

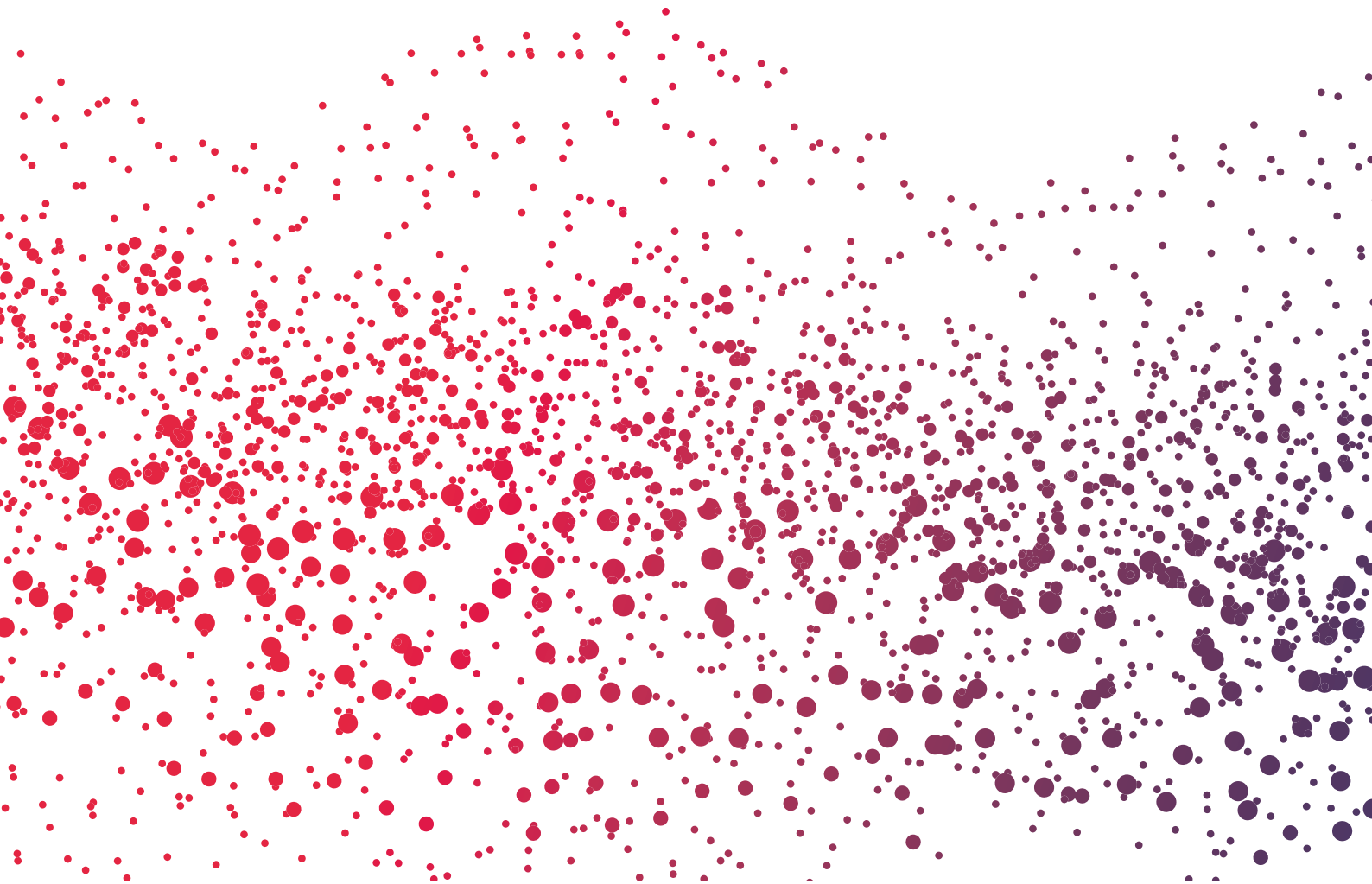
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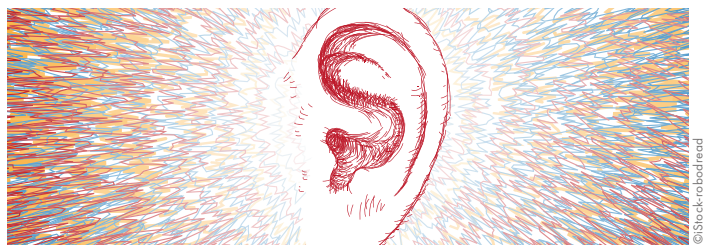


Hearing intervention versus health education control to reduce cognitive decline in older adults with hearing loss in the USA (ACHIEVE)

Web- and app-based tools for remote hearing assessment: a scoping review

Association between Cannabis Use and Tinnitus in US Adults

- 63 HEARING INTERVENTION VERSUS HEALTH EDUCATION CONTROL TO REDUCE COGNITIVE DECLINE IN OLDER ADULTS WITH HEARING LOSS IN THE USA (ACHIEVE): A MULTICENTRE, RANDOMISED CONTROLLED TRIAL.**
Lin FR., Pike JR., Albert MS., et al.
Lancet (2023); 402(10404), 786–797
doi: 10.1016/S0140-6736(23)01406-X.
- 66 SEX-SPECIFIC INTERACTIONS BETWEEN HEARING AND MEMORY IN OLDER ADULTS WITH MILD COGNITIVE IMPAIRMENT: FINDINGS FROM THE COMPASS-ND STUDY.**
Al-Yawer F., Pichora-Fuller MK., Wittich W., et al.
Ear Hear (2023); 44(4), 751–767 – doi: 10.1097/AUD.0000000000001322.
- 67 COMPARISON OF INTRATYMPANIC STEROID AND HYPERBARIC OXYGEN SALVAGE THERAPY HEARING OUTCOMES IN IDIOPATHIC SUDDEN SENSORINEURAL HEARING LOSS: A RETROSPECTIVE STUDY.**
Ajduk J., Peček M., Kelava I., et al.
Ear Hear (2023); 44(4), 894–899 – doi: 10.1097/AUD.0000000000001338.
- 69 “WE FORGET ABOUT PEOPLES’ HEARING LOSS”: IDENTIFYING KEY ASPECTS OF HEARING AID AND COMMUNICATION TRAINING IN RESIDENTIAL CARE HOMES.**
McShea L. & Ferguson M.
Int J Audiol (2023); 62(7), 667–674
doi: 10.1080/14992027.2022.2056720.
- 70 WEB- AND APP-BASED TOOLS FOR REMOTE HEARING ASSESSMENT: A SCOPING REVIEW.**
Almufarrij I., Dillon H., Dawes P., et al.
Int J Audiol (2023); 62(8), 699–712
doi: 10.1080/14992027.2022.2075798.
- 71 IS COVID-19 TO BLAME FOR SENSORINEURAL HEARING DETERIORATION? A PRE/POST COVID-19 HEARING EVALUATION STUDY.**
Taitelbaum-Swead R., Pinhas A., Cohen Tsemah S., et al.
Laryngoscope (2023); 133(8), 1976–1981 – doi: 10.1002/lary.30400.
- 73 TINNITUS FOOTPRINTS IN THE COCHLEA.**
Oliveira CA, Kehrle HM, Granjeiro RC et al.
The International Tinnitus Journal. 2023;27(1):54–57
doi: 10.5935/0946-5448.20230009
- 74 ASSOCIATION BETWEEN CANNABIS USE AND TINNITUS IN US ADULTS.**
Reyes Orozco F., Lin M., Clark B., et al.
Otol Neurotol (2023); 44(6), 611–618
doi: 10.1097/MAO.0000000000003895. Epub 2023 May 31. PMID: 37254263.
- 76 HEALTH INSURANCE COVERAGE OF COCHLEAR IMPLANTATION IN SINGLE-SIDED DEAFNESS AND ASYMMETRIC HEARING LOSS.**
Sorkin DL, Adunka OF, Westin N., et al.
Otol Neurotol (2023); 44(8), e628–e634
doi: 10.1097/MAO.0000000000003969
- 78 EVALUATION OF DEEP MARGINAL FEEDBACK CANCELLATION FOR HEARING AIDS USING SPEECH AND MUSIC.**
Zheng C., Xu C., Wang M., Li X., et al.
Trends in Hearing (2023); 27, 23312165231192290
doi: 10.1177/23312165231192290.
- 79 DIAGNOSING NOISE-INDUCED HEARING LOSS SUSTAINED DURING MILITARY SERVICE USING DEEP NEURAL NETWORKS.**
Moore BCJ. & Schlittenlacher J.
Trends in Hearing (2023); 27 – doi: 10.1177/23312165231184982



