is not only uncomfortable but also leads to feelings of exclusion from their peer group, especially during school activities or group trips.

The second significant technical challenge was the need for frequent charging or battery replacement in the processor (8 mentions). Children pointed out that the device running out of power during the school day or while engaged in activities outside the home can lead to a sudden loss of connection to the world of sounds, causing stress and a sense of uncertainty. This required both them and their caregivers to constantly monitor the battery level and carry spares, which can be inconvenient and limit the spontaneity of daily life.

Another set of problems involved difficulties securing the processor (5 mentions). Children reported that the device can slip or shift during movement or physical activity and can be uncomfortable when worn for extended periods. These issues are especially noticeable during sports, active play, or when wearing headgear, which can negatively affect comfort and willingness to participate.

These technical challenges demonstrate that although cochlear implants provide new opportunities for development and social integration for children with congenital deafness, there is still a need for further technological improvements. Enhancements in water resistance, extended battery life, and improved ergonomics of the processor's attachment could significantly enhance the quality of life for young users and enable them to participate more fully.

Parents' perspective

Interviews conducted with parents and caregivers of children with CIs provided insight into a range of highly important aspects of treatment and rehabilitation that often lie beyond the direct experience of the children themselves. The parents emphasised the crucial role of early diagnosis, highlighting the importance of both newborn hearing screening and genetic testing, which enable the identification of causes of hearing loss and the prediction of the risk of hearing impairments in other family members. Many parents also shared their own experiences related to the history of hearing loss in their families, which affected their vigilance, prompt decision-making, and active pursuit of the best therapeutic solutions for their child.

A strong theme was the tremendous involvement of parents in the development of their CI-wearing child. Caregivers not only actively participated in rehabilitation but also undertook numerous actions to support the development of their children's communication, social, and emotional skills. They expressed the necessity for continuously monitoring progress, motivating their child to engage in work, and building a positive sense of self-worth.

Parents also shared their own strategies for coping with the challenges associated with hearing impairment within the family. These strategies included seeking support in parent groups for children with implants, utilising specialist consultations, and actively participating in their child's school and social life. Some parents highlighted the importance of educating themselves about implant technology, children's rights, and available system support.

A strong conviction was the need to implement comprehensive therapy that went beyond traditional speech therapy. Parents described the need to collaborate with a wide range of specialists: psychologists, educators, special educators for the deaf and hard of hearing, as well as sensory integration therapists. Many caregivers stressed that effective rehabilitation required a holistic approach, encompassing not only speech development but also emotional support, building social relationships, and developing coping skills for everyday challenges.

The parents' perspectives add valuable insight into how a child with a CI functions, extending over medical and genetic factors as well as psychosocial and organisational ones. Their experiences and involvement constitute a valuable source of support and inspiration for creating individualised and effective therapy programs.

Discussion

Use of the ICF in research on CI users

The ICF, together with its child-specific version (ICF-CY), constitutes a universal framework that encompasses all dimensions of human health and selected aspects of well-being. It is not restricted to individuals with disabilities; rather, it applies to all people, providing a comprehensive and standardised language for describing the full spectrum of health-related states. Notably, it conceptualises health in a positive sense, as the overall well-being of an individual, rather than merely as the absence of disease. It organises information in a structured, meaningful, and accessible manner for a broad range of users. The conceptual framework developed by Lorens et al. in 2014 [10] has been internationally validated and thoroughly reviewed by members of the HearRing Group – an international consortium of leading clinical and research institutions specialising in hearing disorders. In collaboration with Melissa Selb from the ICF Research Branch, this work has resulted in the development of a structured methodology for applying the ICF in a comprehensive and standardised manner within international, multicenter research studies [10].

Findings from previous studies [13,14] have demonstrated that the selected ICF categories and associated measurement tools provide a standardised and holistic framework for evaluating outcomes in adult CI users. This ICF-based protocol offers a common language that facilitates consistent assessment across both clinical practice and research contexts, enabling meaningful comparisons at national and international levels, as well as across individual and group cases. The clarity and universality of ICF-based outcome descriptions make them accessible to professionals beyond the field of cochlear implantation, thereby promoting interdisciplinary collaboration and enhancing the understanding of each patient's rehabilitation needs. Integrating this approach into routine clinical care supports a truly patient-centered rehabilitation model, one that considers not only impairments in body functions and structures, but also activity limitations, participation restrictions, and environmental factors. All of this ultimately contributes to improved outcomes for adult CI users.

At the same time, ICF-CY provides an adapted framework specifically suited for capturing the developmental and contextual complexities of pediatric populations. The ICF-CY enables a systematic evaluation of functioning at multiple levels, including body functions and structures (e.g., hearing ability, speech perception, sound localisation), activities (e.g., communication competencies), and participation (e.g., engagement in educational settings and family life). Crucially, it also highlights the role of environmental factors – both facilitators and barriers – that significantly affect the daily experiences, development trajectories, and rehabilitation outcomes of children with CIs. Therefore, in the current project, we are aiming to incorporate the ICF-CY into outcome assessments so as to promote a comprehensive understanding of a child's functioning. In this context, a child with a CI may be viewed as having a physical disability (unable to hear or hard of hearing without the implant), yet, with appropriate social, educational, and family support, they can achieve communication and social competencies comparable to those of their hearing peers. As a result, the concept of "disability" is redefined; it is no longer seen as a permanent limitation but rather the outcome of a dynamic interaction between the individual and their social environment. The ICF-CY categories selected for cochlear implantation provide a structured overview of key domains of functioning that should be assessed; importantly, however, they do not specify corresponding measurement tools [23,24], and this is where our project aims to fill the gap.

Conclusions

Our pilot study demonstrates how interdisciplinary assessment based on the ICF-CY model can be used to evaluate the way in which children with CIs function in daily life. Combining insights from children, their parents, and professionals can yield a rich, holistic view of childrens' experiences and, crucially, reveal important environmental factors that shape communication health after implantation. These factors go well beyond standard medical and audiological metrics and underscore the pivotal roles that social, emotional, and family contexts play in rehabilitation.

Our preliminary findings suggest that the success of a CI in fostering effective communication is linked, among other things, to:

(1) *Parental involvement in the child's development.* The parents' active engagement, emotional support, and consistency in following through with therapy are essential for achieving the full benefits of an implant.

(2) *Balance in leisure activities.* Leisure allows a child to pursue a variety of interests (both individual and group-based), promotes social integration, and helps build self-esteem.

(3) *Strategies for coping with school challenges.* Support from teachers and the school environment helps minimise communication barriers and fosters full participation in classroom life.

(4) *Redefinition of the concept of disability.* Modern rehabilitation technologies mean that an increasing number of children with implants do not perceive themselves as disabled, and this calls for a new perspective on what is needed to support them.

The next phases of the project, planned for 2024–2027, will involve a deeper analysis of the ways by which family, school, and peer environments affect long-term CI outcomes. It is hoped that the results will contribute to the development of new recommendations and standards of practice for CIs in clinical and educational settings, supporting children with CIs achieve their full potential.

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THE LIVED EXPERIENCE OF TINNITUS IN UK MILITARY VETERANS: A QUALITATIVE EXPLORATION

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Contributions:
A Study design/planning
B Data collection/entry
C Data analysis/statistics
D Data interpretation
E Preparation of manuscript
F Literature analysis/search
G Funds collection

Abstract

Introduction: Tinnitus is more prevalent in military veterans compared to the general population and can profoundly impact quality of life, including physical and mental health. Subjective tinnitus is the perception of hearing sound without any external noise corresponding to that sound. Investigating veterans' lived experience of tinnitus can provide valuable insights for developing tailored interventions and healthcare strategies. Thus, our study explores the lived experience of UK veterans who have experienced tinnitus for at least 3 months.

Material and methods: There were 98 veterans who responded to the qualitative online survey. To identify key themes the responses were analysed through reflexive thematic analysis.

Results: Veterans reported that they experienced communication difficulties, social isolation, and disruptions to their daily routine. Four superordinate themes reflecting participants' experiences were developed: (ST1) Impact on the self, mind, and body; (ST2) Influence on the social self; (ST3) Disrupted daily functioning; and (ST4) Coping with tinnitus. The results highlight how tinnitus has a profound impact on veterans' wellbeing, social interactions, and daily functioning. While coping strategies were limited for many veterans, some participants identified helpful management strategies such as sound therapy.

Conclusions: Findings from this study highlight the need for support and intervention strategies for tinnitus management in veterans.

Keywords: hearing loss • tinnitus • reflexive thematic analysis • military veterans

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DOŚWIADCZENIA Z SZUMAMI USZNYMI W ŻYCIU CODZIENNYM BRYTYJSKICH WETERANÓW WOJSKOWYCH: EKSPLORACJA JAKOŚCIOWA

Streszczenie

Wprowadzenie: Szumy uszne występują częściej u weteranów wojskowych niż w ogólnej populacji i mogą znacząco wpływać na jakość życia, w tym na zdrowie fizyczne i psychiczne. Subiektywne szumy uszne to wrażenie słyszenia dźwięku bez obecności zewnętrznego źródła odpowiadającego temu dźwiękowi. Badanie doświadczeń życiowych weteranów cierpiących na szumy uszne może dostarczyć cennych informacji pomocnych w opracowywaniu optymalnych interwencji i strategii opieki zdrowotnej. Nasze badanie koncentruje się na doświadczeniach weteranów brytyjskich, którzy doświadczają szumów usznych od co najmniej trzech miesięcy.

Materiał i metody: W internetowym badaniu jakościowym wzięło udział 98 weteranów. W celu zidentyfikowania kluczowych tematów przeanalizowano odpowiedzi za pomocą refleksyjnej analizy tematycznej.

Wyniki: Weterani zgłaszali trudności w komunikacji, izolację społeczną oraz zakłócenia codziennej rutyny. Na podstawie ich wypowiedzi wyodrębniono cztery nadrzędne tematy: (ST1) wpływ na siebie, umysł i ciało; (ST2) wpływ na funkcjonowanie społeczne; (ST3) zakłócenie codziennego funkcjonowania; oraz (ST4) radzenie sobie z szumami usznymi. Wyniki podkreślają, że szumy uszne mają głęboki wpływ na dobrostan weteranów, ich relacje społeczne oraz codzienne życie. Zakres sposobów radzenia sobie z tą dolegliwością u wielu weteranów był ograniczony, jednak niektórzy wskazali pomocne metody, takie jak terapia dźwiękiem.

Wnioski: Wyniki tego badania podkreślają potrzebę wspierania weteranów w zakresie radzenia sobie z szumami usznymi oraz opracowania metod interwencji.

Słowa kluczowe: utrata słuchu • szumy uszne • refleksyjna analiza tematyczna • weterani wojskowi

Introduction

Tinnitus is the perception of hearing sound without any external auditory source for that sound [1] and this can present in various forms such as ringing, buzzing, or hissing. Tinnitus is mostly described as subjective, whereby it can only be heard by the person perceiving it and it cannot be heard by others or detected with medical instruments [1]. In contrast, objective tinnitus is caused by an actual physical source in the body and can be identified by others [2]. While there are inconsistencies in prevalence rates, tinnitus appears to be more common in the veteran population compared to the general population [3,4]. This increased prevalence in the veteran population is likely multifactorial, with potential risk factors including noise exposure, occupational hazards, traumatic brain injury, and ototoxicity [5–7].

In veterans, tinnitus has been associated with impaired job performance, sleep problems, and psychological difficulties including depression and anxiety [8]. The influence of tinnitus can range from mildly disruptive to severely debilitating with profound social and economic consequences [9,10]. While individuals often encounter distress when experiencing tinnitus, in many, the impact of tinnitus dissipates over time and does not cause enduring stress [7]. However, some may experience consistent, bothersome tinnitus, with symptoms that hinder their quality of life [11]. Though there is no cure for tinnitus, numerous approaches attempting to manage symptoms and associated distress have been developed [1,12,13].

The majority of prior research is quantitative and has focused on measuring tinnitus severity, while few studies have used qualitative methodologies to explore the impact of tinnitus in veterans. Quantitative studies often do not capture the personal meaning and experience and the day-to-day impact of living with tinnitus, especially in veterans. To date, there is little research exploring an individual's self-perception of tinnitus and their likelihood to seek services [14,15]. Additionally, there is currently no intervention offering an effective solution to tinnitus [1,12,13,16] and many management interventions are poorly researched, and often described as experimental or controversial [3,17]. Finally, the majority of research in the veteran population has been conducted in the US and thus there is a large gap of research into the UK population (e.g., [18,19]). A notable exception is a previous qualitative study that explored the lived experience of aged military veterans in the UK [20], a study that highlighted the detrimental impact of tinnitus on veterans' medical, social, and emotional wellbeing. However, this work was conducted on an aged population (veterans born before January 1950), and thus its findings may not reflect the experiences of the entire veteran population.

Given the high prevalence of tinnitus among veterans, its potential impact on daily life, and the limited qualitative research in the UK, there is a need to further explore the lived experience of tinnitus in this population. Such work could throw light on the need for tinnitus management interventions in the veteran population. The current project aims to explore the experience of tinnitus in veterans who self-reported tinnitus for more than 3 months.

Material and methods

Recruitment

This research was conducted by Combat Stress, a UK veterans mental health charity that offers clinical services across the UK. Participants were invited to complete a survey that included questions about tinnitus. The study aimed to recruit an opportunistic sample, with advertisements across a range of social media platforms (Facebook, Instagram, and LinkedIn). Potential participants who expressed interest in sharing their experiences of living with tinnitus were directed to the online qualitative questionnaire. The sample size was unlimited, allowing a comprehensive exploration of participants' experiences to be undertaken.

Ethics and dissemination

Participation in the current study was subject to providing written informed consent. The study was approved by the University of Bath ethics committee (# 6783-10218). Throughout the trial, participants' personal information was password protected, with access limited to the Combat Stress study team. Participants were allocated a unique ID number, with all data stored and references made to this ID. All personally identifiable information was only seen by the Combat Stress research team and data was anonymised prior to analysis.

Screening

The pre-screening questions confirmed that participants: (1) had self-reported experiencing tinnitus (i.e., ringing or buzzing [bilateral or unilateral]) for at least 3 months; (2) had given informed consent to be contacted for research purposes; and (3) had provided a contact email address. The full inclusion and exclusion criteria are set out in **Table 1**.

Data were collected using a self-report survey distributed via SurveyMonkey. Participants were informed of the study aims and were made aware that participation was voluntary. Participants were asked to provide informed consent before answering the questionnaire. Resources for support were provided at the end of the survey, including a comprehensive signposting booklet with relevant services. Data was collected between February 2025 and May 2025.

The survey incorporated questions assessing demographics (e.g., age, gender), in addition to a brief tinnitus measure named the FiveQ [21]. The FiveQ was chosen to minimise participant burden and promote engagement with the qualitative questions, which was the primary focus. Additionally, based on discussions within the research team, the open-ended qualitative questions were developed to capture a broad view of the potential influence of tinnitus on daily life. For example, participants were asked how tinnitus influences their daily life, mental health, social relationships, sleep patterns, and coping strategies. Specifically, questions such as "How do your symptoms of tinnitus affect your daily life" and "In what ways has tinnitus impacted your social interactions and relationships with family, friends, or colleagues?" encouraged participants to provide answers in their own words.

Table 1. Inclusion and exclusion criteria

Inclusion criteria	
1	Above the age of 18
2	Fluent in speaking and reading English
3	UK armed forces veteran
4	Persistent tinnitus for at least 3 months (participants had to confirm the experience of ringing or buzzing [bilateral or unilateral] lasting longer than 3 months)
5	Sign a consent form
Exclusion criteria	
1	Below 18 years of age
2	Unwilling or unable to provide informed consent

To promote depth and nuance, the questions were designed to be as non-leading and open-ended as possible, encouraging participants to elaborate freely and share aspects not specifically prompted. Instructions reiterated that the questionnaire was voluntary.

Qualitative analysis

The qualitative methodology used in the current study followed the guidelines for Reflexive Thematic Analysis (RTA) [22–24]. RTA focuses on analysing qualitative data by generating codes and themes based on the researcher's background and theoretical assumptions [23]. It was used to identify key themes related to the experience of living with tinnitus and its effect on daily life and mental health. RTA incorporates a combination of inductive and deductive approaches, which was appropriate for this investigation. The inductive approach meant that codes were derived directly from the data contents; however, the deductive method was used so that pre-existing expertise informed the development of codes. This approach ensured that experiences of the participants were captured and sufficiently expressed, while allowing for the research interpretation of the dataset. In regard to prior knowledge, the authors were aware that tinnitus negatively impacts quality of life and mental health, and were aware that there is currently no universally effective solution or management option for tinnitus.

The RTA was conducted as a six-step process: (1) all participant responses were familiarised through repeated reading; (2) the data was coded and refined into small meaningful sections line-by-line (e.g., "stress an[d] anxiety building all the time" (P54) was coded into "anxiety"); (3) codes were grouped to form broader themes (e.g., the code "anxiety" was grouped into "emotional and psychological distress", which was consequently grouped into "impact on the self, mind, and body"); (4) themes were reviewed by examining associated coded data considering the broader dataset thus creating a thematic map; (5) the themes were iteratively clustered and analysed to ensure each one captured the coded data; (6) key data supporting the themes were extracted, analysed, and linked to the research aim [22,23]. The dataset was iteratively coded in QDA Miner Lite (v2.0.9; Provalis Research). Specifically, line-by-line coding was completed for all transcripts before preliminary superordinate themes and subthemes were generated. Peer debriefing was conducted with the research team which involved various discussions ensuring the themes and subthemes captured the data. This iterative process meant that codes underwent multiple changes. For example, "communication difficulties" was initially grouped with "interpersonal tension and embarrassment" rather than as two distinct categories, as both related to the social impact of tinnitus. Upon reflection, however, it became clear these experiences were unique aspects of an individual's social world. They were therefore segregated within the second superordinate theme. This iterative process continued until thematic saturation was achieved – i.e., no new themes were generated or deemed applicable by the authors (see [24]). Specifically, this was achieved when further coding or reviewing did not change the thematic structure.

Results

Participants

A total of 98 veterans (95% male; 5% female) responded to the questionnaire. The age of participants ranged from 33 to 86 ($M = 61.1$, $SD = 11.3$) and the majority of participants were retired (42%; $n = 41$) or employed full-time (37%; $n = 36$). All participants (excluding missing data) reported experiencing tinnitus for more than 1 year and the majority reported experiencing tinnitus for more than 10 years (73%; $n = 67/92$). Most participants reported that their tinnitus started during military service (52%; $n = 51$) or after service (41%; $n = 40$). The majority of participants attributed their tinnitus to military service (71%; $n = 70$), while 18% ($n = 18$) somewhat attributed it to military service. Most of the participants had served in the Royal Navy (65%; $n = 64$) or Army (27%; $n = 26$) and the majority had served 5 or more years (96%; $n = 94/98$). **Table 2** provides a summary of the participant characteristics and **Table 3** presents the results from the FiveQ tinnitus measure. Notably, results indicated a mean FiveQ score of 53 ($SD = 23$), with the largest proportion of participants presenting with severe impairment (31%; $n = 30$), followed by moderate impairment (26%; $n = 25$) and mild impairment (21%; $n = 21$).

Table 2. Sociodemographics of sample ($n = 98$)

Variable	n [%]
Age	$M = 61.1$, $SD = 11.3$
Gender	
Male	93 (95%)
Female	5 (5%)
Tinnitus duration (months; $n = 76$)	$M = 281$, $SD = 205$
Employment status	
Employed full-time	36 (37%)
Employed part-time	8 (8%)
Self-employed/freelance	7 (7%)
Not working, looking after the home	1 (1%)
Not working, seeking employment	1 (1%)
Retired	41 (42%)
Other	4 (4%)
Tinnitus onset	
Pre-military	0 (0%)
During the military	51 (52%)
Post-military	40 (41%)
Unsure	7 (7%)
Tinnitus attributed to military service	
Yes	70 (71%)
Somewhat	18 (18%)
No	3 (3%)
Unsure	7 (7%)
Military characteristics	
Length of service (months; $N = 92$)	$M = 232$, $SD = 113$
Branch of military	
Royal Navy (including marines)	64 (65%)
Army	26 (26%)
Royal Air Force	8 (8%)
Part of military reserve	
Yes	4 (4%)
No	94 (96%)

Qualitative findings

The accounts by participants of their experiences of tinnitus and how it affected their daily lives were divided into four distinct but interrelated superordinate themes. The four main themes identified were: (ST1) Impact on the self, mind, and body; (ST2) Influence on the social self; (ST3) Disrupted daily functioning; and (ST4) Coping with tinnitus. **Table 4** illustrates how the superordinate themes were further divided into subthemes and presents some supporting quotes. Here, P is used to indicate the participant number (e.g., P4 is participant number 4).

Table 3. Tinnitus symptoms in the sample as measured using FiveQ ($n = 98$)

Category	n [%]
Slight	11 (11%)
Mild	21 (21%)
Moderate	25 (25%)
Severe	30 (31%)
Catastrophic	11 (11%)

Table 4. Identified superordinate themes and subthemes, with examples

Superordinate theme	Subtheme	Illustrative quotes
ST1: Impact on self, mind, and body	Characterisation of tinnitus (i.e., the self)	"It's like a bug living in my ear making stupid noises" (P18) "I keep this to myself, but it's always there, in the background" (P24) "It's just always there from the second I wake until I get to sleep" (P49) "I think it's the sound of an F16 fighter jet taking off an[d] the whistle on a kettle" (P67)
	Emotional and psychological distress (i.e., the mind)	"the tinnitus had a negative effect on my health especially with Anxiety and going out" (P11) "low mental health" (P30) "Sometimes the tone changes which increases my anxiety level" (P35) "stress an[d] anxiety building all the time" (P54) "all in all destroyed" (P67)
	Cognitive and physical strain (i.e., the body)	"clouds my ability to think clearly somewhat" (P13) "discomfort" (P16) "poor concentration" (P24) "my ability to concentrate is [a]ffected and I need to use background noise" (P81) "pain" (P16)
ST2: Influence on social self	Communication difficulties	"Hearing is difficult so I don't always hear or are responsive to what my partner is saying" (P9) "I struggle to hear people talking over the tinnitus" (P77)
	Social withdrawal	"Try to avoid social/family events, crowded areas" (P7) "Because of my tinnitus, I s[t]opped going out" (P11) "friendship circle has greatly diminished" (P46) "I have become reclusive" (P88)
	Interpersonal tension and embarrassment	"increased family tension to inability to hear as well" (P17) "Ridicule from family" (P27) "constantly have to ask people to repeat what they are saying and I'm embarrassed having to constantly do that" (P54)
ST3: Disrupted daily functioning	Sleep disruption and fatigue	"It makes it harder to get to sleep, especially if you wake up during the night" (P42) "Always feel exhausted" (P46)
	Loss of control and autonomy in daily activities	"my life is completely controlled by tinnitus" (P16) "it affects my hearing & enjoyment of music" (P49) "I used to love walking and running in the country, I take little pleasure in that anymore. Sweet silence has gone forever" (P82)
ST4: Coping with tinnitus	Lifestyle and self-help strategies	"breathing exercises/mindfulness/yoga helps lower my anxiety and helps to take my mind off the tinnitus to focus on something positive" (P11) "walking outside" (P71) "meditation" (P89)
	Psychological coping and reframing	"I just solider through" (P13) "just getting on with it as there's not much other choice really" (P25) "It has taught me that whatever happens, accept it and get on with your life" (P68)
	Therapeutic interventions	"I listen to the radio at night to help" (P2) "I tend to play the radio or music as soon as I wake to go when I go to bed to counteract it" (P6)

Note: P = participant, so P18 is participant 18

The first superordinate theme, "Impact on the self, mind, and body", explores the person's internal experience of tinnitus, which can be further divided into three subthemes: (1) characterisation of tinnitus (i.e., the self); (2) emotional and psychological distress (i.e, the mind); and (3) cognitive and physical strain (i.e., the body). In this way, the impact of tinnitus on a person's inner world, mental health, and physical health could be gauged.

The second superordinate theme, "Influence on the social self", captures the difficulties participants experienced in their social life, which could be divided into three subthemes: (1) communication difficulties; (2) social withdrawal; and (3) interpersonal tension and embarrassment. These subthemes highlight how tinnitus can disrupt a person's social identity and interpersonal relationships.

The third superordinate theme, "Disrupted daily functioning", explores the impact of tinnitus on a person's functioning and environment, and is comprised of two subthemes: (1) sleep disruption and fatigue and (2) loss of control and autonomy in daily activities.

The final superordinate theme, "Coping with tinnitus", considers how people manage and cope with tinnitus and was grouped into three subthemes: (1) lifestyle and self-help strategies; (2) psychological coping and reframing; and (3) therapeutic interventions.

Superordinate Theme One (ST1) Impact on the self, mind, and body

Participants' narratives highlight how tinnitus is more than just a physical symptom. Tinnitus becomes entangled with their identity, psychological health, and physical functioning. The impact on the self, mind, and body was further divided into subthemes: (a) the characterisation of tinnitus; (b) emotional and psychological distress; and (c) cognitive and physical strain.

ST1 Subtheme: Characterisation of tinnitus

For many participants the internal experience of tinnitus was shaped by how they understood and communicated their symptoms. Specifically, the participants often explained tinnitus in emotive and metaphorical terms, highlighting its intrusive, permanent, and unpredictable manner. One participant shared how tinnitus was "unpredictable [as] it comes and goes without warning" (P9) and another described this unpredictability by likening tinnitus to a "continuous hissing with occasional [bursts] of ringing" (P45). Further, participants expressed feelings of permanence and hopelessness, with one noting they "worry it will never stop" (P10) and others echoed this by describing how "tinnitus is always there" (P11, P12). Further, this permanence was emphasised by some participants who expressed worry that the condition would deteriorate: one shared that they were "worried that it may increase and become more severe" (P40).

ST1 Subtheme: Emotional and psychological distress

Participants' responses highlighted the significant emotional and psychological distress imposed by tinnitus. One participant shared: "I do suffer with anxiety over not being able to hear or take appropriate action in dangerous or threatening situations" (P6). Similarly, another participant reported the feeling of "anxiety" (P26) when "working as a senior nurse or prescriber double checking I have heard correctly" (P26), and another shares "when I'm in a quiet place its far more pronounced and this raises my frustration and to some degree anxiety" (P32).

In addition to expressing feelings of anxiety, low mood was also common with one participant sharing they "have developed mild depression" (P32), another reporting a "lower mood" (P36), and one participant reporting "reduce[d] mental wellbeing" (P18). Notably, there were some reports of suicidal ideation with one participant sharing, "during bad times I feel suicidal" (P34), while adding they "fully understand why some people commit suicide" (P34). Additionally, another participant shared how "tinnitus pushed [me] over the edge a few times with hurting myself" (P11). Though experiences of suicidal ideation and self-harm were reported by a minority of participants, this illustrates the profound psychological distress tinnitus may inflict. As one participant reflected, tinnitus has "certainly affected [their] mental health. During spikes it is high" (P32), illuminating how tinnitus can exacerbate existing mental health challenges, which in turn, may increase symptoms of tinnitus. This illustrates the potential reciprocal relationship between tinnitus and mental health.

ST1 Subtheme: Cognitive and physical strain

Beyond emotional and psychological distress, participants expressed various cognitive and physical difficulties they experienced when living with tinnitus. The persistent presence of sound is not only commonly seen as a distraction, but also something that impairs participants' ability to process information and concentrate effectively. One participant shared that tinnitus "clouds my ability to think clearly" (P13), and another noted that it is "hard to concentrate with ringing in ears" (P15). This difficulty concentrating was echoed by others, with one participant sharing "it causes me difficulty in concentrating or focusing" (P79). This impact of concentration difficulties extends into occupational life, with one participant sharing, "I just find focusing and concentrating at work difficult" (P54). In addition to cognitive difficulties, participants also expressed physical difficulties such as "pain" (P16) and "discomfort" (P16, P36). These cognitive difficulties, intertwined with the physical strain associated with tinnitus, illustrate the significant influence of tinnitus on veterans' cognitive and physical functioning.

Superordinate Theme Two (ST2) Influence on the social self

The effect of tinnitus on participants' social self and interpersonal relationships was evident, as it appeared to create communication difficulties and interpersonal tension, thus leading to feelings of isolation and withdrawal. One participant shared: "I do not take part in conversations as I find it embarrassing to constantly ask people to repeat themselves. This has now led to little or no social life and the feeling of loneliness adds to my depression" (P59). While some of the communication difficulties and interpersonal tension may be influenced by co-occurring hearing loss, this illustrates how tinnitus and associated auditory difficulties impact one's social self.

ST2 Subtheme: Communication difficulties

Many participants expressed their difficulty in communicating with others, particularly in environments with noisy backgrounds. For example, one participant reported that they "struggle to hear conversations in noisy environments or when speech is low volume" (P4) and another reported "difficulty when listening to conversations in busy environments" (P5). Such communication difficulties evidently affect participants' social and interpersonal lives, with one participant reporting that "hearing is difficult, so I don't always hear or are responsive to what my partner is saying!" (P9), and another reporting that they find it "difficult to hear what colleagues are saying" (P26). Communication difficulties thus inevitably influence both personal and professional lives.

These hearing difficulties are commonly managed by asking others to repeat themselves, with veterans often "asking for repetitions" (P37). This strategy was echoed by multiple other participants, such as one expressing how their "family [is] constantly having to repeat themselves" (P46) and how they "need to have people repeat statements" (P52). While this repetition can assist in understanding what others say, it illustrates the social strain of living with tinnitus, which may be exacerbated in busy environments. One participant shared: "I struggle to hear conversations in certain loud environments which means I 'go quiet' or stop trying to participate in conversations" (P79). The communication difficulties can contribute to a sense of social withdrawal and reduced interpersonal connection.

ST2 Subtheme: Social withdrawal

As a result of the difficulties tinnitus poses to interpersonal interactions, participants commonly described withdrawing from social situations. Specifically, one participant said "I feel excluded & isolated on occasions when I can not participate in conversations because I can not hear due to the tinnitus" (P4), and another said "I tend to avoid crowded social gatherings as it is impossible to hold a conversation" (P6). One participant noted "It is a socially isolating condition" (P52) with others similarly reporting that they feel "isolated". Though some of these experiences may be influenced by co-occurring auditory difficulties, they illustrate how tinnitus, combined with possible hearing difficulties, may increase social withdrawal and isolation.

ST2 Subtheme: Interpersonal tension and embarrassment

Beyond the difficulties with communication and social withdrawal, participants also express interpersonal tension and embarrassment. Specifically, the narratives reflect interpersonal tension that arises from others' frustration, with one participant sharing how they "never catch what is said the first time and have to constantly ask to repeat, which is frustrating and annoying for both of us" (P6) and another noting "my wife and family get frustrated when I don't hear them or cant make out what they say" (P12). Interestingly, many participants share this frustration and interpersonal tension in the context of family relationships rather than other contexts such as friendships and work environments. Notably, only one participant expresses how this frustration does extend to both their "family and friend[s]" (P39).

In addition to interpersonal tension, participants express embarrassment that arises from struggling to communicate. For example, one participant shares how they "find this very embarrassing … thinking I came across as arrogant and not interested in conversations" (P11) and another shares how they think "asking people to repeat themselves is embarrassing" (P18). The majority of these feelings of embarrassment often arise from the repeated need to clarify what is said, thus causing feelings of social difficulty. This highlights how hearing difficulties not only impair communication but also create conflict between the burden of asking for repetition and feelings of embarrassment.