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Dear Reader, the Amplifon Centre for Research and Studies, CRS, houses one of the finest private libraries in the field of audiology and otorhinolaryngology, offering the sector’s most important international journals. Every quarter, a team of Amplifon Audiologists from around the globe select the most relevant publications in the field of Otolology and Audiology and make a comprehensive review. The Amplifon Centre for Research and Studies coordinates the development of this quarterly review. We are happy to share these new reviews with you. For this issue, our team reviewed 11 interesting articles published in the third quarter of 2023. This issue opens with two articles on the relation between hearing and cognition. The first article focuses on the ACHIEVE study, which is the first interventional longitudinal study, investigating the influence of hearing aid usage on cognitive decline in comparison to a control group, showing a significant 48% reduction in cognitive decline for the intervention group with higher risk of cognitive decline. The second article sheds light on sex-specific interactions between hearing and memory in older adults experiencing Mild Cognitive Impairment. This journal also features a retrospective study comparing the outcomes of Intratympanic Steroid and Hyperbaric Oxygen Salvage Therapy for sudden hearing loss. Additionally, an article on the key aspects of hearing aid and communication training in residential care homes emphasizes the importance of involving significant others and caregivers in the hearing rehabilitation process for each customer. COVID-19 has posed a number of challenges in the audiological world. It has led to a surge in the use of online tools in hearing care. However, a scoping review of remote web and app-based tests concludes, that the quality ranged in the poor to good range, often leading to misleading results. Furthermore, a Pre/Post Hearing Evaluation Study found that, when controlling for age and the duration between pre- and post-COVID hearing tests, there was no significant deterioration in average hearing thresholds. Other articles investigate tinnitus footprints in the cochlea and the unexpected association between cannabis use and tinnitus in U.S. adults. Still in the U.S., the FDA’s expanded criteria to include cochlear implantation for single-sided deafness and asymmetric hearing loss has led to successful health insurance coverage for most adults. However, as the article explores, this was more challenging for paediatric patients. Encouragingly, 67% of clinicians managed to overturn denials through motivated appeals. This issue concludes with two articles exploring the application of artificial intelligence in ear and hearing care. The first article focuses on enhancing feedback cancellation for hearing aids using speech and music, while the second aims to improve the diagnostics of Noise-Induced Hearing Loss incurred during military service. We hope you enjoy this issue of our CRS Scientific Journal

Mark Laureyns

Global International CRS & Medical Scientific Research Manager





HEARING INTERVENTION VERSUS HEALTH EDUCATION CONTROL TO REDUCE COGNITIVE DECLINE IN OLDER ADULTS WITH HEARING LOSS IN THE USA (ACHIEVE): A MULTICENTRE, RANDOMISED CONTROLLED TRIAL



Lin FR., Pike JR., Albert MS., et al.

Lancet (2023): 402(10404), 786–797

doi: 10.1016/S0140-6736(23)01406-X. Epub 2023 Jul 18.

PMID: 37478886; PMCID: PMC10529382.

By Veronica Hoffman–Italy–New Zealand

This study explores the findings of the ACHIEVE trial, the first ever published randomised controlled trial examining whether hearing intervention can reduce cognitive decline in older adults.

Compelling evidence suggests the existence of a link between hearing loss (HL) and an increased risk of dementia and cognitive decline in older adults. To date, only retrospective analyses have explored the impact of hearing intervention on cognitive outcomes. The ACHIEVE (Aging and Cognitive Health Evaluation in Elders) trial, which is the focus of this study, marks the first published randomised controlled trial examining whether hearing intervention can mitigate cognitive decline in older adults.

The trial was conducted across multiple field sites, with participants from two main populations: healthy volunteers recruited via advertisement (the ‘De novo group’); participants who were already monitored due to an increased risk for dementia due to cardiovascular problems, recruited from the Atherosclerosis Risk in Communities (the ‘ARIC group’) study. A total of 977 participants without dementia, with a mean age of 76.8 (range: 70 to 84 years), were recruited based on the following inclusion criteria: the presence of mild-to-moderate hearing impairment of 30–70 dBHL as assessed by four-frequency PTA average of 0.5–4 kHz; word recognition of at least 60% in the better ear; being fluent in English; and residing in the community. Exclusion criteria were: previous hearing aid (HA) use in the last year; poor vision; self-reported disability in more than two daily tasks; permanent conductive hearing loss (HL) and refusal to wear HAs on a regular basis. Participants were randomly assigned on a 1:1 ratio to one of two groups: best-practice hearing intervention (HAs and audiological care); or the health education control group. Given the nature of the intervention participants could not

CRITICAL NOTE

This landmark study investigates the correlation between hearing loss intervention and cognitive decline in older adults. In this randomised control trial, individuals at higher risk of cognitive decline demonstrated a significant 48% reduction in cognitive decline in global cognition and language domains compared with those given education but no hearing aids. It is important to note that for executive function and memory domains the difference was not statistically significant. It will be interesting to see whether any differences emerge in the overall study population at the conclusion of this six-year study considering the slow rate of cognitive change observed so far in low-risk individuals.

be blinded to wearing hearing devices, however, a number of steps were taken to minimise bias such as not providing access to previous study visit results.

Participants in the hearing intervention group received bilateral HAs fitted to NAL-NL2 prescriptive targets, with real ear measurement. Additional hearing assistive technology was supplied as required. Participants from this group attended four one-hour sessions with a study audiologist. During these sessions they received instructions on how to use the devices as well as on communication strategies. Additionally, every six months they attended a “booster” session to review these instructions. Patients from the control group underwent an individual “10 Keys to Healthy

Ageing” programme with a certified health educator, with four sessions over a one to three-week period. This group also received booster sessions every six months.

Between March 2020 and June 2021 due to the COVID-19 pandemic, sessions were conducted remotely via phone with protocols adapted as necessary.

Outcome Measures

	Baseline	Frequency of follow up
Comprehensive neurocognitive assessment	Yes	Annually
Mini Mental State Examination (MMSE)	Yes	6 monthly
Hearing Handicap Inventory for Elderly – Screening (HHIS)	Yes	Annually
Brain MRI Scan (50% cohort)	Yes	3 year mark

Additional measures of social, physical and mental wellbeing were also measured at baseline and then annually, the outcomes of these will be reported in future analyses.