Superordinate Theme Three (ST3) Disrupted daily functioning

Tinnitus influences participants' ability to function in day-to-day life and control their surrounding environments. This theme captures the disruptions caused by tinnitus in relation to key aspects of daily living, including sleep and engagement in activities.

ST3 Subtheme: Sleep disruption and fatigue

Participants describe how tinnitus consistently disrupts their ability to both initiate and maintain sleep, often resulting in fatigue. Difficulties falling and staying asleep are common, with 51 participants reporting disrupted sleep patterns. One participant reflects, "I noticed changes to sleep patterns or quality of rest as a result of tinnitus, sleep can be tricky. If I tune into the tinnitus I can't stop hearing it which stops me from sleeping" (P10). Additionally, numerous participants express difficulties getting to sleep, with one participant noting that "the high pitched noise means I struggle to get to sleep on occasions" (P4) and another sharing "sleep is not possible without medication" (P16). Additionally, participants report sleep maintenance difficulties, such as one participant who notes they couldn't "get back to sleep if woken up" (P1).

Sleep difficulties often result in fragmented or insufficient sleep, with one participant reporting they "never [experience] a full nights sleep…" (P67) and another reporting a "lack of sleep" (P71). The consequences of limited sleep are evident, with participants reporting "feeling tired" (P1) and "fatigue" (P81). This sleep difficulty is compounded with participants reporting that the tinnitus becomes "very prominent in the silence of the night" (P11) as it "appears much louder" (P28), potentially reinforcing the cycle of alertness and exhaustion.

ST3 Subtheme: Loss of control and autonomy

In addition to sleep disruption and resulting fatigue, participants also share a sense of losing control of their life due to tinnitus. For example, one participant shares that tinnitus "completely affects all aspects of my life" (P16). This loss of control may create an overwhelming feeling, with one participant not knowing where to begin when asked how tinnitus influences their life: "where do I start" (P34). This loss of autonomy is often described in relation to tinnitus disrupting daily routines. Specifically, one participant shares that tinnitus "limits family activities" (P22) and others share how tinnitus influences "undertaking sports and exercise" (P30) or other activities such as "watch[ing] TV or go[ing] to the cinemas" (P39). These daily activities often involve places where background noise is higher such as "music concerts or loud sporting events" (P61) or "listening to music, talking on the phone, watching TV" (P77).

Superordinate Theme Four (ST4) Coping with tinnitus

While participants express the numerous negative influences that tinnitus has on their lives, participants also reflect on how they learn to manage it. This superordinate theme delves into the strategies participants use to cope with tinnitus, which range from lifestyle adjustments to therapeutic interventions. Though some participants report using tinnitus management techniques, 31 did not, and 7 indicated that they have not yet attempted any approach.

ST4 Subtheme: Lifestyle and self-help strategies

Various lifestyle adjustments and self-help strategies are described as participants attempt to manage the ongoing challenges of tinnitus. While no strategies eliminate tinnitus, many participants express that engaging in lifestyle and self-help strategies alleviate some difficulties. Among these included strategies such as taking breaks and/or isolating oneself, with one participant sharing "taking short breaks at work helps" (P2), and another sharing that they "find somewhere to be away from everything" (P9). This is echoed with another participant sharing they "stopped going out" (P11) to manage their symptoms. In addition to lifestyle strategies, some report mindfulness and "breathing methods" (P11) which includes strategies such as "breathing exercises/ mindfulness/ yoga" (P11). Additional lifestyle strategies such as "exercise" (P32) and "eating healthy" (P32) are shared. Additionally, another participant echoes this by sharing, "physical exercise is my 'go to' control method" (P59).

ST4 Subtheme: Psychological coping and reframing

In addition to lifestyle adjustments and self-help strategies, participants express a variety of internal, psychological strategies they use to manage tinnitus. These highlight how individuals focus not only on the practical aspects but also attempt to shift their internal response. Many participants express that distraction is a positive management strategy, with multiple individuals reporting they "try and ignore it" (P24/P27/P75/P68/P42). This is echoed by another participant that expresses how they "try to bloke it out and cope with it" (P57) and another expressing how they have "learned to ignore it most of the time" (P72). This distraction technique is accompanied by a participant expressing the desire to keep "busy" (P11). This was reflected by another participant that shares how "activities counter the effect by not having to think about it". Additionally, some participants speak about developing a sense of acceptance, recognising that while tinnitus is unlikely to go away, they can shift their response to it. Specifically, one participant shares how they have developed "acceptance that it will always be there and the knowledge [of] why [they] can hear it" (P11). Further, another participant adopts this acceptance that they "have to live with it" (P36).

ST4 Subtheme: Therapeutic interventions

Additionally, many participants express the use of therapeutic interventions that assist in reducing the perceived intensity of tinnitus. The most reported intervention is sound therapy which ranges from using other external sounds (e.g., the radio) to using white noise and hearing aids to reduce the perceived intensity of tinnitus. For example, one participant noted that they used "white noise during the day" (P1) and "listene[ed] to [the] radio, music or sleep ap[plications] at night" (P1). This is echoed by multiple other participants, such as one sharing, "I always make sure I have background noise like a radio/TV on to make the noise in my ears" (P4) and another sharing "I always [e]nsure that there is some other background noise in very quiet areas" (P8). More than 40 participants report on the use of other external sounds (e.g., radio, television) to manage tinnitus. Additionally, approximately 10 participants note that hearing aids help with tinnitus management, with one sharing, "my go to strategies are hearing aids with white noise, ambient white noise from a Bluetooth speaker" (P11) and another noting that "I wear hearing aids with a tinnitus reduction tech" (P13).

Discussion

This study has explored the lived experiences of veterans who reported having had tinnitus for more than 3 months. Thus, the results provide insight into how tinnitus influences daily life and mental health outcomes in the veteran population. The qualitative analysis concluded that there were four main themes: (ST1) Impact of tinnitus on the self, mind, and body; (ST2) Influence on the social self; (ST3) Disrupted daily functioning; and (ST4) Coping with tinnitus.

Impact on the self, mind, and body (ST1)

The study revealed the intrusive impact of tinnitus on the mind, body, and self and this theme included three subthemes: the characterisation of tinnitus, emotional and psychological distress, and cognitive and physical pain. One study conducted in the general population proposes how personality can alter the persistence of tinnitus by influencing an individual's likelihood of being aware of it [25]. These findings support the current results regarding an individual's characterisation of tinnitus – the emotional and perceptual experience of tinnitus is important.

Further, the results provide insight into how veterans describe and emotionally experience their tinnitus, exposing how the participants were not only reporting tinnitus symptoms but were also emotionally interpreting how the condition influenced them. Such findings are consistent with prior research that highlights the association between tinnitus and emotional and psychological distress in addition to poor physical health [11]. The finding that poor mental health may exacerbate tinnitus severity, and that tinnitus itself may worsen mental health, illuminates the potential reciprocal relationship between the two. Although it is difficult to determine causality, prior research supports the association. For example, one study illustrated how a decrease in depression was associated with a decrease in tinnitus prevalence and severity [26], and another qualitative study illuminated how stress can increase the severity of tinnitus [27]. This highlights how addressing mental health may be a promising strategy to reduce the burden of tinnitus.

Prior studies in veteran populations highlight how tinnitus negatively impacts various aspects of functioning, including mood, psychological difficulties (e.g., anxiety and depression), and general physical health [5,19,28]. Though these studies were conducted in the US population, the current results support these findings and provide insight into the UK military population and how tinnitus influences the mind, body, and self.

Influence on the social self (ST2)

The results highlight how tinnitus impacts people's social self and may be associated with interpersonal disruptions – reflected in the key subthemes of communication difficulties, social withdrawal, interpersonal tension, and embarrassment. The findings that tinnitus and hearing loss may increase communication difficulties is supported by previous research which has highlighted how, in a veteran population, tinnitus appears to negatively impact communication skills [19]. Furthermore, another US study indicated that both service members and veteran participants with tinnitus exhibited greater difficulty in understanding speech with background noise, perceiving sound, and distinguishing sound quality [8]. This is consistent with the results of the current study, which found that some participants experienced greater communication difficulties in contexts with higher background noise. Specifically, hearing loss, which is commonly comorbid with tinnitus in the aging population [29] may explain or compound communication challenges. Additionally, communication difficulties associated with tinnitus and difficulties with social isolation and altered social relationships have been noted [30]. As such, it is not surprising that our current population experienced social withdrawal in addition to interpersonal tension and embarrassment. The results of the current study illustrate how veterans with tinnitus experience communication difficulties, social withdrawal, interpersonal tension, and embarrassment.

Disrupted daily functioning (ST3)

The study highlighted how tinnitus influences daily functioning and environmental control which included the subthemes of sleep disruption and fatigue and of loss of control and autonomy in daily activities.

The results of the current study highlight the potential influence tinnitus has on sleep quality and quantity, with the majority of participants voluntarily sharing their sleep difficulties. This is consistent with previous research [31–33]. Further, there is evidence that greater tinnitus severity appears to be significantly associated with greater sleep disturbances [19,28]. Although there is no agreed reason for an association between tinnitus and sleep difficulties, various theories have been introduced. For example, the heightened awareness of tinnitus during quiet nighttime environments may increase the focus on tinnitus and thus create anxiety, lengthening sleep onset [34]. Interestingly, prior research highlights how the time of day contributes to both tinnitus loudness and distress, with tinnitus being perceived as louder and more distressing during the night and early morning hours than during the day [35]. This is consistent with the results of our study, which highlight how individuals felt a noticeable intensification of tinnitus during the night, increasing the focus and thus annoyance. Further, the findings of the current study illustrate the influence of tinnitus on daily activities. This is supported by prior research, such as one qualitative study in the veteran population that highlighted how tinnitus negatively impacted daily activities and daily life [19]. This finding has been echoed in other studies in the general population [36,37].

Coping with tinnitus (ST4)

Finally, although participants described the negative influence of tinnitus on their lives, they also reflected on strategies and techniques that enabled them to cope with it. This involved three main subthemes: lifestyle and self-help strategies, psychological coping and reframing, and therapeutic interventions. Participants expressed how all coping strategies were a form of management (i.e., managing the actual tinnitus sound or associated consequences) rather than treatment. This finding is not surprising given that there is currently no intervention that offers an effective or satisfactory solution to tinnitus [1,12,13,16]. Nonetheless, these three superordinate themes align with existing recommendations for managing tinnitus [9,38–40]. This highlights the complex interconnected nature of the three superordinate themes, as isolation not only emerged as a coping mechanism but also as a negative consequence of tinnitus itself (ST2). Thus, while isolation may provide a form of management, it may reinforce the psychological and social challenges, such as loneliness and worsening mood.

Additionally, it is important to note that while some participants set out various management strategies, many participants expressed how they did not have any coping strategy ($n = 31$) or had not tried any ($n = 7$). This is unsurprising given there is no cure or intervention that is universally effective for tinnitus. However, considering the substantial impact of tinnitus on veterans' mental health and daily life, as well as the lack of current treatment and management options, there is a need to explore alternative treatment options or management strategies.

The results of this qualitative study provide similar findings to a prior qualitative study conducted in an aged UK veteran population [20] which highlighted the impact of tinnitus on veterans' medical, social, and emotional wellbeing. However, the prior study was conducted in an aged population, and so the current results are novel.

Strengths and limitations

There are limitations that should be noted when interpreting the findings. Firstly, participants were recruited through the social media pages of a veterans' mental health charity. This recruitment strategy may have produced a sample that is not representative of the wider veteran population, as individuals engaging with a mental health charity may be more likely to experience mental health difficulties. Additionally, tinnitus in the veteran population may have comorbidities such as hearing loss or PTSD, and this study did not examine how such comorbidities may have influenced or confounded participants' experiences. As such, the results of the study (e.g., difficult sleep experiences) cannot solely be attributed to tinnitus itself. Specifically, because no audiometry was conducted and hearing was not otherwise assessed, we cannot separate the effects of tinnitus from those of hearing loss. Further, the sample included an overrepresentation of Royal Navy veterans, which further limits generalisability to the wider veteran population. Another key limitation is the cross-sectional nature of this study which means causality cannot be determined and only associations can be inferred. The lack of a comparison group (i.e., veterans without tinnitus or a non-veteran sample), means it is not possible to determine whether the difficulties are specific to veterans with tinnitus or illustrate more general experiences. Also some veterans may have been excluded because they found the questionnaire difficult to understand or complete, potentially limiting the generalisability of the findings across literacy levels. Additionally, although peer debriefing and discussion was carried out, a notable limitation was the lack of multiple coders independently analysing the data to assess intercoder reliability. Future studies would benefit from including independent coding by multiple researchers. Nonetheless, the current study adds to the limited qualitative literature on tinnitus in the UK veteran population and provides insight into how tinnitus influences the daily lives of veterans.

Conclusions

This study has illustrated the profound influence tinnitus has on the internal, social, and everyday lives of veterans. The majority of participants characterised tinnitus as intrusive, which consequently influenced their sense of self, psychological wellbeing, and physical functioning. Socially, tinnitus was often experienced alongside communication difficulties, isolation, and feelings of interpersonal tension and embarrassment. Additionally, participants reflected on the influence on their daily functioning, specifically through disturbances and loss of control of daily activities. While the majority of participants shared their lack of strategies to manage/eliminate the consequences of tinnitus, others shared potential self-help, psychological, and therapeutic strategies that helped them cope. Overall, these insights illustrate the burden of tinnitus in the veteran population while highlighting the need for support and intervention strategies in tinnitus management. Future research should conduct a qualitative study with a comparator group and should adapt a mixed-methods approach with a more representative sample.

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Competing interests

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Supplementary material: Comprehensive questionnaire

Demographics

What is your gender?	Male
	Female
	Other
	Prefer not to answer
Age (years)	Xtext-boxX
Tinnitus duration (years and months)	Xtext-boxX
Did your tinnitus start pre-military, during the military, or post-military?	Pre-military
	During the military
	Post-military
	Unsure
Do you attribute your tinnitus to your military service?	Yes
	Somewhat
	No
	Unsure
Employment status	Employed: Full-time
	Employed: Part-time
	Self-employed/Freelance
	Not working, looking after the home
	Not working, seeking employment
	Retired
	Other
Current occupation	Xtext-boxX
Military branch	Royal Navy (including marines)
	Army
	Royal Air force
Currently part of UK military reserve	Yes
	No
When did you leave the military?	Xtext-boxX
How many years did you serve?	Xtext-boxX

Tinnitus severity – FiveQ

To answer each question, select *one* of the numbers that is listed for that question. Answer each question based on **the past week.**

Over the last week, my tinnitus has prevented me from sleeping	1 – no impact	2	3	4	5	6	7	8	9	10 – intense impact
Over the last week, my tinnitus has impacted on my ability to concentrate	1 – no impact	2	3	4	5	6	7	8	9	10 – intense impact
Over the last week, my tinnitus has affected my ability to relax	1 – no impact	2	3	4	5	6	7	8	9	10 – intense impact
Over the last week, my tinnitus has affected my ability to perform day to day activities	1 – no impact	2	3	4	5	6	7	8	9	10 – intense impact
Over the last week, my tinnitus has affected my ability to hear	1 – no impact	2	3	4	5	6	7	8	9	10 – intense impact

Qualitative questions

	Do you experience any of the following symptoms that you feel are related to your tinnitus?	List of symptoms (headaches, dizziness or vertigo, ear pain, fatigue, nausea, difficulty concentrating, sensitivity to sound (hyperacusis), insomnia or sleep disturbances, tension, increased heart rate, concentration… etc. and another option for free text)
1	How do your symptoms of tinnitus affect your daily life?	Xtext-boxX
2	Tinnitus can sometimes cause feelings of frustration, anxiety, or depression. Can you describe how tinnitus has affected your mental health over time?	Xtext-boxX
3	In what way does tinnitus affect your ability to engage in daily activities?	Xtext-boxX
4	In what ways has tinnitus impacted your social interactions and relationships with family, friends, or colleagues?	Xtext-boxX
5	Have you noticed any changes in your sleep patterns or quality of rest as a result of tinnitus? How has this affected your overall well-being?	Xtext-boxX
6	What coping strategies, if any, have you found helpful in managing the emotional or mental health challenges associated with tinnitus?	Xtext-boxX
7	What coping strategies, if any, have you found helpful in managing the tinnitus itself (e.g., white noise or sound therapy)?	Xtext-boxX
8	In what other ways not listed has tinnitus impacted your life?	Xtext-boxX

Note: All questions are optional. Participants are able to share as much or as little as they would like.