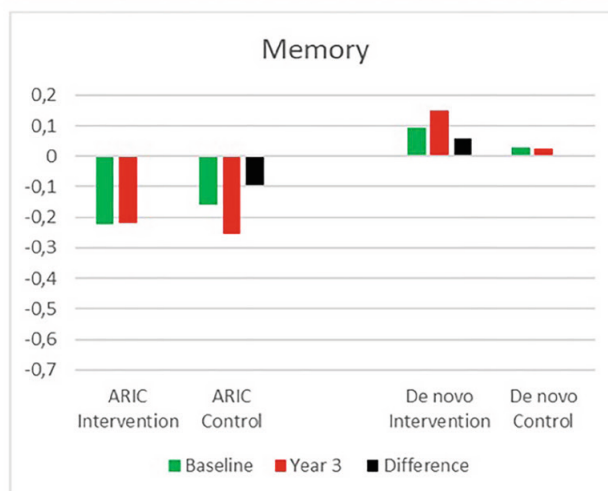
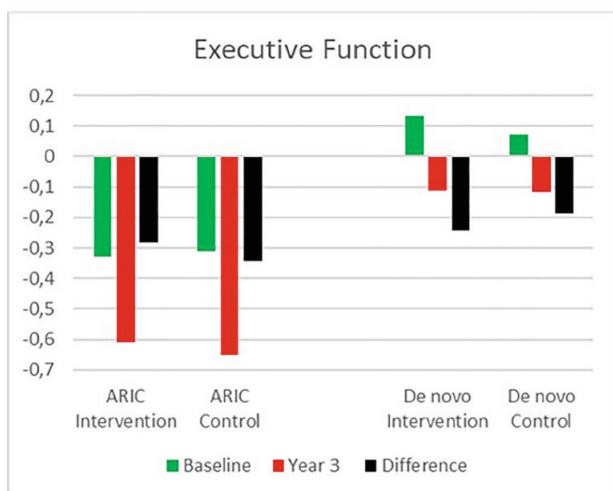
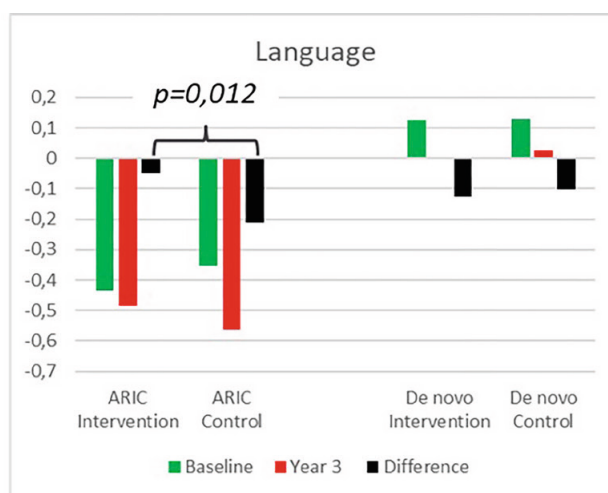
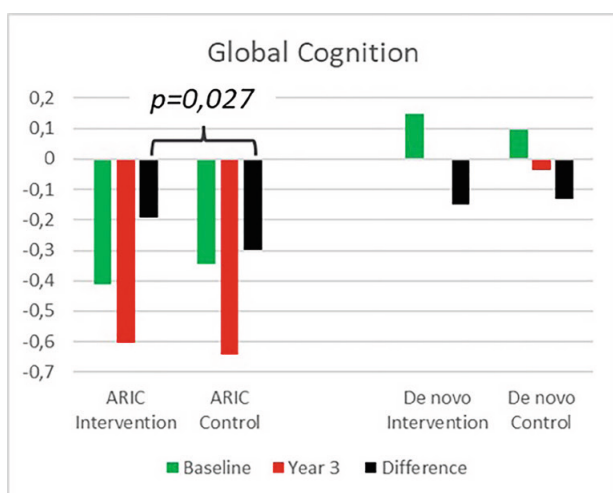
Baseline differences were observed between the De Novo and ARIC cohorts. Patients from the latter were typically older, female, had lower levels of education and income, higher rates of other diseases, lower perceived hearing

problems, slightly lower MMSE scores and lower baseline scores in global cognition.

Results

Target adherence to both hearing intervention and health education was achieved. Only 2% of participants from the hearing intervention group stopped wearing their HAs, whereas 16% assigned to the health education sessions opted to obtain HAs themselves outside of the study. No significant adverse events were reported in either group. The primary analysis, which assessed cognitive changes between the hearing intervention and health education control group did not reveal any statistically significant differences as measured by change in standard deviation (SD) units over the three years.

However, three-year cognitive change in participants from the ARIC group (higher risk of cognitive decline) assigned to hearing intervention showed a significant 48% reduction in cognitive decline as opposed to those who received education but no HAs. The protective effect was seen at statistically significant levels in both global cognition and language domains. While there were also positive differences in executive function and memory domains, these were not statistically different between the ARIC hearing intervention and control group.



For individuals at lower risk of cognitive decline (De novo group) no significant change in cognitive function was found over the three-year period between those with hearing intervention and those who received health education. It is of note that the ARIC group showed a 2.7 times greater rate of cognitive change (-0.19 SD units per year) over the three-year study period as compared to the De novo group (-0.04 SD units per year). This very slow rate of decline in the De novo group highlights one of the main limitations of this study: its relatively short follow-up timeframe given the nature of cognitive decline.

Those in the hearing intervention group across the whole study population reported wearing their hearing devices for a mean of 7.2 hours per day and had a reduction in HHI scores at year 3 from a mean baseline of 15.7 (mild to moderate communication impairment) to 7.8 (no communication impairment). Conversely those in the health education group demonstrated a slight increase in HHI during the study period from 14.9 to 16.2 (remained mild to moderate communication impairment).

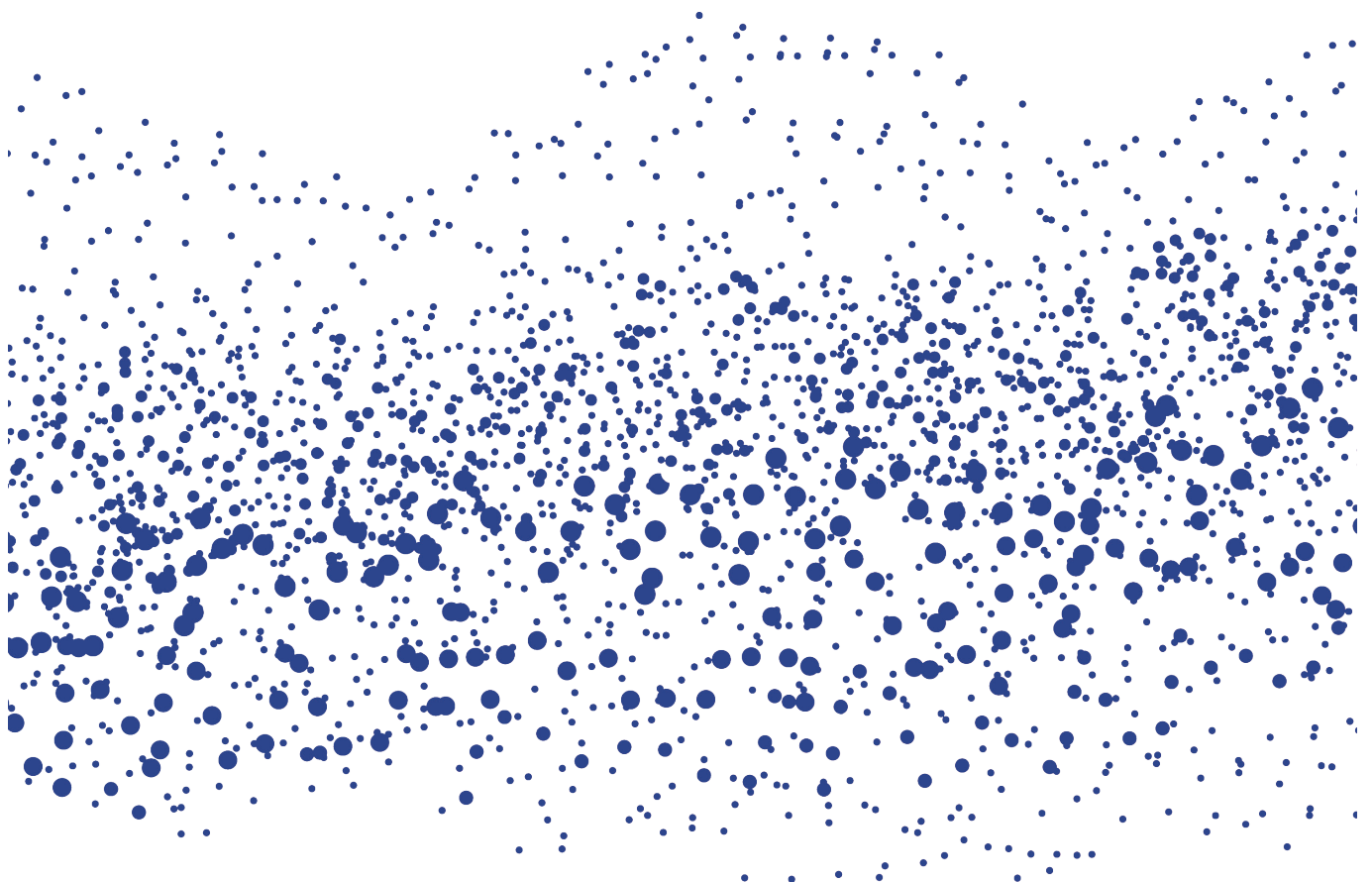
SUMMARY AND DISCUSSION

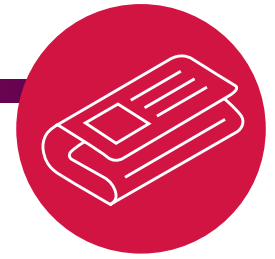
This study constitutes a significant step in our understanding of the relationship between hearing intervention and cognitive decline in older adults.

The findings reveal varying benefit levels of hearing intervention on cognition across different populations depending on their risk for cognitive decline, with those at increased risk deriving significant benefit, whereas no benefit was recorded for low dementia risk individuals during the three-year observation window. This once more underscores the limitations of the relatively short follow-up duration of the study.

Unlike many other interventions targeting dementia reduction, focusing primarily on pharmaceutical solutions, HAs are well tolerated – with an average adherence to HA use of 98% in this study – with very low to no associated risks or adverse effects. Further analysis of social, physical, mental wellbeing and brain MRI results from this study will be made available in the future. These should offer valuable insights into the broader benefits of hearing intervention in older adults beyond the primary focus of this study focusing more specifically on cognitive effects.

The information gathered over the remaining three years of this study may provide further evidence as to whether hearing intervention should be considered as a vital public health target for dementia prevention globally. •





SEX-SPECIFIC INTERACTIONS BETWEEN HEARING AND MEMORY IN OLDER ADULTS WITH MILD COGNITIVE IMPAIRMENT: FINDINGS FROM THE COMPASS-ND STUDY.



Al-Yawer F, Pichora-Fuller MK, Wittich W., et al.

Ear Hear (2023): 44(4), 751–767

doi: 10.1097/AUD.0000000000001322.

Epub 2022 Dec 29. PMID: 36607746.

By Kartik Iyer - Australia

This study highlights the complex relationship between hearing, memory, and potential gender-specific patterns within the context of Mild Cognitive Impairment.

There has been extensive research on the effects of hearing impairment and cognitive decline with ageing. However, only a handful of studies have focused on gender-based intricacies. The study under review encapsulates the central theme of the research, and highlights the complex relationship between hearing, memory, and the examination of potential gender-specific patterns within the context of Mild Cognitive Impairment (MCI).

This study, as the introduction highlights, sets out to investigate the relationship between hearing abilities and memory performance in the context of MCI, with a deliberate focus on gender-specific subtleties. The authors contextualise this line of research, underlining its significance within the broader framework of cognitive ageing research. While the introduction does outline the rationale behind the study, a more comprehensive overview of existing research in this area would have provided a stronger foundation.

Participants

- Study population: 101 individuals, aged between 60 and 85 years old, with cognitive issues and who were proficient in English or French, recruited across 20 locations in Canada.
- MCI diagnosis was established using standardised assessment tools, with impairment in at least one cognitive domain.

Exclusions:

- Individuals with brain disease, drug or alcohol issues, lack of study partner and a low score on Montreal Cognitive Assessment score were excluded.

Method:

- Data was retrieved from the COMPASS-ND (Comprehensive Assessment of Neurodegeneration and Dementia) study

CRITICAL NOTE

This article makes a substantial contribution to the comprehension of the intricate interplay between hearing and memory in older adults with MCI, with particular emphasis on potential gender-related disparities. While the methodology appears robust, improved transparency concerning the assessment tools and statistical techniques would enhance the study's methodological rigour. Furthermore, a more exhaustive exploration of the practical implications and limitations of the findings for clinical practice and future research directions would reinforce the article's impact within the realm of cognitive ageing.

- Cognitive measures were assessed using the Montreal Cognitive Assessment Scale, Rey Auditory Verbal Learning Test and Brief Visuospatial Memory Test-Revised, to explore gender-based and hearing-related highlights

- Participants were categorised into two groups – Normal Hearing (NH) and Hearing Loss (HL) – using Pure tone screening and Speech-in-noise threshold parameters on the Canadian digit triplet test (CDTT)

The use of data from the COMPASS-ND Study implies access to a sizable and presumably representative sample of older adults with MCI, enhancing the study's external validity. Nevertheless, greater transparency regarding the specific hearing and memory assessment tools employed would offer readers a clearer understanding of the measures used.

Results

- No difference across social activity, percentage of hearing impairment or use of listening devices across genders were noted.

- Minimal degree of gender-based differences across Rey Auditory Verbal Learning test (RAVLT) and Brief Visuospatial memory test (BVMTR) was found.
- Significant correlation was identified for CDTT and cognitive variables in one of the female groups (with better speech results).
- Females with HL scored lower on the Montreal Cognitive assessment scale; the NH group established significantly high cognitive measures.
- Males in the NH group demonstrated effects on visuospatial memory function.

The findings highlight the existence of sex-specific interactions between hearing and memory in older adults with MCI.