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PRELIMINARY EVALUATION OF AN ECOLOGICALLY ADAPTED VERSION OF THE TURKISH HEARING-IN-NOISE TEST: NORMATIVE DATA FOR YOUNG ADULTS

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Contributions:
A Study design/planning
B Data collection/entry
C Data analysis/statistics
D Data interpretation
E Preparation of manuscript
F Literature analysis/search
G Funds collection

Abstract

Introduction: Recent research highlights the importance of ecological validity in speech-in-noise testing to better reflect real-world listening. In the original Hearing in Noise Test (HINT), speech-shaped noise is presented from one loudspeaker and target sentences from another. This preliminary study introduces an ecologically adapted Turkish HINT (Eco-HINT), which uses running-speech maskers and a three-speaker setup to create a more spatially complex and realistic listening environment. It establishes normative data for young adults with normal hearing.

Material and methods: Two text-based and two dialogue-based running-speech maskers were created from recordings of two voice actors (Masker Text and Masker Dialogue), at a 44.1 kHz sampling rate, recorded using Logic Pro for Mac. These recordings were edited, combined, and integrated into the HINT software. Target sentences were presented at 0°, with maskers at 100° and 260°. Some 42 normal-hearing Turkish adults (23 females, 19 males; aged 18–45 years) were tested with Eco-HINT. The Reception Threshold for Sentences at 50% accuracy (RTS50) and final signal-to-noise ratios (SNRs) were recorded. Descriptive statistics, sex comparisons, and test–retest reliability (intraclass correlation coefficient) were analysed.

Results: No significant sex-related differences were found in any test condition ($p > 0.05$). A percentile distribution is presented in which the 25th, 50th, 75th, and 95th percentile values for males are slightly better. Reliability was good for Masker Text SNR [dB], Masker Text RTS50 [dB], and Masker Dialogue SNR [dB] but lower for Masker Dialogue RTS50 [dB].

Conclusions: The Turkish Eco-HINT provides a promising alternative to the original Turkish HINT. The normative data obtained from young adults will serve as a foundation for future use. Our findings imply that in order to capture the complexity of daily listening challenges, ecological validity must be incorporated. The preliminary Turkish Eco-HINT suggests it can more realistically assess a listener's functional hearing performance in noisy environments.

Keywords: noise • adult • speech • normalization • Turkish Eco-HINT

WSTĘPNA OCENA EKOLOGICZNIE DOSTOSOWANEJ WERSJI *TURKISH HEARING IN NOISE TEST*: DANE NORMATYWNE DLA MŁODYCH DOROSŁYCH

Streszczenie

Wprowadzenie: Najnowsze badania podkreślają znaczenie ekologicznej trafności testów percepcji mowy w hałasie w celu lepszego odzwierciedlenia rzeczywistych warunków słyszenia. W oryginalnym *Turkish Hearing in Noise Test* (HINT) szum maskujący o widmie mowy jest odtwarzany z jednego głośnika, a docelowe zdania z drugiego. Niniejsze wstępne badanie przedstawia ekologicznie dostosowany turecki test HINT (Eco-HINT), który wykorzystuje do maskowania szum mowy i konfigurację trzech głośników w celu stworzenia środowiska słuchowego bardziej złożonego przestrzennie i bliższego rzeczywistemu. Badanie ustala także dane normatywne dla młodych osób dorosłych ze słuchem w normie.

Materiał i metody: Stworzono cztery rodzaje szumu maskującego z wykorzystaniem głosów dwóch osób: dwa oparte na tekście czytanym i dwa zapisy dialogów w (Masker Dialogue), z częstotliwością próbkowania 44,1 kHz, nagranych przy użyciu programu Logic Pro dla komputerów Mac. Nagrania te zostały zredagowane, połączone i zintegrowane z oprogramowaniem HINT. Zdania docelowe były prezentowane pod kątem 0°, a szum maskujący pod kątem 100° i 260°. Grupa badana złożona z 42 dorosłych Turków ze słuchem w normie (23 kobiety i 19 mężczyzn; w wieku 18–45 lat) została przebadana za pomocą Eco-HINT. Zarejestrowano próg rozumienia mowy przy 50-procentowej poprawności (RTS50) oraz końcowe stosunki sygnału do szumu (SNR). Przeanalizowano statystyki opisowe, wyniki w zależności od płci oraz rzetelność testu–retestu (współczynnik korelacji wewnątrzklasowej).

Wyniki: Nie stwierdzono istotnych różnic związanych z płcią w żadnym z warunków testowych ($p > 0,05$). Przedstawiono rozkład procentowy, w którym wartości 25., 50., 75. i 95. percentyla dla mężczyzn są nieco lepsze. Niezawodność okazała się dobra w przypadku Masker Text SNR [dB], Masker Text RTS50 [dB] i Masker Dialogue SNR [dB], ale niższa dla Masker Dialogue RTS50 [dB].

Wnioski: Turecki Eco-HINT stanowi obiecującą alternatywę dla oryginalnego tureckiego testu HINT. Dane normatywne uzyskane od młodych dorosłych posłużą jako podstawa dalszych badań. Nasze wyniki sugerują, że aby uchwycić złożoność codziennych wyzwań związanych ze słyszeniem, należy uwzględnić ekologiczne walidacje. Wstępne wyniki uzyskane dla tureckiego Eco-HINT sugerują, że może on trafniej oceniać funkcjonalną sprawność słuchu w hałaśliwym otoczeniu u osoby badanej.

Słowa kluczowe: hałas • osoba dorosła • mowa • normalizacja • turecki Eco-HINT

Introduction

As hearing technology continues to advance, the demand for hearing evaluations under conditions that simulate real life also increases. With growing awareness among clinicians and researchers in hearing science, efforts to address this issue are rapidly expanding. The Hearing in Noise Test (HINT) [1] is one of the most effective and widely used tools for evaluating hearing performance in noise under everyday listening conditions, and it has been adapted into many languages [2–10].

Although numerous studies have developed test environments or tasks simulating real-world conditions to evaluate hearing [11,12], the importance of updating these tests [13] and providing more ecologically valid versions has been increasingly discussed in recent decades [14]. In 2004, Neuhoff advocated the concept of "ecological psychoacoustics" and criticised traditional psychoacoustic testing methods for their limited focus on the auditory system's response without consideration of real-world parameters [15]. Following his discussion of the term "ecological validity", the concept has been used in hearing science to indicate that the test conditions should more realistically reflect everyday listening situations [16–18]. Within the framework of the World Health Organization's International Classification of Functioning, Disability and Health (WHO-ICF) [19], hearing researchers have increasingly emphasised the importance of assessing hearing-related functioning, activity, and participation in real-life contexts [20–23]. Although the concept of ecological validity may seem relatively new to hearing testing, it has long been recognised in psychology and related disciplines.

Motivated by this concept, hearing researchers have recently proposed an alternative procedure to standard Hearing in Noise Test application [24,25]. This alternative version introduces new noise signals and more effective presentation configurations [26–28]. By integrating a running-speech masker into the HINT system and presenting it through two spatially separated loudspeakers (100° and 260° azimuth), while the target speech is delivered from a third loudspeaker at 0°, these adaptations target a more realistic listening environment. Although the original HINT offers a standardised method for assessing speech understanding in noise, it employs speech-shaped noise presented from a fixed single direction. In contrast, the adapted version, by using running-speech maskers and multi-directional presentation of them (at 100° and 260°), represents an important step toward evaluating listening performance under more ecologically valid conditions.

In this study, we developed an ecologically adapted version of the Turkish HINT (Eco-HINT) by incorporating running speech maskers and naturalistic presentation positions. The specific term "Ecological HINT" is not yet established in the literature; we use the term to highlight its relevance to real-life rather than imply it is a formally standardised protocol. Accordingly, this study aims to develop a Turkish Eco-HINT and establish normative data for a sample of young adults with normal hearing sensitivity.

Material and methods

Participants

This study was conducted in the audiology laboratory of a private university. Ethics committee approval was obtained (date 24.10.2024, number 08/910). Volunteer participants were invited, and written consent was obtained from all of them.

A total of 42 participants (23 females, 19 males) aged 18–45 years were included. This specific age range was selected to provide a representative sample of the young adult population and to minimise the potential for age-related hearing effects. The sample size was determined using the G*Power (version 3.1.9.7) program prior to data collection. For an independent samples *t*-test, with an alpha level of 0.05, an effect size (Cohen's d) of 0.80, and a theoretical power ($1-\beta$) of 0.80, the minimum total sample size was calculated as 42 participants. Inclusion criteria were normal otoscopic findings, a bilateral pure-tone average (0.5–4 kHz) between −10 to 25 dB HL, and being a native Turkish speaker. Participants with a history of acoustic trauma, otological/neurological disorders, or difficulty in understanding speech in noise were excluded.

Turkish Eco-HINT software adaptation

Although the Eco-HINT software uses the same database as the original HINT software, it requires recorded and edited running-speech as noise. To generate this noise, speech samples from two voice actors were recorded using the Logic Pro for Mac program at a sampling rate of 44.1 kHz in a sound recording studio. Before recording, elementary school reading books were reviewed and several plain text passages (read in a neutral, narrative style) and dialogue passages (read in an interactive conversational style) were selected. The voice actors were instructed to read naturally, fluently, and clearly. Sentences that sounded unnatural or unclear were re-recorded. In total, four different speech samples (two plain text format and two dialogue format) were obtained, each approximately

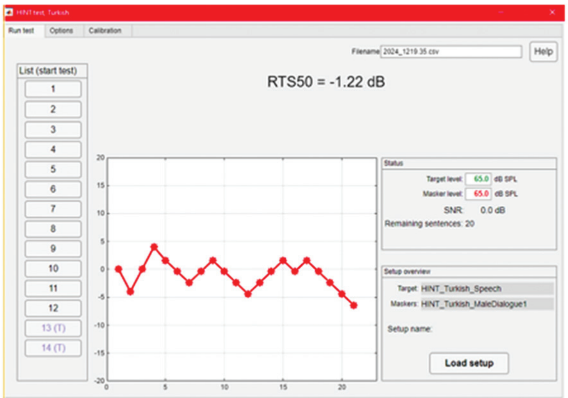

Figure 1. Software screen of Eco-HINT showing a Reception Threshold for Sentences (RTS) of –1.22 dB, the SNR at which the test person can correctly repeat 50% of the sentences

10 minutes long. The recordings were edited and integrated into HINT software in the Interacoustics Research Unit (IRU). The Eco-HINT screen is shown in **Figure 1**.

Both plain text-based and dialogue-based maskers were used to check if they yielded different results. The Reception Threshold for Sentences (RTS) refers to the SNR at which the test person can correctly repeat 50% of the sentences. Therefore, the RTS at the 50% sentence accuracy level (RTS50) can be measured based on the correct sentence score [4]. In the adaptive HINT procedure, the signal-to-noise ratio (SNR) is varied depending on the listener's responses. The final SNR refers to the average SNR of the sentences presented after the adaptive procedure has reached convergence.

Test conditions

A quiet room with no echo or reverberation was selected for testing. Unlike the original HINT applications, the Eco-HINT setup requires 3 high quality speakers. Therefore, as shown in **Figure 2**, three JBL One speakers were placed on three adjustable stands (Alctron model MS120). Each was positioned 1 m from the center of the participant's head with the height adjusted individually. The target sentences were presented from a loudspeaker positioned at 0° azimuth (front), while the two other loudspeakers playing maskers were positioned at 100° and 260° to simulate a more real-life listening situation [27,28]. The position of the participant is not changed during the test.

Figure 3 compares the spectral content of the original Turkish HINT test and the Turkish Eco-HINT. Both noise files were uploaded into ACS Audio Editor (version 11.1), and the Frequency Spectrum tool used for analysis. In the analysis window, the FFT size was set to 4096, the window type to Hanning, the vertical axis to dB, and the horizontal axis to frequency (Hz).

Data collection

Before starting the test, the speakers were calibrated with speech-shaped noise (SSN). The calibration level was maintained at a minimum of 70 dB SPL and a maximum of 90 dB SPL [29]. The software contained 12 lists (240 sentences). Each participant listened to one list of 20 sentences, presented randomly by the Eco-HINT system. A standard adaptive procedure was applied. The noise level was fixed at 65 dB SPL, while the starting level for target speech was 65 dB SPL. Participants were asked to repeat the sentences, and the tester marked the responses as "correct" or "incorrect". The step-size was 4 dB for the first four sentences, meaning that a correct response corresponded to a decrease in SNR of 4 dB, whereas an incorrect response meant there was a 4 dB better SNR for the next sentence. The step-size for the remaining sentences was set as 2 dB. Unlike the original HINT, participants were tested only in one condition (speech from the front, noise from both sides). All participants were tested under both masker types (text-based and dialogue-based),