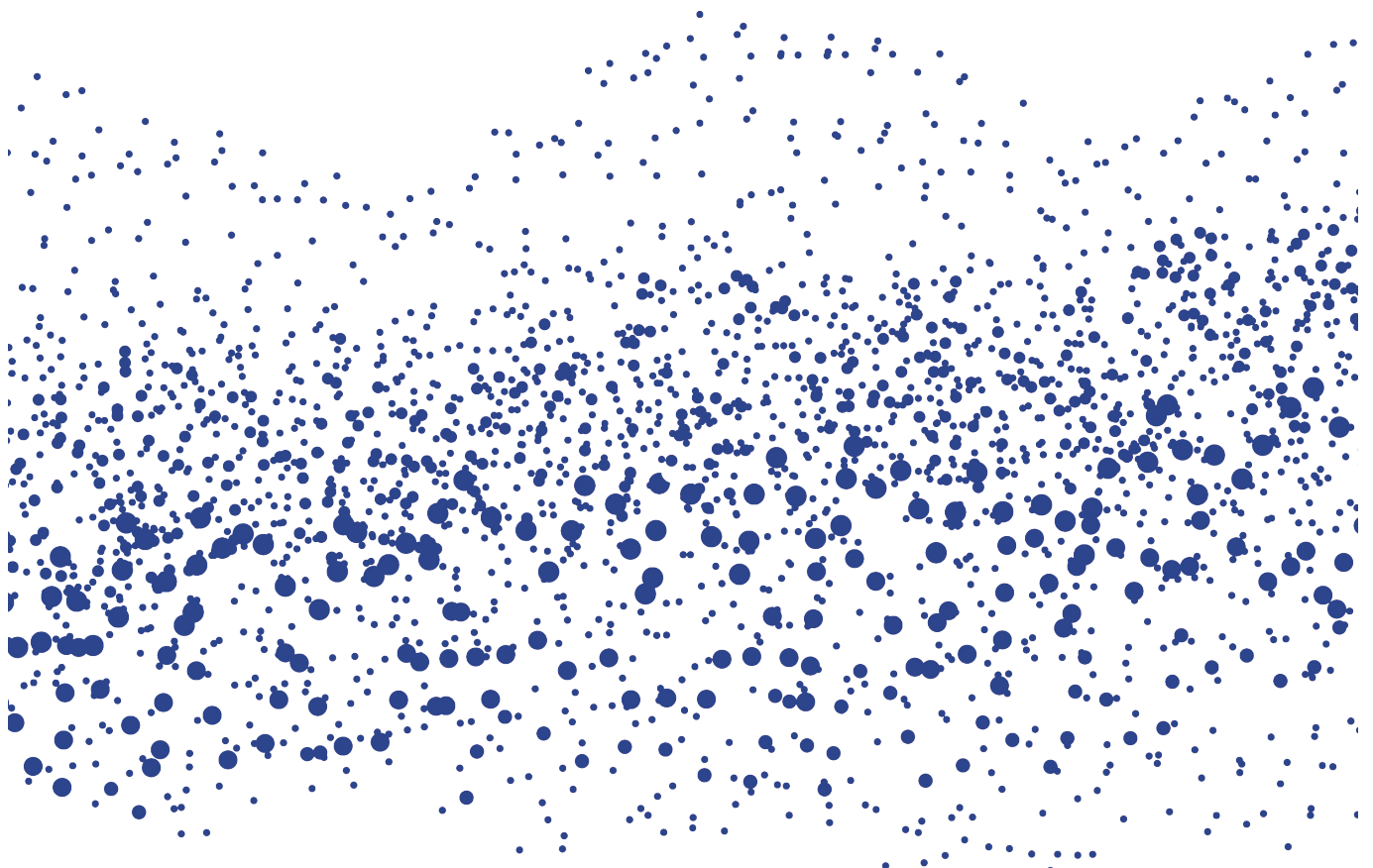
Discussion

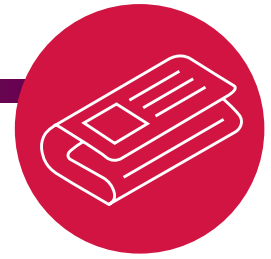
The authors present a compelling argument that hearing impairment may exert a more substantial impact on memory function in males with MCI compared to females. They provide

insightful hypotheses and potential explanations for these sex-specific interactions, including hormonal disparities and cognitive reserve. Overall, this section would benefit from a more comprehensive examination of the limitations of these hypotheses and avenues for future research. Furthermore, providing a more detailed explanation of the statistical methodologies applied, with particular attention to control variables and potential confounding factors, would enhance the analytical rigour and strengthen the interpretability of the study's findings.

Conclusion

The conclusion emphasises the necessity of considering gender-specific factors in future research and clinical interventions for individuals with MCI. Expanding on the practical implications of the research for healthcare practitioners, caregivers, and policymakers involved in the care of individuals with MCI would underscore the real-world significance of this study's findings. •





COMPARISON OF INTRATYMPANIC STEROID AND HYPERBARIC OXYGEN SALVAGE THERAPY HEARING OUTCOMES IN IDIOPATHIC SUDDEN SENSORINEURAL HEARING LOSS: A RETROSPECTIVE STUDY.



Ajduk J., Peček M., Kelava I., et al.
Ear Hear (2023); 44(4), 894–899
 doi: 10.1097/AUD.0000000000001338.
 Epub 2023 Jan 20. PMID: 36693145.
 By Melissa Babbage – New Zealand

This study aimed to compare the results of Intratympanic Steroid and Hyperbaric Oxygen Salvage Therapy in patients with SSNHL after conventional systemic steroid treatment had proven ineffective.

The most common first-line treatment for addressing sudden sensorineural hearing loss (SSNHL) is systemic steroids. While treatment protocols vary, the rate of significant hearing improvement after treatment typically averages over 60%. Nevertheless, the factors contributing to poor responses to treatment are not yet well understood. In cases where systemic steroid treatment proves ineffective, clinical guidelines recommend salvage therapy for improving hearing. This encompasses intratympanic steroids (ITS), which provides a higher steroid concentration in the perilymph than systemic steroids, and hyperbaric oxygen (HBO) therapy, which is believed to increase oxygen tension in the blood and inner ear. Previous studies into the efficacy of ITS and HBO as salvage therapy for SSNHL have yielded inconsistent results. The current study seeks to compare the outcomes of each of these therapies in patients with SSNHL who did not respond to systemic steroids.

Method

This comparative retrospective nonrandomized interventional cohort study included 134 patients who were treated for SSNHL at a tertiary referral otology centre. Primary treatment for all patients was a six-day course of intravenous steroids (methylprednisolone) followed by an additional six days of oral steroids. All patients began treatment within two weeks of SSNHL onset. Patients whose follow-up audiograms after the primary treatment showed <10 dB of cumulative improvement on three contiguous frequencies were offered salvage therapy. Each patient was presented with the choice of: ITS; HBO; or observation without further intervention. Each selected their preferred option.

CRITICAL NOTE

This article provides compelling data indicating that salvage therapy, whether involving intratympanic steroids (ITS) or hyperbaric oxygen (HBO), can effectively enhance rates of hearing recovery when systemic steroid therapy for sudden sensorineural hearing loss (SSNHL) proves ineffective. However, despite the inclusion of a control group in the study design for which patients underwent observation rather than medical treatment following primary therapy for SSNHL, the absence of data for this group makes critical comparisons difficult. Notably, the data highlighting a substantial reduction in tinnitus following ITS salvage therapy is of significant interest to clinicians and patients alike. For more robust insights, it would be valuable to replicate these comparisons within larger patient cohorts and explore the advantages and disadvantages of each treatment, whether as a salvage or a primary therapy. Such investigations will offer valuable information for clinicians in their decision-making processes.

Among the participants, 35 patients received HBO therapy (60 minutes daily for four weeks for a total of 20 sessions), and 43 patients received four ITS over 10 days. The remaining 48 patients opted to not pursue salvage therapy and therefore constituted the control group. Importantly, no statistically significant differences in terms of age, sex, and degree of hearing loss (HL) prior to secondary treatment were observed among these groups.

Puretone audiograms were performed both before and one month after beginning salvage therapy in the ITS and HBO groups. Audiograms in the control group were performed at the same time interval. The authors defined hearing recovery as a cumulative improvement >30 dB across all tested frequencies.

Results

When assessing the mean change in hearing across all frequencies (0.25–8 kHz), the ITS group exhibited a post-treatment improvement of 13.6 dB, while the HBO group showed an improvement of 7.4 dB. Notably, both treatment groups demonstrated significantly better outcomes than the control group, for which no statistically significant changes were observed after one month (specific data is not provided). The rate of hearing recovery was 60.5% in the ITS group and 42.9% in the HBO group.

Moreover, the findings highlighted that hearing improvement was positively correlated with age and negatively correlated with the severity of HL within both intervention groups. Patients reporting tinnitus prior to salvage therapy were less likely to experience substantial hearing improvements, with an average of 4.67 dB less hearing improvement. Of particular note, ITS therapy significantly reduced the incidence of tinnitus compared to the HBO and control groups.

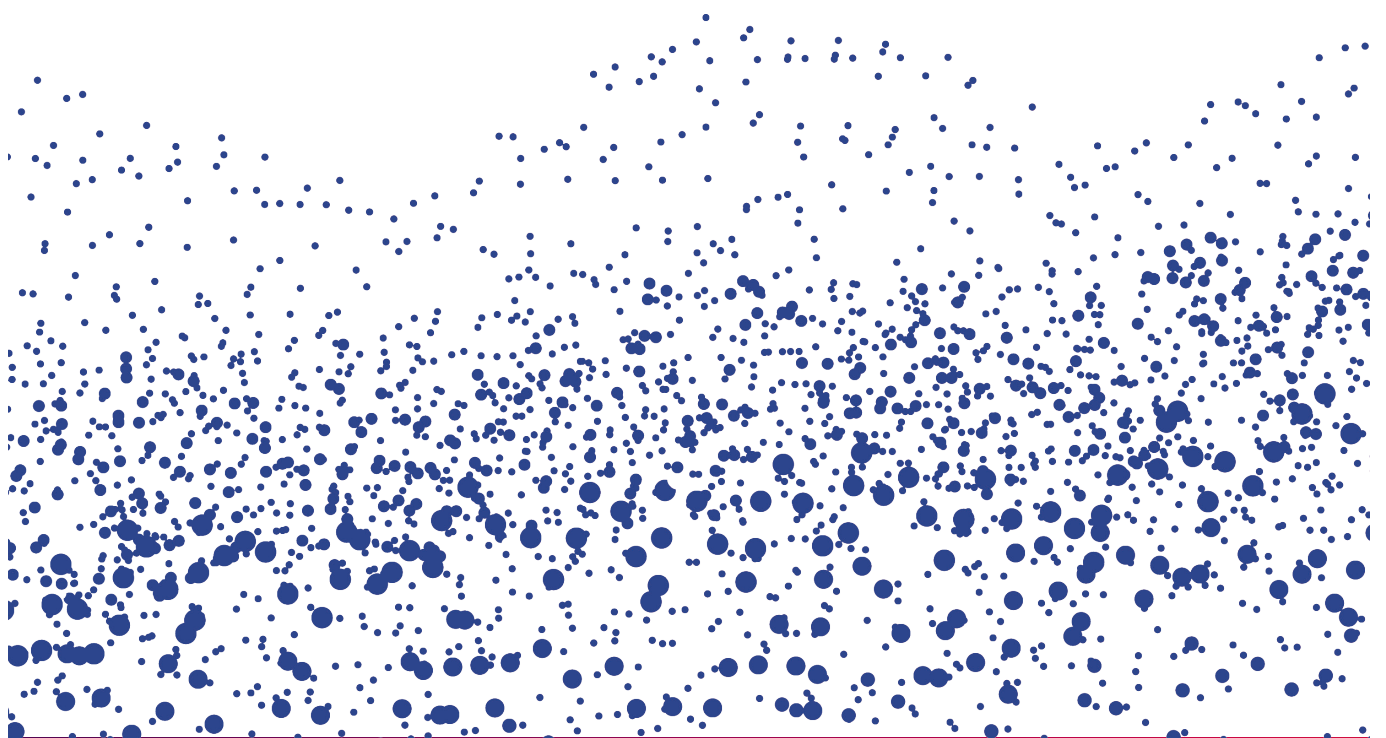
Discussion

The findings of this study suggest that both intratympanic steroids (ITS) and hyperbaric oxygen (HBO) represent viable options for salvage therapy following unsuccessful systemic steroid treatment for SSNHL. They result in higher rates

of hearing improvement compared to observation alone. Notably, the rate and degree of improvement were higher for the ITS group than the HBO group. However, as the authors themselves acknowledge, the high spontaneous recovery rate commonly associated with idiopathic SSNHL and the presence of varying treatment guidelines can complicate direct comparisons of treatment outcomes.

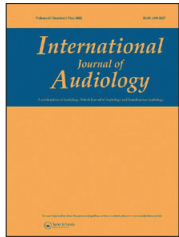
The analyses conducted in this study revealed that greater degrees of HL were associated with reduced improvement both treatment approaches, supporting previous studies. However, in contrast to previous findings, this study did identify greater post-treatment hearing improvement with increasing age. The reason for this finding remains unclear and warrants further analysis.

Patients who reported experiencing tinnitus at the outset of salvage therapy showed less favourable hearing improvement following treatment. The authors propose that this could indicate more substantial cochlear damage heralded by the presence of tinnitus. Moreover, patients with tinnitus achieved better outcomes following ITS treatment than HBO. The authors highlight it would be valuable to determine whether a similar effect persists when these treatments are administered as primary rather than salvage therapies. While the findings of this research support the idea that salvage treatment is superior over observation, the conclusions that can be extrapolated are limited by the lack of randomisation and the relatively small number of participants in each group. As the authors duly highlight, the potential for a placebo effect or spontaneous recovery could not be ruled out completely. •





“WE FORGET ABOUT PEOPLES’ HEARING LOSS”: IDENTIFYING KEY ASPECTS OF HEARING AID AND COMMUNICATION TRAINING IN RESIDENTIAL CARE HOMES.



McShea L. & Ferguson M.
Int J Audiol (2023): 62(7), 667–674
 doi: 10.1080/14992027.2022.2056720.
 Epub 2022 Apr 18. PMID: 35436162.
 By Tali Bar-Moshe – Israel

This study set out to investigate the applicability of an e-learning programme for the implementation of a cascading training initiative designed for Sense support workers, focusing on hearing aid-related communication and care challenges. The objective was twofold: to assess whether trainees could, in turn, train other support workers within the organisation; and to identify critical elements in this training programme.

The study outlined in this article was initiated following the identification of the crucial need to train support workers about hearing aids (HA) and communication strategies by the Practical Development Team of Sense, a UK charity for people with complex disabilities and/or dual sensory impairment. A “support worker” here is understood as an employee responsible for providing care and support to adults with disabilities in residential services.

Objectives:

1. To evaluate the relevance of the “Hearing Champion Training” (HCT) and the “C2Hear” e-learning programme for training a group of Sense support workers («Sense Hearing Champions» – SHC) about HAs.
2. To assess the possibility of using these SHC in cascading training to other support workers within the organisation.
3. To identify the critical elements of the HCT and C2Hear programmes that are integral to the cascading training.

Participants:

The SHC group comprised 14 support workers (11 females and three males), all holding managerial positions within Sense residential services in the UK or Northern Ireland.

Questionnaires:

All SHC participants were required to complete two questionnaires—Hearing Aid Confidence and Hearing Aid and Communication Knowledge—at three stages of the study: pre-training; immediately post-training; and three to six months post-training.

Training event:

All SHC participants joined a half-day face-to-face training event that included a two-hour HCT training programme

CRITICAL NOTE

Although this article presents some significant limitations, it does underscore the critical importance of empowering caregivers by building their awareness, knowledge and skills regarding hearing disabilities and hearing rehabilitation. As hearing professionals, it is paramount we include significant others and caregivers in the hearing rehabilitation process of each customer. We must ensure we equip them with the information they require for understanding the importance of the process, its goals, and of course, support the patient in a positive and efficient way.

about hearing, hearing loss (HL) and HAs; discussion and demonstration of C2Hear; provision of a “Care Kit” comprising essential items for basic HA maintenance. In addition, participants were required to complete the two questionnaires pre-and post-training.

Cascading training:

Following the initial training session, each participant received the HCT PowerPoint slides and the C2Hear DVD. Participants were asked to use whichever training package they preferred in whatever format they wanted, to impart the knowledge they had acquired during the training to their colleagues.

Post-training follow-up meetings with SHC (three to six months later):

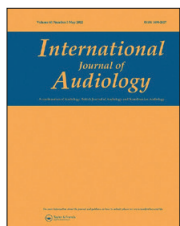
During these follow-up sessions, the research team gathered both quantitative and qualitative data. Quantitative data included information regarding the cascading training and the completion of the two questionnaires. Qualitative insights were gathered through semi-structured interviews, where

participants shared their individual experiences and reflected on the impact of the training on their daily practices.

The research findings indicated that the training provided to the SHCs enhanced their understanding, skills and confidence in matters related to HL and HAs. This newfound expertise

enabled them to effectively transmit this knowledge to fellow support workers within their organisation. The cascading training approach empowered the participants, fostering a heightened awareness of hearing disabilities and solutions, ultimately resulting in an improvement in the quality of care they were able to provide to the individuals under their charge. •

WEB- AND APP-BASED TOOLS FOR REMOTE HEARING ASSESSMENT: A SCOPING REVIEW.



Almufarrij I., Dillon H., Dawes P., et al. Int J Audiol (2023): 62(8), 699–712 doi: 10.1080/14992027.2022.2075798. Epub 2022 Jun 9. PMID: 35678292. By Thomas Tedeschi – US

This review was built to serve three key objectives: to identify and assess the functionality of commercially available remote hearing assessment tools; to identify which solutions had been evaluated in peer-reviewed publications thanks to a scoping review of existing literature; and to report on the accuracy and reliability of these validations.