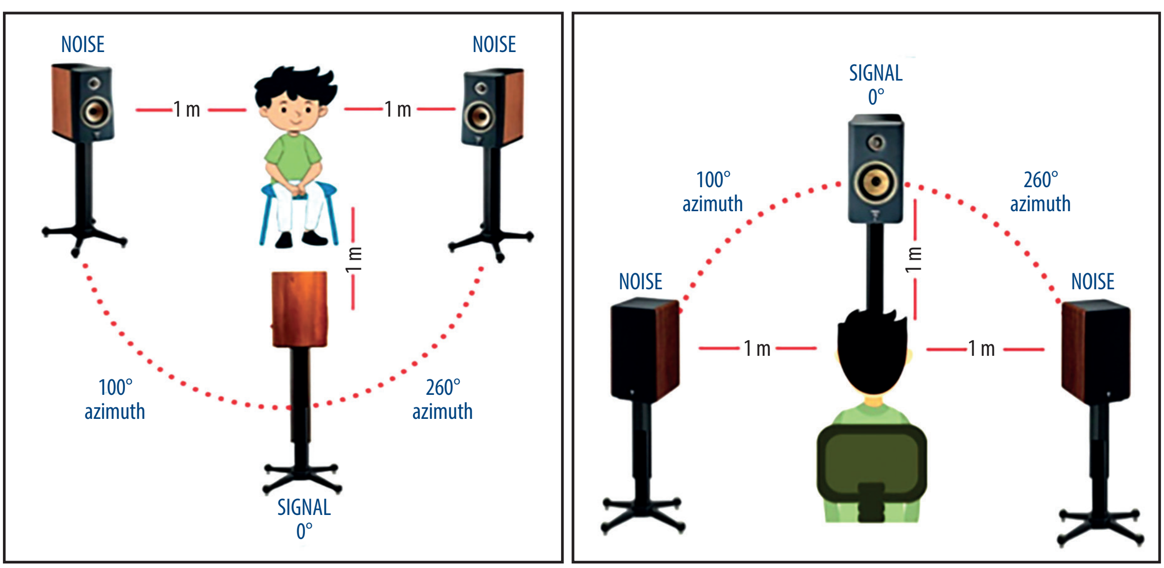

Figure 2. Front and back views of the Eco-HINT set-up

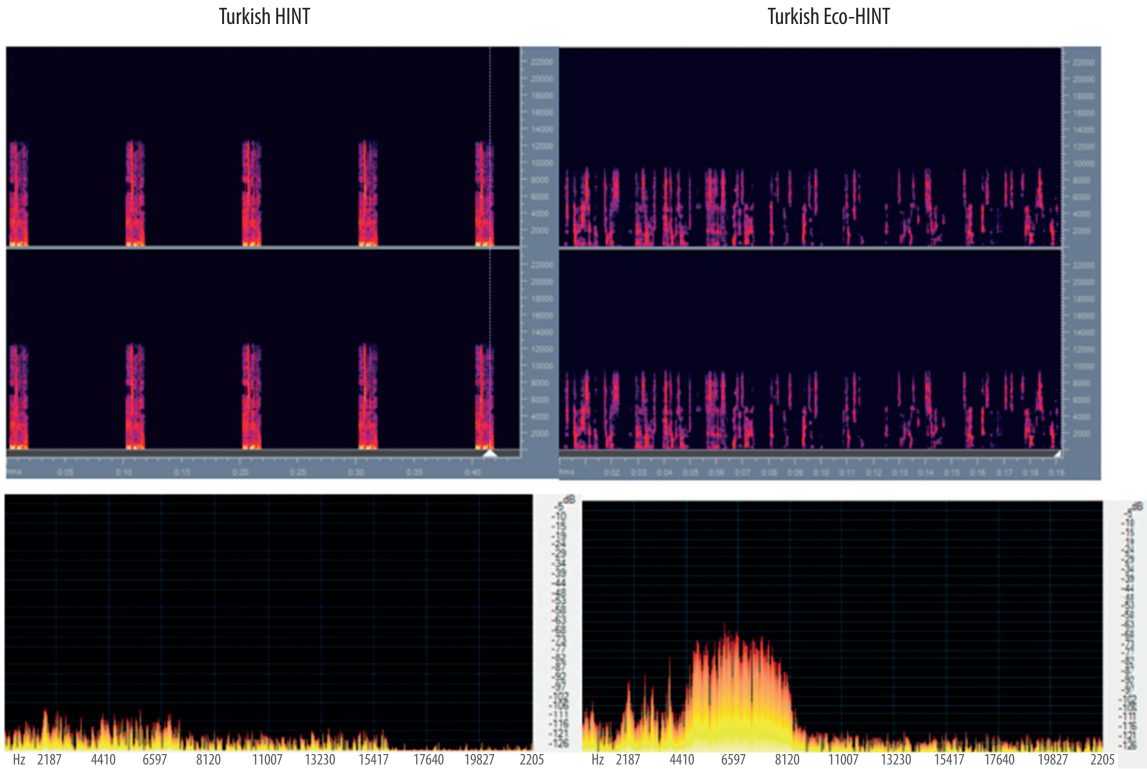

Figure 3. Sample spectra of the standard Turkish HINT test (left) and the Turkish Eco-HINT test (right). At top is a time–frequency plot and at bottom is an averaged spectrogram

Table 1. Descriptive values for all participants

All participants (*n* = 42)	Mean ± *SD*	Median (IQR)	Min–Max
Age [years]	30.7 ± 7.8	28 (26 – 39)	19 – 45
Masker (Text) SNR [dB]	–1.79 ± 3.03	–1.4 (–5.2 – 0.4)	–7.6 – 3.6
Masker (Text) RTS50 [dB]	–1.76 ± 2.71	–1.98 (–3.39 – –0.66)	–8.3 – 4.1
Masker (Dialogue) SNR [dB]	–0.99 ± 2.69	–1.2 (–2.8 – 1.2)	–8.4 – 4.4
Masker (Dialogue) RTS50 [dB]	–0.67 ± 2.8	–0.89 (–1.79 – 1.6)	–7.1 – 5.5

Note: *SD*, standard deviation; IQR, 25th – 75th percentiles

and the presentation order of the masker types was counterbalanced across participants. Short practice trials were provided before each condition. To evaluate the test–retest reliability, 15 participants (11 females, 4 males), were retested 1 week after the first session using the same setup and protokol. RTS50 and final SNR were recorded for each session.

Statistical analysis

The statistical analysis was conducted using SPSS (Statistical Package for the Social Sciences) version 25.0 for Windows. Descriptive statistics were calculated: number, percentage, minimum, maximum, mean, standard deviation, median, and interquartile range. Normality was assessed with kurtosis and skewness values. An independent sample *t*-test, and one-way analysis of variance (ANOVA) were performed, followed by Bonferroni adjustments. Pearson's correlation coefficient was applied to test the relationship between numerical variables. To assess test–retest reliability, an intraclass correlation coefficient (ICC) was calculated to determine the level of agreement between repeated measurements. Significance was set as $p < 0.05$.

Results

Descriptive statistics for all participants are shown in **Table 1** and a comparison of males and females is presented in **Table 2**. There was no significant age difference between males and females. The participants' ages ranged from 19 to 45 years, with a mean age of 30.7 ± 7.8 years and a median of 28 years. The mean age for females was 31.9 ± 7.8 years and for males 29.5 ± 7.8 years.

Table 2. Comparison of males and females

	Male (*n* = 19)		Female (*n* = 23)		*p*
	Mean ± *SD*	**Median (IQR)**	**Mean ± *SD***	**Med (IQR)**	
Age [years]	29.5 ± 7.8	29 (22.3 – 38.8)	31.9 ± 7.8	28 (27 – 42)	0.392 (*z* = –0.857)
Masker (Text) SNR [dB]	–2.44 ± 3.17	–1.7 (–5.2 – 0.20)	–1.22 ± 2.85	–1.20 (–3.60 – 1.20)	0.190 (*t* = –1.334)
Masker (Text) RTS50 [dB]	–2.35 ± 2.38	–1.67 (–3.75 – –0.73)	–1.24 ± 2.91	–1.98 (–3.15 – 0.99)	0.183 (*t* = –1.354)
Masker (Dialogue) SNR [dB]	–1.64 ± 2.60	–1.60 (–2.8 – 0.20)	–0.43 ± 2.7	–0.40 (–1.2 – 1.2)	0.142 (*t* = –1.497)
Masker (Dialogue) RTS50 [dB]	–0.92 ± 2.88	–1.15 (–2.29 – 1.6)	–0.45 ± 2.77	–0.66 (–1.74 – 1.32)	0.586 (*t* = –0.549)

Note: $^*p < 0.05$ statistically significant; *SD*, standard deviation; IQR, 25th – 75th percentiles; *t*, independent samples *t*-test; z, Mann–Whitney *U*-test

Table 3. Percentile distributions

		Percentiles												
		5	**10**	**20**	**25**	**30**	**40**	**50**	**60**	**70**	**75**	**80**	**90**	**95**
Masker (Text) SNR [dB]	All participants	–6.68	–5.88	–5.20	–5.20	–3.6	–2.0	–1.4	–0.88	0.24	0.40	1.20	2.48	3.44
	Male	–7.56	–6.74	–5.36	–5.20	–5.20	–3.92	–1.7	–1.28	–0.4	0.2	0.4	1.2	3.48
	Female	–6.0	–5.2	–3.92	–3.6	–2.80	–2.0	–1.2	–0.4	0.4	1.2	2.0	2.8	3.44
Masker (Text) RTS50 [dB]	All participants	–6.49	–5.31	–3.71	–3.39	–3.19	–2.58	–1.98	–1.14	–0.8	–0.66	–0.25	2.73	3.67
	Male	–8.26	–6.45	–3.87	–3.75	–3.36	–3.01	–1.67	–0.99	–0.8	–0.73	–0.48	–0.15	1.38
	Female	–5.83	–5.27	–3.49	–3.15	–2.75	–2.37	–1.98	–1.24	–0.76	0.99	2.64	3.62	4.02
Masker (Dialogue) SNR [dB]	All participants	–6.32	–4.4	–2.8	–2.8	–2.64	–1.2	–1.2	–0.4	0.4	1.2	1.2	2.8	2.8
	Male	–8.2	–4.4	–2.8	–2.8	–2.80	–2.8	–1.6	–1.2	–0.4	0.2	0.4	2.6	2.8
	Female	–6.32	–5.04	–2.32	–1.2	–1.20	–1.2	–0.4	0.72	1.2	1.2	1.84	2.8	4.08
Masker (Dialogue) RTS50 [dB]	All participants	–6.87	–4.36	–2.5	–1.79	–1.72	–1.24	–0.89	0.18	0.79	1.6	1.82	2.79	3.39
	Male	–7.1	–6.54	–2.63	–2.29	–1.79	–1.41	–1.15	–0.84	1.36	1.6	1.71	3.26	3.39
	Female	–6.37	–4.36	–2.18	–1.74	–1.63	–1.10	–0.66	0.56	0.73	1.32	2.22	2.79	4.99

Table 4. Test–retest reliability

	ICC	95% C.I. lower	95% C.I. upper
Masker (Text) SNR [dB]	0.815	0.45	0.938
Masker (Text) RTS50 [dB]	0.882	0.647	0.96
Masker (Dialogue) SNR [dB]	0.855	0.568	0.951
Masker (Dialogue) RTS50 [dB]	0.385	–0.832	0.794

Note: ICC, intraclass correlation coefficient; 95% C.I., 95% confidence interval

The four conditions presented in the tables are defined as follows. Masker (Text) SNR [dB] refers to the final SNR obtained under text-based condition. Masker (Text) RTS50 [dB] shows the RTS score for the SNR at which the test participant can correctly repeat 50% of the sentences under text-based condition. Masker (Dialogue) SNR [dB] refers to the final SNR obtained under dialogue-based condition. Masker (Dialogue) RTS50 [dB] shows the RTS score for the SNR at which the test participant can correctly repeat 50% of the sentences under dialogue-based conditions.

Mean (*SD*) and median (IQR) values are presented in **Table 2**. There were no significant differences between males and females under any of the conditions. The percentile distributions of the data is presented in **Table 3**. Overall, the 25th, 50th, 75th, and 95th percentiles values for males were slightly better.

Pearson correlation was applied to examine the relationship between Masker (Text) SNR and Masker (Text) RTS50 scores to confirm internal consistency between the two measurement outcomes. The analysis revealed a strong positive correlation ($r = 0.86$, $p < 0.001$), indicating that the participants who performed better (lower SNR) also had lower RTS50 values.

Test–retest reliability was checked with intraclass correlation coefficient and is presented in **Table 4**. Reliability was good for Masker (Text) SNR [dB], Masker (Text) RTS50 [dB], Masker (Dialogue) SNR [dB], but lower for Masker (Dialogue) RTS50 [dB].

Discussion

This study aimed to develop a Turkish Eco-HINT and to establish normative data for young adults by presenting percentile distributions. The results demonstrated high internal consistency across Eco-HINT measures, as indicated by the strong correlation between Masker (Text) SNR and Masker (Text) RTS50 ($r = 0.86$, $p < 0.001$). Overall, the Eco-HINT provided reliable estimates of speech-in-noise performance across most conditions; however, one condition showed a relatively lower ICC, suggesting that test–retest stability may vary depending on the specific listening condition.

Although sex comparison was not a primary objective, it was included to confirm the homogeneity of the normative dataset. No significant sex differences were found, indicating that the Eco-HINT normative results are applicable for both males and females. This finding aligns with previous studies reporting no sex-related variability in speech-in-noise performance when hearing sensitivity is within normal limits [30]. Similar to most previous normative HINT studies, the present study did not control for participants' educational or socioeconomic status. Although these factors are typically not considered in this type of research, they may still contribute to individual variability in speech-in-noise performance. Future studies are therefore encouraged to examine and control for these variables when feasible.

The term "ecological validity" is commonly used in psychoacoustics and audiology literature to denote a study's relevance to real-world hearing environments, often without formal statistical analysis [14,15,31]. From this perspective, the Eco-HINT offers a more ecologically valid approach than the original HINT, owing to two major design modifications. First, it employs running speech maskers, which better simulate real-world listening environments compared to speech-shaped noise. Second, it utilizes bilateral noise presentation via two loudspeakers positioned at 100° and 260°. In real-life communication, listeners naturally position themselves so that noise is behind and the speaker is in front. These spatial characteristics reflect natural listening conditions, where speech and competing sounds rarely come from a single fixed direction. This is the reason that such positioning was implemented in the Eco-HINT design. Consequently, Eco-HINT engages binaural mechanisms essential for understanding speech in realistic acoustic scenes [33,34].

When comparing the two different types of maskers, higher SNR values were obtained in the dialog-based masker than in the plain text-based condition, indicating that listeners found speech recognition more challenging when the masker was in a dialogue format. In contrast, the RTS50 values obtained under the dialogue-based masker showed slightly lower reliability, possibly due to the fluctuating and dynamic nature of conversational noise. These findings highlight that the linguistic and temporal characteristics of the masker – whether text-based or dialogue-based – can substantially influence both the difficulty and reliability in a speech-in-noise assessment.

Recent developments in hearing science emphasise the importance of test paradigms that simulate real-world acoustic scenes, leading to an increasing use of the term ecological validity in hearing research [31,34]. It has been argued that hearing aid fitting and auditory assessment should incorporate more ecologically valid measures, as they better represent real-life listening demands [35–38]. The Eco-HINT was designed with this perspective, combining realistic speech-like maskers and spatially distributed noise sources to reflect everyday auditory environments. Although the importance of evaluating hearing performance in noise is well recognised, hearing-in-noise tests are not routinely included in standard audiological test batteries [39]. One reason is that such tests are not easy to produce [1]. Additionally, the setup and pre-test adjustments can be challenging for practitioners. For instance, these tests are conducted in a free-field, requiring a sufficiently large room for loudspeaker placement. Although some centers have large acoustic booths, many others operate in small or acoustically treated rooms that may not meet full free-field standards. One limitation of this study is that measurements were conducted in a quiet room, rather than an acoustic booth. Therefore, quiet-condition measurements (threshold SRT) were not obtained. Another limitation is that noise loudspeakers were placed at 100° and 260° as suggested in previous studies. Alternative angular presentations or additional loudspeaker arrangements could also be explored in future work. While in real life people often position themselves with the speaker in front and noise behind, in some environments – such as factories – listeners are exposed to only directional noise. Although numerous studies exist on the original HINT in many languages, research focusing on ecological adaptation/validation remains scarce.

In this study, a Turkish Eco-HINT was prepared, which includes more realistic background noises reflecting daily life and suggests a new presentation position. Mean (SD), median (IQR), and percentage distribution of the data were presented. The mean and median SRT values were higher than –2 dB, which falls within but toward the higher end of the range reported for original HINT studies [40]. This means that Eco-HINT may impose a somewhat more challenging listening condition, potentially due to presentation positions and noise characteristics, compared to values typically reported in previous HINT normative studies. For reference, the article by Soli and Wong, which summarizes normative data across multiple studies, should be consulted [40].

As the number of studies on this subject increases in the literature, cross-study interpretation and comparison of findings will become increasingly feasible.

Conclusions

This study introduced the Turkish Eco-HINT, which is designed to better simulate real-world listening environments for testing hearing performance in noise. As normative data may only be valid for a specific group, the normative data obtained from young adult participants will serve as a foundation for future use. Our findings confirm that to capture the complexity of daily listening challenges, tests should have enhanced ecological validity. The Eco-HINT allows researchers alternative methods to assess a listener's functional hearing performance in noisy environments. Moreover, Eco-HINT may support decision-making in hearing aid verification and counseling by providing data that more closely reflect patients' real-life communication abilities. Future studies should further validate Eco-HINT and investigate applicability across different age groups and hearing impaired populations, as well as compare its outcomes with those of other ecologically valid measures. Continued studies of this topic will advance scientific understanding and the clinical management of hearing in complex auditory environments.

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Data Availability Statement

The data for this study can be provided upon request from the responsible author. The data is not publicly available due to confidentiality or ethical restrictions.

Conflict of interest statement

The authors have no conflict of interest.

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Case studies

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PERCEPTION OF MUSICAL HARMONY: A CASE STUDY OF ONE COCHLEAR IMPLANT USER AND TWO NORMAL-HEARING SUBJECTS

Contributions:
A Study design/planning
B Data collection/entry
C Data analysis/statistics
D Data interpretation
E Preparation of manuscript
F Literature analysis/search
G Funds collection

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Abstract

Introduction: The perception of musical intervals is a fundamental component of melody and harmony. Intervals can be presented melodically (successive tones) or harmonically (simultaneous tones), with the latter playing a critical role in the perception of consonance and chordal structure. In the chromatic scale, intervals are measured in semitones, and their perceived pleasantness (i.e., consonance or dissonance) is determined by the frequency ratio between them. Cochlear implant (CI) users are likely to perceive harmonic intervals differently from normal-hearing individuals due to technological limitations in transmitting the spectral and temporal complexity of musical sounds. Factors affecting perception of sounds in CI users include placement of the electrode array inside the cochlea and spread of excitation along the auditory nerve.

Case report: To explore differences in how harmonic intervals are perceived, this study presents three case studies of the ranked pleasantness of consonance and dissonance by (1) a normal-hearing individual without musical training; (2) a normal-hearing musician; and (3) a cochlear implant user.

Conclusions: The findings provide a foundation for future investigations into interval perception and have implications for auditory rehabilitation and music-based therapy.

Keywords: cochlear implant • musical intervals • harmonic interval • consonance • dissonance

PERCEPCJA HARMONII MUZYCZNEJ: STUDIUM PRZYPADKU UŻYTKOWNIKA IMPLANTU ŚLIMAKOWEGO I DWÓCH OSÓB Z PRAWIDŁOWYM SŁUCHEM

Streszczenie

Wprowadzenie: Percepcja interwałów muzycznych, czyli odległości między dźwiękami mierzonej w półtonach, stanowi kluczowy element w odbiorze melodii i harmonii. Interwały mogą występować w formie melodycznej (dźwięki następujące po sobie) lub harmonicznej (dźwięki brzmiące jednocześnie), przy czym te drugie odgrywają istotną rolę w odbiorze współbrzmień i akordów. W skali chromatycznej odczuwana przyjemność brzmienia interwałów harmonicznych (określana jako konsonans lub dysonans) wynika z relacji częstotliwości pomiędzy dźwiękami tworzącymi dany interwał. Użytkownicy implantów ślimakowych mogą postrzegać interwały harmoniczne inaczej niż osoby prawidłowo słyszące, ponieważ implanty mają ograniczenia w przekazywaniu złożonej struktury czasowej i widmowej sygnałów muzycznych. Na percepcję dźwięków u użytkowników implantów ślimakowych wpływają różne czynniki, w tym: rozmieszczenie elektrod w ślimaku oraz rozkład pobudzenia nerwu słuchowego.

Opisy przypadków: W niniejszej pracy przedstawiono trzy przypadki, w których dokonano oceny przyjemności brzmienia interwałów harmonicznych: 1) osobę ze słuchem prawidłowym bez wykształcenia muzycznego, 2) muzyka ze słuchem prawidłowym oraz 3) użytkownika implantu ślimakowego.

Wnioski: Uzyskane wyniki stanowią punkt wyjścia do dalszych badań nad percepcją interwałów muzycznych oraz jej potencjalnym znaczeniem w procesie rehabilitacji słuchu i terapii opartej na muzyce.

Słowa kluczowe: implant ślimakowy • interwały muzyczne • interwały harmoniczne • konsonans • dysonans

Introduction

The perception of musical intervals is a fundamental issue in musicology and in how musical sounds are perceived. Intervals, defined as the difference in pitch between two sounds, play a central role in the way melody and harmony are perceived and how musical structure is shaped. The recognition of intervals depends on both the acoustic properties of a sound and on the cognitive experience of the listener [1].

Musical intervals come in two basic forms: melodic, when sounds are presented sequentially in time, and harmonic, when they occur simultaneously. While melodic intervals build melody, the perception of harmonic intervals plays an important role in the perception of harmony, consonance, and chords, which are the foundation of most musical systems – whether classical or popular.

In the chromatic scale, commonly used in music, the ratios of two fundamental frequencies of sounds are measured in semitones, so that 12 semitones correspond to a doubling of frequency. Specific ratios such as the octave (12 semitones) or the pure fifth (7 semitones) are perceived as the most pleasing, while others such as the minor second (1 semitone) or the major seventh (11 semitones) are perceived as the most unpleasant. A list of all the simple intervals within the octave is given in **Table 1**. When two sounds are presented to a listener simultaneously (harmonically), the relationship between their fundamental frequencies (together with cultural exposure) determines how pleasant the composite sound is perceived. Musically, the result is deemed pleasant (consonance) or unpleasant (dissonance) [2,3]. In European-style tonality, dissonance is subjectively harsh, and introduces a tension that requires resolution, i.e., a transition to consonance [4]. Consonances are divided into perfect and imperfect consonances (perfect consonances sound smooth or congruent, while imperfect ones sound sufficiently congruent to not require resolution) [5]. Evaluating simple intervals on a category of pleasantness makes it possible to construct a pattern of harmonic intervals.

Users of cochlear implants (CIs) will tend to experience harmonic intervals differently from individuals with normal hearing. Spitzer et al. [6] demonstrated that the typical pattern of interval perception is less distinct in CI users – specifically, the differences in pleasantness ratings between particular intervals are significantly reduced compared to those of normal-hearing listeners. This altered perception may lead to a musical piece being experienced in a way that diverges from the composer's original intent. Although CIs significantly improve speech understanding, their limited temporal and frequency resolution results in substantially reduced performance in conveying many musical features, particularly melody and harmony [7]. Several factors contribute to the atypical perception of musical intervals in CI users compared to those with acoustic hearing. These include the limited number of electrode channels, electrode interaction, current spread from electrodes, the depth of electrode array insertion, and the specific signal encoding strategy employed [8–11].

While the literature includes numerous studies on melody perception in CI users, considerably less attention has been given to the perception of harmony [12,13]. The aim of this paper is to present three case studies in which the perception of harmonic intervals was examined. We identified three target groups – normal-hearing individuals, normal-hearing musicians, and CI users – and examined

Table 1. Basic musical intervals

Interval	Distance between notes (semitones)	Consonance/dissonance
Perfect unison	0	Perfect consonance
Minor second	1	Dissonance
Major second	2	Dissonance
Minor third	3	Imperfect consonance
Major third	4	Imperfect consonance
Perfect fourth	5	Perfect consonance
Tritone	6	Dissonance
Perfect fifth	7	Perfect consonance
Minor sixth	8	Imperfect consonance
Major sixth	9	Imperfect consonance
Minor seventh	10	Dissonance
Major seventh	11	Dissonance
Perfect octave	12	Perfect consonance

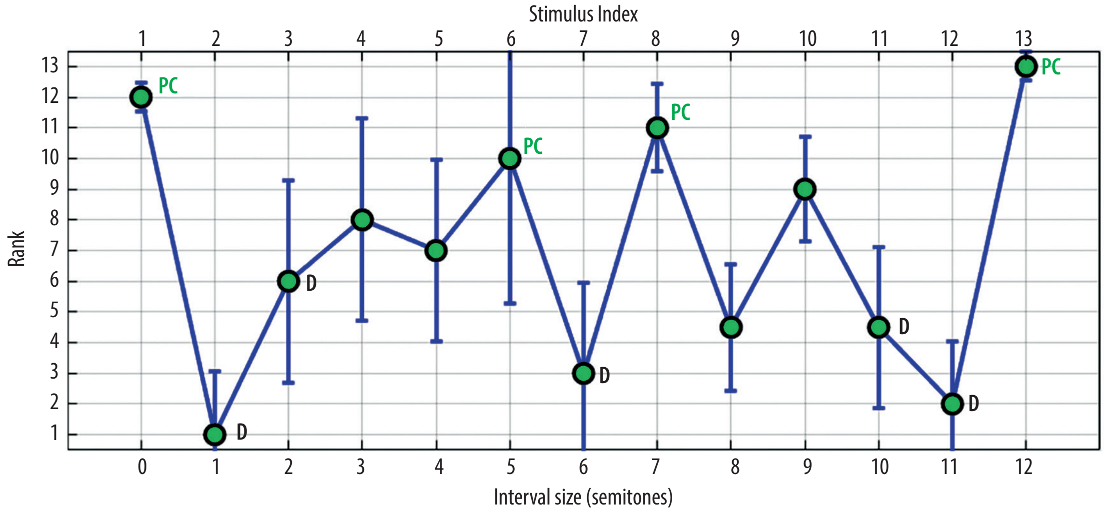

Figure 1. Results for case 1. Pleasantness (rank 1–13, vertical axis) of two harmonically presented tone pairs as gauged by a normal hearing subject. The horizontal axis is the number of semitones between the two tones. PC = perfect consonance; D = dissonance

one case from each of these. An additional objective was to assess the test procedure based on pair comparisons.

Methods

Non-invasive psychoacoustic tests were performed using the PsyWorks 7.1.1 software from Med-El (Innsbruck, Austria). Two harmonic stimuli (intervals "1" and "2") were presented to the listener in sequence and the listener was asked to indicate which one was more pleasant. Each stimulus consisted of two tones presented simultaneously, forming a harmonic interval. In each stimulus, the ratio of fundamental frequencies corresponded to one of 13 different values, ranging from unison (0 semitones) to an octave (12 semitones). The lower tone always had a fundamental frequency of 440 Hz, corresponding to A440 (A4 in musical notation).

The midpoint comparison (MC) procedure, described by Long et al. [14], was used to determine, through pairwise comparisons, the pleasantness of the 13 stimuli. The MC algorithm orders a set of items by iteratively comparing pairs and updating a provisional ranking as more data are collected. Each new tone is first compared with the stimulus located at the midpoint of the current ranking, and the tone pairs are each compared only once per run. Participants are not allowed to respond that two tones are equally pleasant; even if uncertain, they are required to make a choice. This forced-choice design ensures that the algorithm can continuously refine the ordering based on the accumulation of comparison outcomes.

The study was conducted with the approval of the Bioethics Committee at the Institute of Physiology and Pathology of Hearing, Warsaw (No. KB.IFPS 10/2024).

Case reports

Case 1

Case 1 was a 41-year-old male with normal bilateral hearing who underwent the musical interval perception test using earphones. He performed pairwise comparisons of tones generated by the PsyWorks software. In the resulting graph (**Figure 1**), the vertical axis represents the assigned pleasantness score (ranked 1–13).

As shown in **Figure 1**, the perfect consonance (PC) intervals were ranked as the most pleasant. These included the unison (0 semitones), perfect fourth (5 semitones), perfect fifth (7 semitones), and octave (12 semitones), which were assigned ranks between 10 and 13. Other consonant intervals also ranked relatively high: the minor third (3 semitones), major third (4 semitones), minor sixth (8 semitones), and major sixth (9 semitones) received ranks ranging from 4.5 to 9. In contrast, dissonant (D) intervals were ranked much lower: the minor second (1 semitone), major second (2 semitones), tritone (6 semitones), minor seventh (10 semitones), and major seventh (11 semitones) were all assigned ranks between 1 and 6.

Case 2

Case 2 was a 41-year-old female with normal bilateral hearing and a background in formal music education. She was actively engaged in musical activities, particularly the piano. The musical interval perception test was again administered through earphones.

As shown in **Figure 2**, the PC intervals were again ranked as the most pleasant. These included the unison (0 semitones), perfect fourth (5 semitones), perfect fifth (7 semitones), and octave (12 semitones), which were assigned ranks between 9 and 13. Other consonant intervals were also ranked highly: the minor third (3 semitones) and major third (4 semitones) received ranks of 8 and 10 respectively, while the minor sixth (8 semitones) and major sixth (9 semitones) were assigned slightly lower ranks, 4 and 6 respectively. In contrast, D intervals were ranked significantly lower: the minor second (1 semitone), major second (2 semitones), minor seventh (10 semitones), and major seventh (11 semitones) all received ranks between 1 and 5. The tritone (6 semitones), typically considered dissonant, was

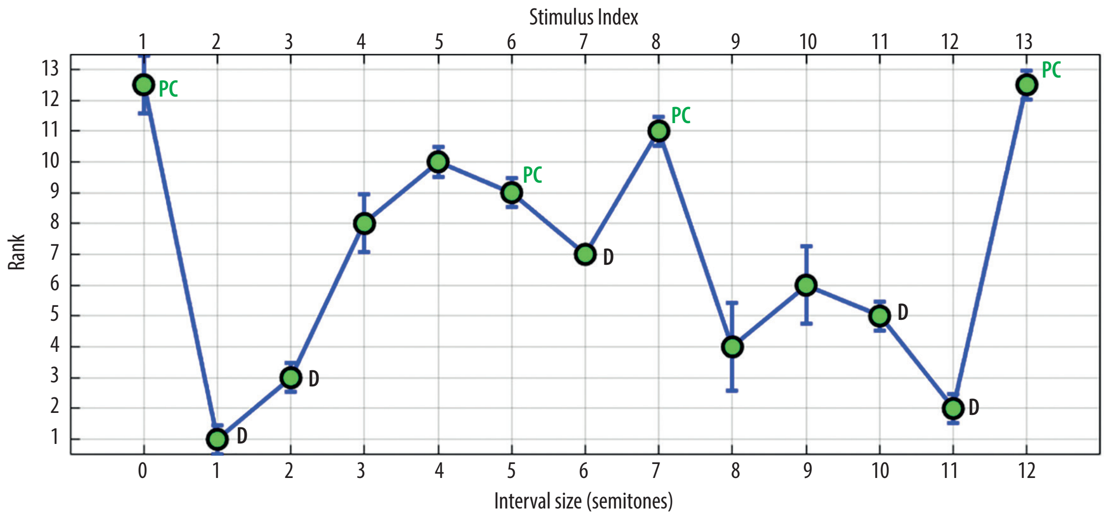

Figure 2. Results for case 2. Pleasantness (rank 1–13) of harmonically presented tone pairs as gauged by a musically trained subject. The horizontal axis is the number of semitones between the two tones. PC, perfect consonance; D, dissonance

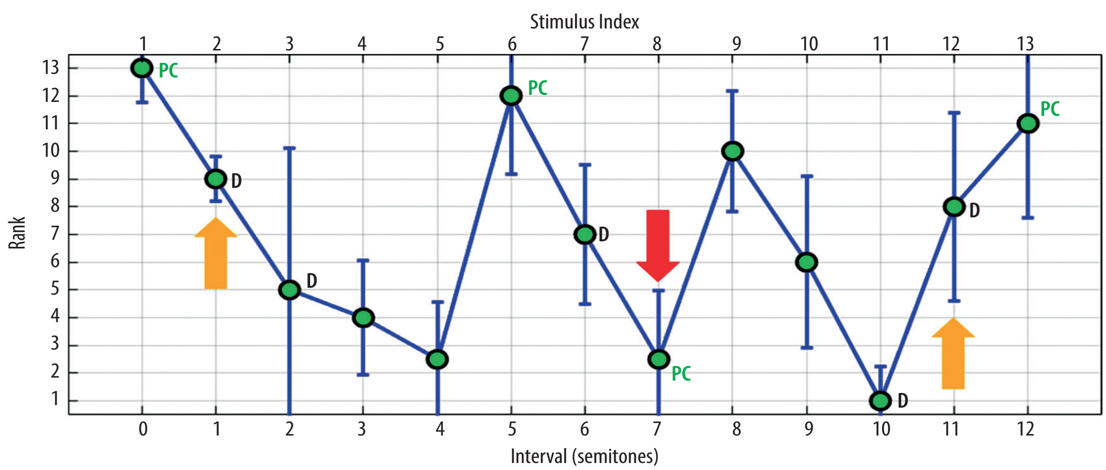

Figure 3. Results for case 3. Pleasantness (rank 1–13) of harmonically presented tone pairs as gauged by a subject having bilateral CIs, with the tones delivered to the right CI. Layout as per previous figures. Scores that differ significantly from those of the normal-hearing individuals in **Figures 1 and 2** (defined as a difference of more than 5 in rank) are highlighted – orange arrows indicate intervals rated significantly higher and red arrows indicate intervals significantly lower

ranked 7. In general, the ranking scores in case 2 showed less variation (smaller standard deviations) than in case 1. This smaller variability may be attributed to the subject's formal ear training and ongoing musical experience.