Web- and app-based tools for remote hearing assessment have gained popularity in recent years, primarily owing to their convenience and widespread accessibility. Remote assessments became extremely helpful during the successive lockdowns of the COVID-19 pandemic. Such tools are specifically designed to help individuals assess their hearing abilities from the comfort of their own homes. This proves particularly helpful for individuals who live in rural or underserved regions around the world, where access to professional audiological services may be limited. Today, the number of individuals using smartphones is at an all-time high. A number of apps enabling individuals to perform basic hearing tests are now readily available for smartphones and tablets. These apps typically involve the presentation of sounds at varying frequencies and volumes, with users responding to and indicating when they can hear the sounds. Similarly, some websites offer online hearing tests which can be completed using a computer or mobile device. These tests often follow a similar format with users responding to sounds presented at various frequencies and volumes. Nevertheless, when using web and app-based tools for hearing assessment, it is important to consider the validity

CRITICAL NOTE
Overall, remote web and app-based tests exhibited a spectrum of performance, ranging from poor to good, thereby rendering the interpretation of results potentially misleading. Several factors contribute to the poor performance scores, with the key issues revolving around the calibration of headphones and the testing environment. Although these results may not always provide a definitive assessment, they can serve as a valuable prompt for individuals to seek professional assistance. Looking ahead, the future of remote testing is likely to emphasise a hybrid approach, with a stronger emphasis on speech stimuli. However, in the present moment, it remains prudent to approach any web or remote-based assessment tools with a degree of scepticism and refrain from regarding them as entirely precise indicators of hearing capabilities.

and reliability of the tool. Research studies and validation data on the accuracy of these assessments has thus far remained somewhat limited. In an attempt to address this gap, the authors designed the present study with a threefold objective:

1. Identify and assess the functionality of commercially available, remote hearing assessment tools on app stores and online platforms.
2. Conduct a comprehensive literature search to ascertain which of the identified tools have been evaluated in peer-reviewed publications
3. Report on the accuracy and reliability of these validations.

The authors conducted an extensive review of 187 remote hearing assessment tools and also examined 101 validation studies. The authors chose to use a scoping review format according to the Preferred Reporting Items for Systematic Review and Meta-Analyses–Extension for Scoping Reviews (PRISMA-ScR) guidelines. Each app was tested in both iOS and Android systems. These remote tests were categorised into four distinct formats: tone assessment; speech-based assessments; self-reporting assessments; and assessments that employed a mixed or hybrid approach.

Tone assessment tools were the most common among the remote testing tools. This stemmed from their capability to generate an “audiogram” profile, recognised as the comprehensible visual representation of hearing loss (HL). In the majority, for these tone-based tools, the quality score for functionality for the majority of the tone tools fell within the “poor” to “acceptable” range. Accuracy for this category of tests varied widely, due in part to whether the test was conducted with a calibrated or an uncalibrated headset, as well as the environmental conditions of the test, i.e. quiet

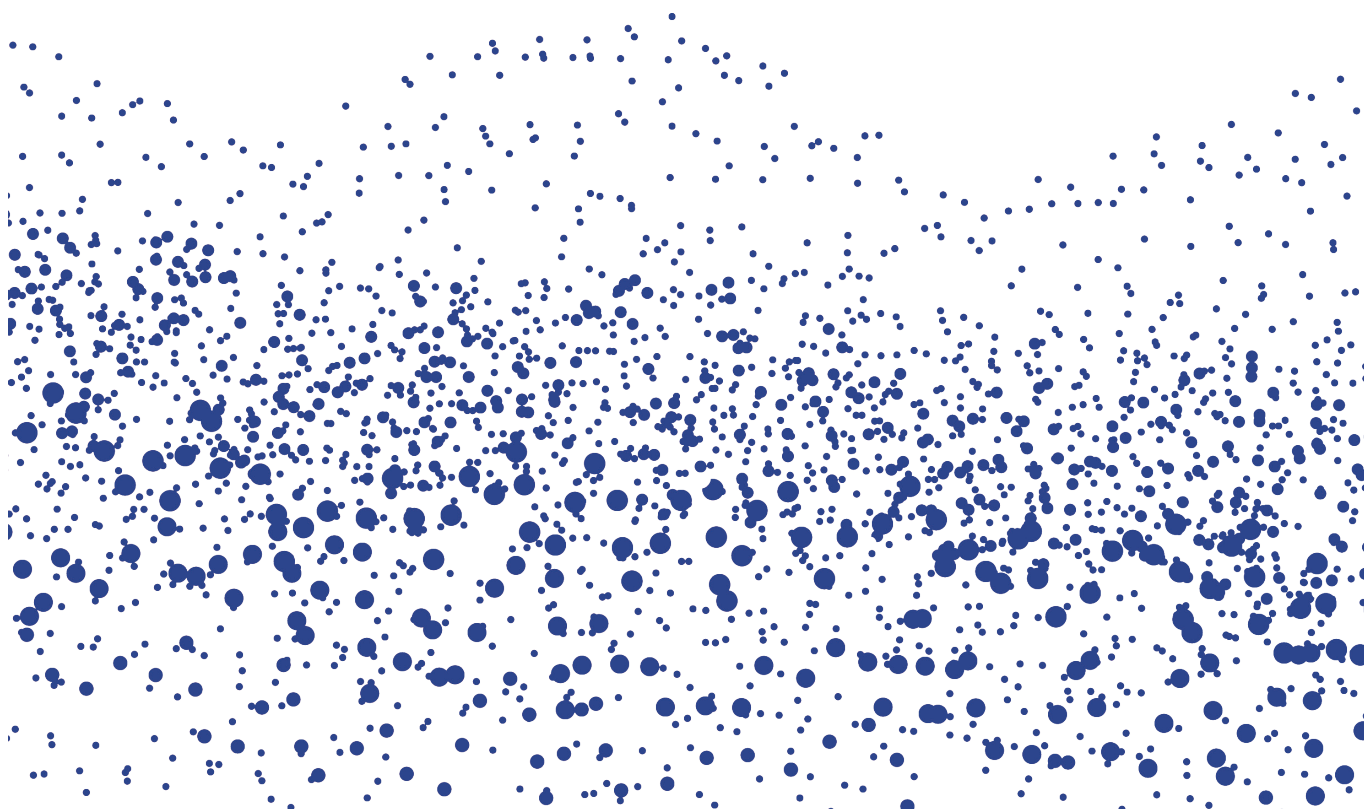
or noisy. Furthermore, inconsistencies were observed in the results of one same test across multiple studies.

Speech-based hearing assessment tools adopted diverse formats, including assessments using non-sense syllables, digit-based tests, and sentence-based evaluations. A common feature across most of these assessments was the incorporation of speech-in-noise scenarios. Notably, the outcomes of the speech-based tests exhibited considerably higher accuracy compared to their tonal counterparts, consistently falling within the “good” range.

This superior performance of speech tests can be attributed, in part, to their reduced reliance on calibration procedures, simplifying their use. While speech assessment tools yielded higher accuracy, specificity and functionality ratings, they all shared a common drawback: they relied on language, making them language dependent, limiting their potential reach.

Self-report assessment tools had the fewest number of tests. The quality of these tools ranged from “poor” to “good”. One important element to bear in mind, as highlighted in the review by the authors, is that no self-report tests have been peer reviewed. However, such tests can provide valuable insights into the subjective impact of HL on individuals.

Mixed-type assessments, which combine both tone and speech stimuli, were identified as the second most prevalent form of self-assessment. Notably, these mixed assessments achieved the highest quality score among all the assessment formats, with outcomes spanning the range from acceptable to good. •





IS COVID-19 TO BLAME FOR SENSORINEURAL HEARING

DETERIORATION? A PRE/POST COVID-19 HEARING EVALUATION STUDY.



Taitelbaum-Swead R., Pinhas A.,
Cohen Tsemah S., et al.

Laryngoscope (2023): 133(8), 1976–1981

doi: 10.1002/lary.30400.