Case 3

Case 3 was a 36-year-old female with bilateral cochlear implants (Pulsar and Synchrony 2 with Sonnet 2 speech processor from Med-El). The first implant was placed in the right ear at the age of 20; the second was implanted 1 year ago. The FS4 coding strategy was used in both. During testing, auditory signals were delivered to the right implant via a cable connected to the direct audio input of the speech processor, and the results are shown in **Figure 3**.

As shown in **Figure 3**, PC intervals were generally ranked as the most pleasant, with the notable exception of the perfect fifth (7 semitones). The unison (0 semitones), perfect fourth (5 semitones), and octave (12 semitones) were assigned high ranks, in the range of 11–13. In contrast, the perfect fifth of 7 semitones, which is typically ranked highly by normal-hearing individuals, was assigned one of the lowest ranks in this case (2.5). Other consonant intervals, such as the minor third (3 semitones) and major third (4 semitones), also received relatively low ranks (4 and 2.5 respectively), whereas the minor sixth (8 semitones) and major sixth (9 semitones) were ranked more favorably (10 and 6 respectively).

Interestingly, D intervals were rated more pleasant by this CI user compared to normal-hearing listeners. For example, the minor second (1 semitone) is usually ranked as the most unpleasant by normal-hearing individuals, but was placed near the top of the scale at rank 9, while the major second (2 semitones) received a mid-range rank of 5. The most unpleasant interval for the CI user was the minor seventh (10 semitones), which was assigned the lowest rank (1). By way of contrast, among normal-hearing individuals, the major seventh (11 semitones) and the minor second (1 semitone) are typically ranked as the least pleasant intervals.

In **Figure 3**, scores of PC and D that differ significantly from those of normal-hearing individuals (defined as a difference of more than 5 in rank) are highlighted. Orange arrows indicate intervals that were rank significantly higher, and red arrows indicate intervals that received significantly lower rankings.

Discussion

The results of musical interval perception in normal-hearing individuals, as presented in this study, are largely consistent with earlier literature findings [15,16]. They reveal a relatively fixed pattern in the perception of both consonant and dissonant intervals. The smaller variability in judgments observed in the case of the normal-hearing individual with musical training may be attributed to their musical experience and prior ear training. It can be assumed that in the case of musicians, their interval evaluations may be influenced by their personal preferences, not just perceptual differences. The literature indicates that the ability to discriminate and evaluate harmonic intervals improves with musical training. Individuals with such experience demonstrate greater precision in identifying intervals and heightened sensitivity to subtle differences in intonation [15]. In contrast, individuals without musical training tend to rely more on general acoustic properties than on tonal relationships. Interestingly, in this case, the musician ranked the tritone higher (by 4 ranks), which could be because musicians tend to favor tritones more than non-musicians due to their tonal instability and resolution-seeking quality.

The case of the CI user described here shows major deviations in the perception of harmonic intervals compared to the other two normal-hearing individuals. These differences may result from a combination of factors. Technological limitations of the CI – particularly its reduced spectral and temporal resolution – are likely contributors. Additionally, individual-specific factors such as age at implantation, the quality of the electrode–neuron interface, electrode array length and its placement within the cochlea, and neuroplasticity should also be considered [17, 18]. To the authors' knowledge, there is no clear position in the literature as to whether CI users are able to unequivocally perceive dissonance and consonance for harmonic intervals using electric hearing. Brockmeier et al. [19] reported that CI users were able to discriminate musical chords, but discrimination was worse than in normal-hearing listeners. CI users ($n = 31$) and normal-hearing listeners ($n = 67$) had significantly different scores for discrimination of pitch, melody, and chords and for detection and identification of instruments, although no significant differences were observed in scores for the subtests of rhythm discrimination, dissonance evaluation, and emotion evaluation [19]. In contrast, Knobloch et al. [18] reported that CI users were able to discriminate chords, and their preference ratings of selected isolated chords were generally similar to those of normal-hearing listeners. Surprisingly, for the single CI user in this study, the consonant interval of the perfect fifth was ranked very low. We can only speculate that the pleasantness of particular musical intervals perceived through a CI is related to many factors, among which the health of the cochlear nerve (i.e., the survival of neural elements) at the site of excitation, as well as interactions between stimulated electrodes due to the spread of electric current, could play a major role.

In their work, Spitzer et al. [6] assessed the perceived dissonance of harmonic intervals in individuals with single-sided deafness (SSD) who had received a CI ($n = 11$). The study compared subjective pleasantness ratings for intervals presented to the CI ear alone (CI-only listening), the normal-hearing ear (NH-only listening), and both ears simultaneously (NH + CI listening). When listening with the NH ear only, intervals such as the minor second, major second, and major seventh were rated as the least pleasant, whereas the major third, perfect fifth, and octave were rated as the most pleasant. In the CI-only condition, the ratings differed from those of the NH ear and exhibited less variation in pleasantness, resulting in a flatter pattern of responses. Ratings obtained in the NH + CI condition were similar to those from NH-only listening. The authors observed notable asymmetry in interval ratings between ears within individual participants, and only a few showed correlations between their NH-only and CI-only ratings. However, at the group level, mean ratings were highly correlated between NH-only and CI-only conditions ($r = 0.85$, $p < 0.001$), suggesting that relative dissonance was similarly perceived across acoustic and electric hearing. In the present study, the pattern of pleasantness rankings for different intervals under CI-only listening conditions differed noticeably from that observed in individuals with normal hearing. A direct comparison between the current findings and those of Spitzer is limited by significant methodological differences – specifically, the current study employed ordinal pleasantness rankings, whereas Spitzer's work used pleasantness ratings on an analog scale.

Nevertheless, a tentative comparison is possible by relating the ranking patterns from the current study to the *z*-score–normalized rating patterns reported by Spitzer. This approximation reveals some similarities. For example, in Spitzer's study of electric hearing (CI-only), the major third (4 semitones) received a notably lower rank and lower rating compared to acoustic hearing conditions, an outcome similar to the NH ear of the SSD patients and to our cases 1 and 2.

When considering hearing under acoustic-only conditions, there also appears to be consistency between our studies and those of Spitzer: despite the differing methodologies, dissonant intervals were consistently judged as less pleasant by normal-hearing individuals, both in the ranking-based method used here and the rating-based approach of Spitzer. Yet this similarity did not extend to electric hearing. In our work, the CI user unexpectedly ranked dissonant intervals – the minor second (1 semitone) and the major seventh (11 semitones) – as relatively pleasant. In contrast, Spitzer found that dissonant intervals were rated as unpleasant in both electric and acoustic hearing, suggesting that perception of dissonance under CI stimulation in their SSD cohort more closely resembled normal-hearing patterns. To truly understand whether musical interval perception is more or less the same under electric and acoustic conditions – or whether it differs entirely or depends upon the individual – further research with larger cohorts is necessary. It may be possible to identify specific factors about CI use – such as speech processor settings – that influence musical perception, potentially making it possible to optimize them for better musical appreciation.

An additional aim of our study was to evaluate the test procedure based on pair comparisons. The results appear promising and suggest that this tool may provide a valuable complementary assessment, alongside traditional speech-based tests, to gauge the benefits of cochlear implantation. It may also provide a useful measure for evaluating the effectiveness of post-implantation rehabilitation, including music-based listening training and music therapy interventions. We plan to expand the study to three larger groups: those with normal-hearing but no musical education, professional musicians with normal hearing, and individuals with CIs.

Conclusions

The pattern of musical interval perception observed in the two normal-hearing participants in this study is consistent with patterns previously reported in the literature. The results of the musically experienced individual were characterised by smaller variability in pleasantness rankings, a finding that aligns with other studies showing that musical training enhances perceptual consistency. In contrast, the perception of consonance and dissonance of our CI user deviated markedly from the pattern observed in the other normal-hearing individuals, and this highlights the need for further investigation.

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REPORT ON THE 17TH CONGRESS OF EUROPEAN FEDERATION OF AUDIOLOGY SOCIETIES (EFAS), 14–17 MAY 2025, VIENNA, AUSTRIA

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The Congress of the European Federation of Audiology Societies (EFAS) is a unique event offering opportunities to gain new knowledge, exchange experiences, and showcase research findings and achievements in audiology. It provides a platform to explore research directions and address patient needs. From 14 to 17 May 2025, Vienna hosted the 17th Congress of EFAS. This year's congress focused on the most important and recent developments in the field of audiology.

Key topics included the impact of artificial intelligence on audiology and the growing area of telemedicine, such as telefitting, which has gained prominence post-pandemic. Other widely discussed subjects included advancements in hearing implants, results of inter-center studies, bimodal hearing, and therapeutic approaches in audiology.

The Institute of Physiology and Pathology of Hearing was represented by Piotr H. Skarzynski, Artur Lorens, Aleksandra Chodkiewicz, Emilia Czaplicka, Anna Ratuszniak, Adam Walkowiak, Katarzyna B. Cywka, and W. Wiktor Jedrzejczak.

At the opening ceremony, Prof. Georg Sprinzl welcomed all participants and outlined the congress's themes. Workshops were also held on the first day, covering topics such as auditory processing disorders and screening tests for children in primary schools.

On the second day, Prof. Piotr H. Skarzynski chaired a panel on the treatment of partial deafness, during which Prof. Artur Lorens and Dr. Adam Walkowiak presented their work. The findings from various research centers garnered significant interest, as did the possibilities of processor fitting for partial deafness and the role of steroids in preserving residual hearing. The panel involved interactive discussion, encouraging the chair and attendees to ask questions.

In a subsequent session, Prof. Piotr H. Skarzynski presented his work on *Outcomes of cochlear implantation in patients with far-advanced otosclerosis who had previously undergone stapes surgery*. This attracted considerable interest due to the complex nature of the condition and the large cohort of patients involved.

In a session on artificial intelligence, Prof. W. Wiktor Jedrzejczak presented his work, *ChatBot AI in audiology*, discussing the potential applications of ChatBot technology in modern audiology. Prof. Artur Lorens delivered a presentation on *Cochlear implantation in children with single-sided deafness*, demonstrating the benefits of cochlear implants for children with congenital and acquired SSD.

Dr. Kelley Graydon presented a study, *Does early conductive hearing loss impact longer-term listening ability?* Her research examined a group of children with a history of otitis media and associated hearing loss. At the time of the study, all children had normal hearing test results. However, the findings revealed a correlation between conductive hearing loss and deficits in listening skills, highlighting the need for early intervention in children with conductive hearing loss and the importance of screening programs to aid diagnosis. In a session on objective hearing measurements, Dr. Adam Walkowiak presented his study *Does impeded biomechanics influence cochlear implant hearing preservation?*

Participants in the panel discussion *Partial deafness treatment with EAS*. From left: Andro Košec, Andreas Büchner, Astrid Magele, Silke Helbig, Adam Walkowiak, Artur Lorens, Piotr H. Skarzynski

Aleksandra Chodkiewicz gave two presentations: *Normative values for tests of auditory processing disorders in children aged 6 to 12*, which garnered significant interest due to the large number of patients studied, and *Hyperbaric oxygen therapy as an adjunct to glucocorticosteroids treatment for sudden sensorineural hearing loss*. This work sparked a discussion on the necessity of adopting unified criteria for the treatment and rehabilitation of patients with sudden hearing loss.

In the session on *Screening and diagnostics*, Dr. Jorge Burdiles-Aguirre shared the results of hearing screenings conducted among primary school students in Chile. She emphasized the critical need for screening in this group due to the lack of regulations and the high prevalence of hearing loss identified during pilot studies.

During the session on hearing implants, Emilia Czaplicka presented an intriguing case involving a patient with Treacher–Collins syndrome who was fitted with a bone conduction implant. Given the rarity of using bone conduction implants in such patients, her presentation captured the attention of participants, who asked numerous questions.

On the third day, Dr. Anna Ratuszniak presented her study on *Improving hearing performance in middle ear implant users: a comparison of the Samba2 and previous Vibrant Soundbridge audio processors*. Her findings showed that the use of the new Vibrant Soundbridge (VSB) processor significantly enhanced audiological outcomes and patient functioning. In the same session, Emilia Czaplicka presented the results of using bone conduction implants in patients with single-sided deafness, highlighting the importance of these devices for patients unable to use traditional CROS systems or cochlear implants due to anatomical abnormalities.

Dr. Jocelyn Phillips delivered an engaging presentation on *Barriers and facilitators to teleaudiology infant diagnostic testing*. She emphasized the need to develop remote diagnostic models to identify hearing disorders in newborns during pandemics and the need to access diagnostic services.

In the *Hearing implants* session, Aleksandra Chodkiewicz shared results on the cochlear implantation in young children with profound hearing loss and congenital CMV infection. She underlined the significance of treating hearing loss in this group due to the additional burdens these patients face, which complicate daily functioning. In the same session, Prof. Artur Lorens presented his study, *Subjective benefit after cochlear implantation in different groups of patients*. Using data from the APHAB questionnaire, he demonstrated that cochlear implants improve the quality of life and functioning across various groups of patients with different types and degrees of hearing loss.

On the final day, Dr. Adam Walkowiak presented his preliminary study on *The impact of stimulus burst duration on electrically evoked stapedius reflex thresholds in pediatric CI users*. He highlighted the importance of these measurements in optimizing CI fittings, especially for patients whose behavioral responses are unreliable.

The closing ceremony was conducted by Prof. Vinay Swarnalatha Nagraj, president of EFAS. He thanked all panelists and participants for their presentations and active engagement throughout the congress.

The next EFAS congress will take place June 2–5, 2027, in Odense, Denmark.

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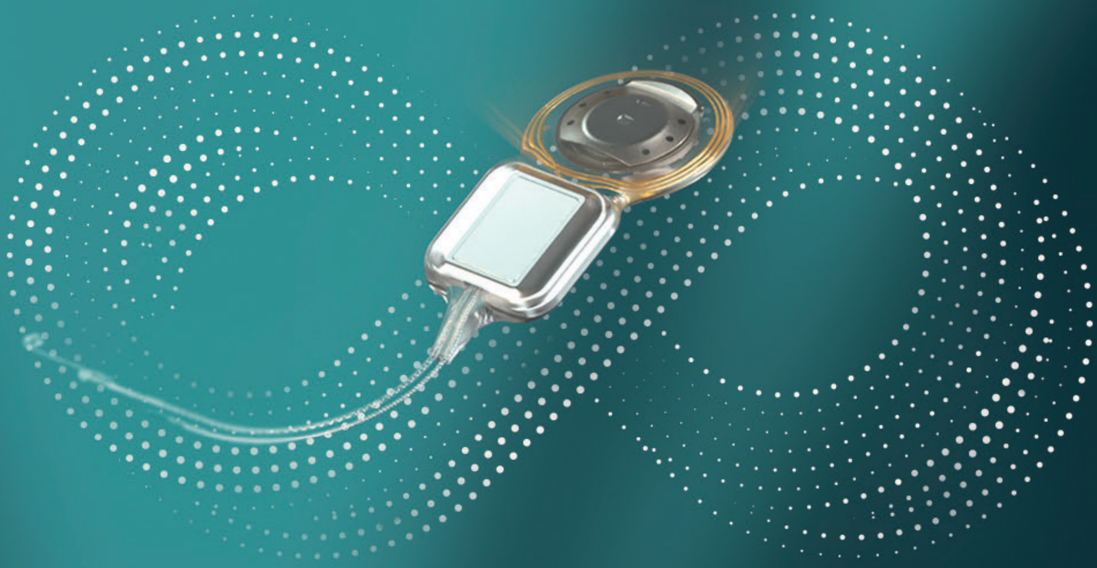

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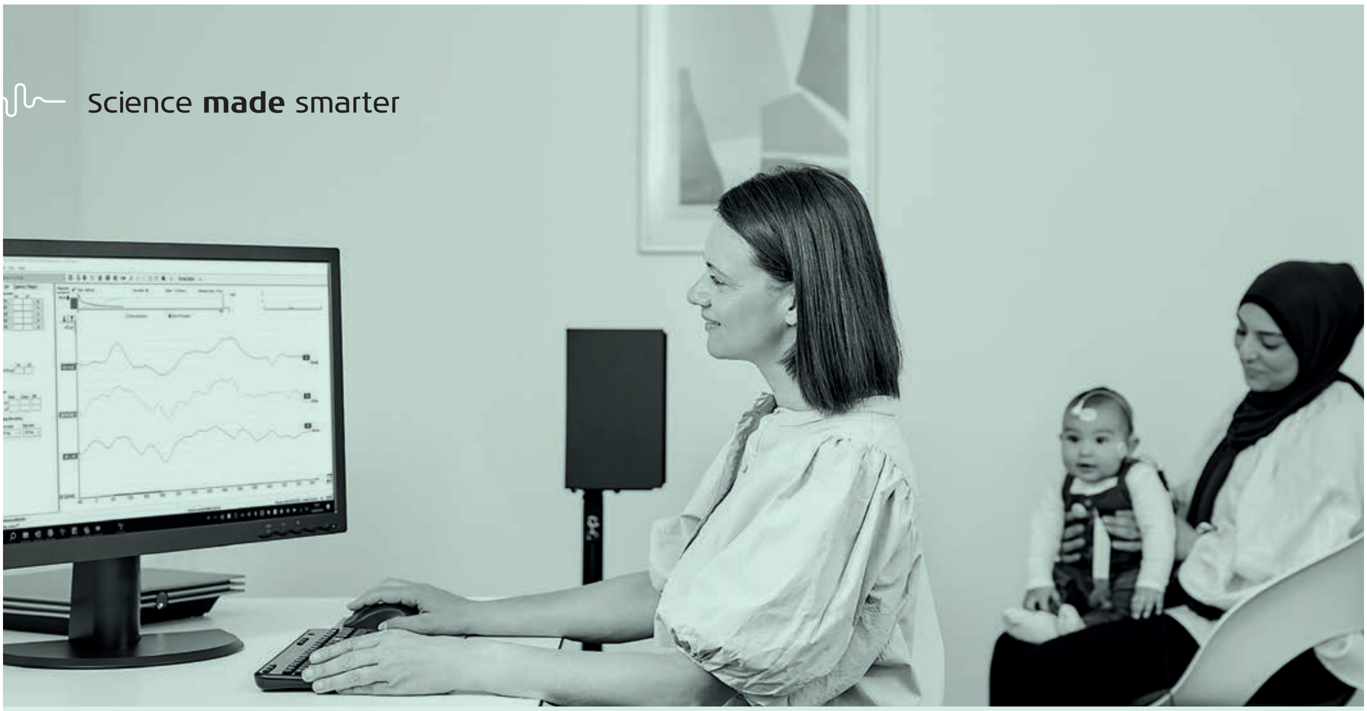

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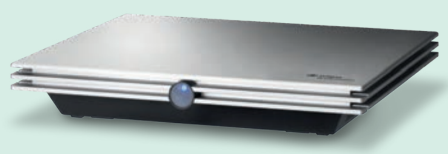

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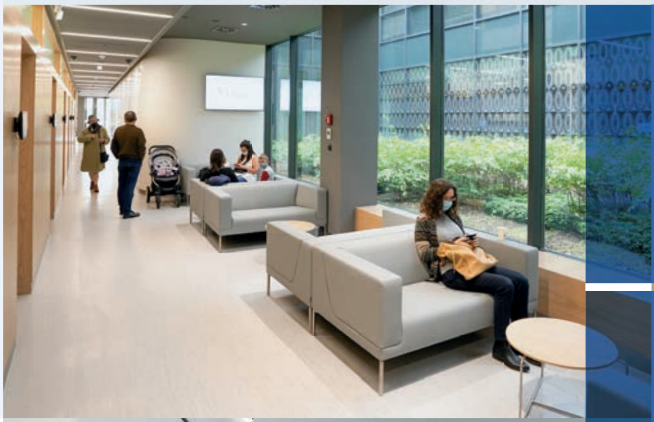

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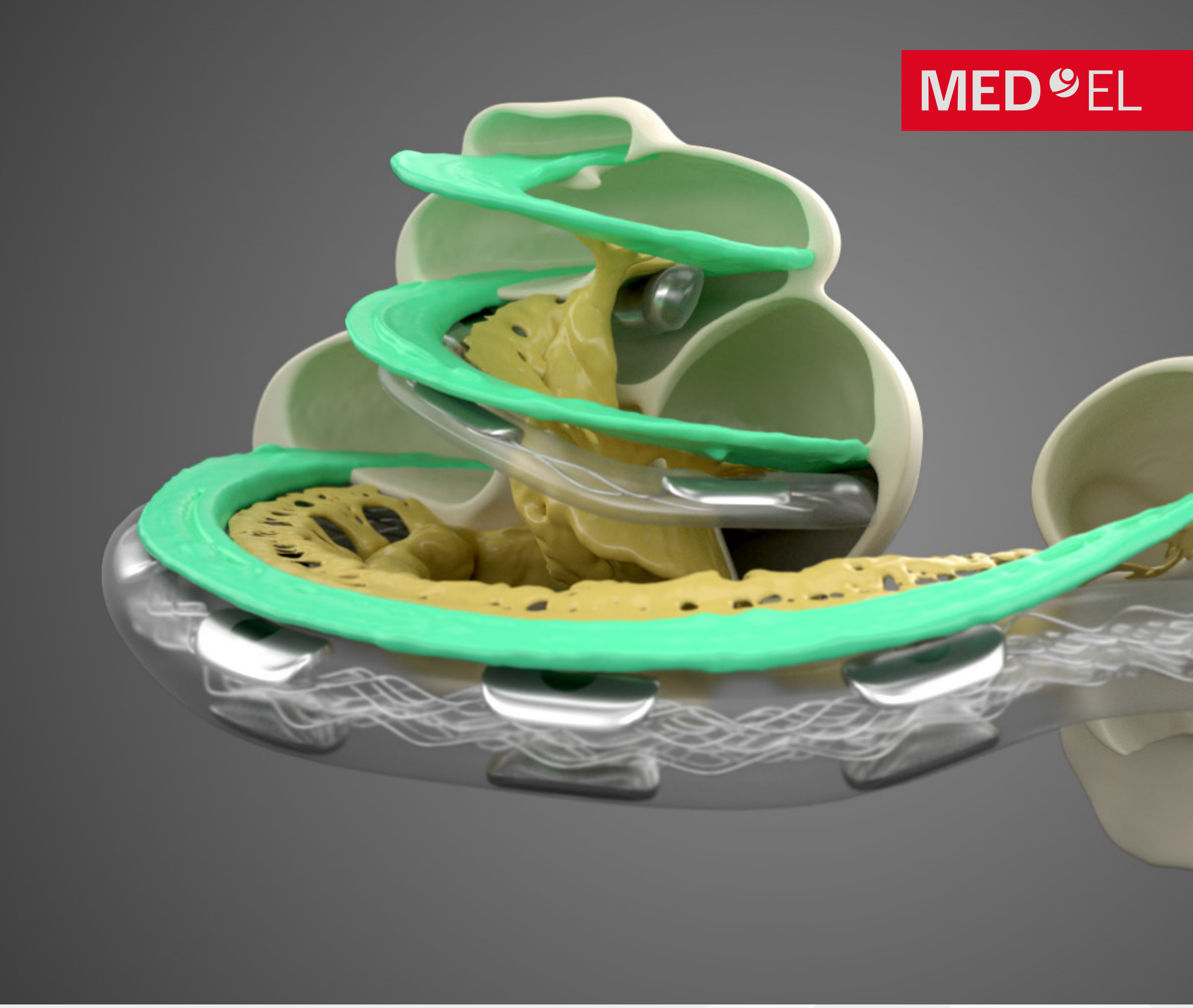

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STIMULATOR OF THE POLYMODAL SENSORY PERCEPTION (SPPS-S) by Skarzynski method

helps children with various groups of disorders that coexist with the auditory processing disorders, such as:

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- difficulties in reading and writing,
- stuttering,
- voice disorders.

SPPS-S combines auditory stimulation with psychological training.

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- It influences improvement of concentration, coordination and integration different senses.

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Hearing is the main sense stimulated with the help of the SPPS. The method is based on the improvement and integration of auditory perception with other senses.

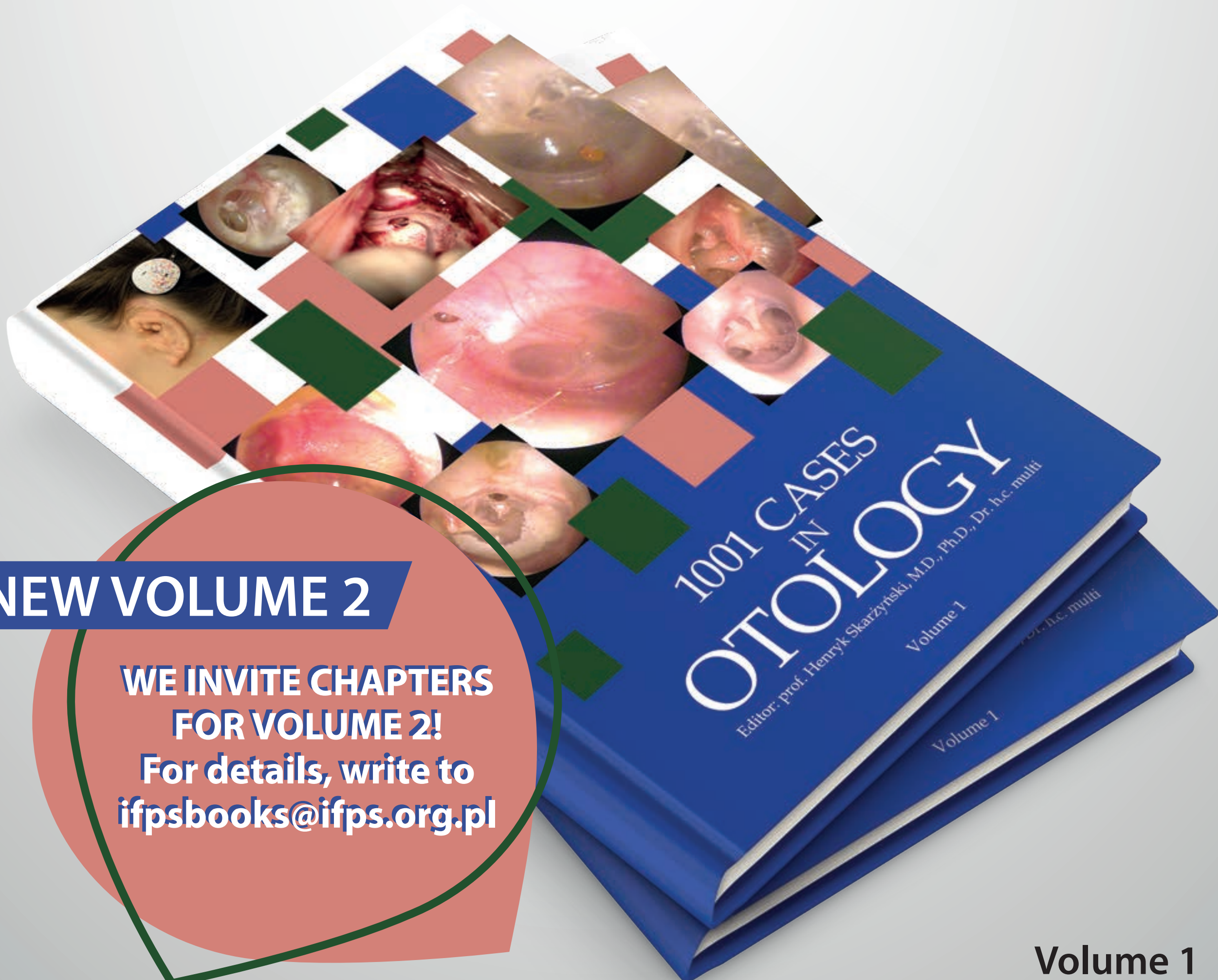
Vision is one of the senses which is additionally stimulated with the help of the SPPS. Visual perception enables to recognize reality just as hearing does. The sessions on multimedia iPad panel enable the development of coordination and integration with other senses.

Touch is another sense which is stimulated with the help of the SPPS. The use of this sense in exercises emphasizes polysensory impact in this method.

1001 Cases in Otology

Editor: prof. Henryk Skarżyński, M.D., Ph.D., Dr. h.c. multi

A unique compendium of cases in otology described by prominent doctors – practitioners and specialists who on everyday basis deal with hearing impairments in the Wold Hearing Centre in Kajetany and in other leading ontological clinics and otosurgical centres in the world. This manual contains among others a detailed presentation of outer, middle and inner ear abnormalities, guidelines for their treatment and obtained results. It is an invaluable source of practical knowledge for all doctors and specialists who, relaying on prominent experts' experience, want to improve their skills in the treatment of hearing disorders.



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Journal of Hearing Science®

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WORLD HEARING CENTER

OF THE INSTITUTE OF PHYSIOLOGY AND PATHOLOGY OF HEARING

The World Hearing Center is a modern specialized hospital providing medical care at the highest quality level in the fields of otolaryngology, audiology, phoniatrics, rehabilitation and biomedical engineering. It is superbly equipped for research and education, and includes modern conference facilities. The Center conducts a wide range of research and educational activities addressed to specialists from Poland and other countries. The Center is one of the leading medical institutions in the field of hearing disorders treatment, running, among others, one of the largest hearing implant programs in the world and performing 15,000 to 21,000 surgical procedures yearly.

The Center provides its patients with comprehensive diagnostics, conservative treatments, and surgery for the rehabilitation of:

- congenital and acquired malformations of the external, middle and inner ear,
- hearing, speech and balance disorders of different etiologies,
- disorders of the mouth cavity, throat and larynx,
- disorders of the nose and paranasal sinuses,
- sleep disorders.

World Hearing Center:

- is a global leader in terms of the number of performed otorhinolaryngological surgeries and the number of outpatient consultations (more than 200,000 consultations per year),
- is the place where unique and highly specialized medical procedures are performed, including reconstruction surgeries of congenital defects of the outer ear, treatment of profound and partial deafness with various hearing implants, phonosurgeries, endoscopic sinus surgeries under image guidance, and many others,
- employs a team of highly qualified and experienced specialists,
- has state-of-the-art medical equipment and instrumentation,
- offers comfortable conditions for hospital stays,
- uses the most modern telemedical solutions providing remote consultations via the world-first National Network of Teleaudiology.

The team of the Institute of Physiology and Pathology of Hearing and its individual employees are winners of numerous international and national awards.

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