By Melissa Babbage – New Zealand

This paper explores potential correlations between COVID-19 infection and deterioration in sensorineural hearing thresholds in a cohort of unvaccinated patients.

In the aftermath of the COVID-19 pandemic, it has been suggested that this virus might damage the cells of the inner ear leading to post-infection sensorineural hearing loss (SNHL). Several case series and control-group studies have provided data suggesting a possible influence of COVID-19 on hearing, with increased rates of hearing loss (HL), tinnitus and dizziness. However, such findings have not been consistent across the existing body of literature. Many of these studies have inherent limitations, such as relying on self-reported changes in hearing or otologic symptoms, retrospective data collection, and the use of control groups. In light of these constraints, the present study was designed to address some of these limitations by conducting a comparative analysis of audiological data in individual patients, both before and after COVID-19 infection.

In this retrospective study, the primary objective of the authors was to assess the potential associations between COVID-19 infection and the deterioration in sensorineural hearing thresholds, while accounting for the influence of age, within a cohort of unvaccinated patients. Additionally, the study explored whether known risk factors for HL, such as hypertension, diabetes mellitus, and smoking, increased the likelihood of hearing deterioration after COVID-19 infection.

Method

The authors procured data from the medical records of adult patients covered by a major healthcare insurer in Israel. Patients were eligible if they had a positive PCR for COVID-19 between March and December 2020 (prior to the availability of vaccines), had both pre- and post-COVID hearing tests available, and had no known ear diseases. All 83 patients who met the criteria had some extent of pre-existing SNHL

CRITICAL NOTE:

This article offers evidence based on repeated audiologic assessments of the same participants, suggesting that COVID-19 infection is not associated with sensorineural hearing deterioration. Although the use of audiometric data rather than self-report is a valuable contribution to this field of research, the study is limited by its use of average hearing changes across the cohort. The rate of sensorineural hearing loss reported in previous studies has typically been low, and averaging data across an entire cohort of 83 participants may obscure isolated cases of significant hearing loss. The inclusion of not just averages but also rates of hearing loss would have been substantially strengthened of the authors' conclusions. There is also an inherent bias in the use of retrospective data in those patients reporting changes in hearing post-COVID-19 are likely to have been more motivated to return for a hearing assessment after infection. It is therefore intriguing that even within this group, significant hearing changes were not documented. This study contributes to an emerging and important body of research that will continue to determine the short- and long-term effects of COVID-19 on the auditory system.

pre-COVID. The age range of the participants spanned from 20 to 91 years, with 70% being over 55 years old.

Audiometric assessments included: air and bone conduction thresholds; speech reception threshold (SRT); and phonemically balanced (PB) word identification scores. Additionally, the presence of tinnitus or vertigo was recorded.

Air conduction thresholds for each participant were divided into three frequency ranges: low = 250–500 Hz; mid = 1000–3000 Hz; and high = 4000–8000 Hz. Changes in average thresholds within each frequency band, SRTs, and word identification scores pre- and post-infection were analysed with and without patient age and the time elapsed between the pre- and post-hearing tests as covariates. Furthermore, the study computed correlation coefficients to examine the linear associations between hypertension, diabetes mellitus, smoking, and the average hearing changes within each frequency range.

Results

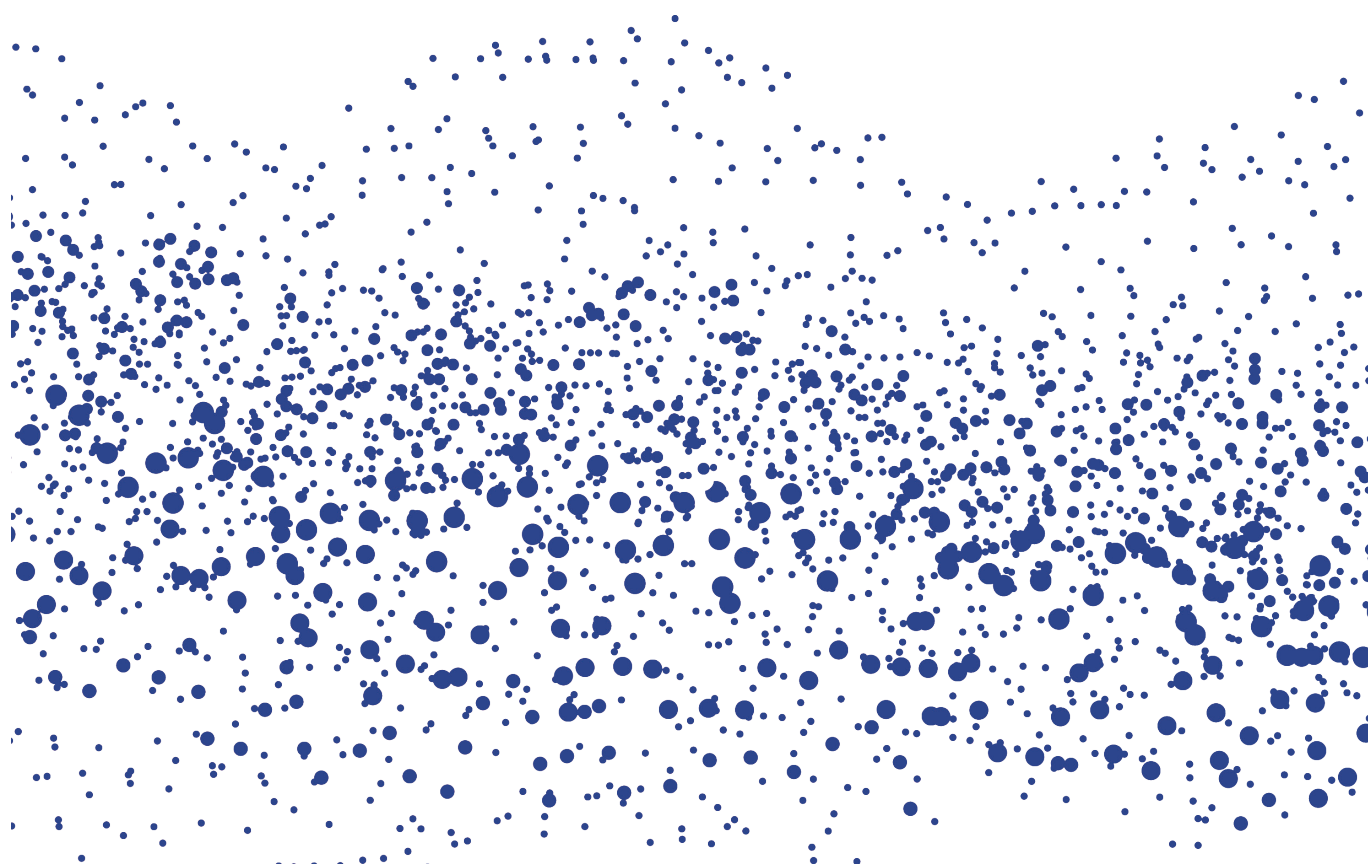
The analyses revealed that, on average, hearing thresholds within all frequency ranges exhibited a modest increase (3–4 dB) following COVID-19 infection. However, when considering age and the duration between the pre- and post-infection tests as covariates, these changes did not demonstrate statistical significance. No notable difference in SRTs or PB words scores were found pre- and post-infection. Moreover, no significant linear correlation was between the presence of health risk factors and shifts in hearing thresholds, and no marked difference in the number of self-reported cases of tinnitus or vertigo pre- and post-infection. The mean interval between hearing assessments was approximately four years. The documented reasons put forward by patients for post-infection hearing tests included

routine follow-up, self-reported hearing deterioration, and worsening of symptoms or appearance of new symptoms.

Discussion

The findings of this study indicated that, after adjusting for the influence of age and the duration between pre- and post-COVID-19 hearing assessments, there was no significant deterioration in average hearing thresholds following COVID-19 infection. Further, there was no evidence of greater deterioration in the hearing in COVID-19 patients with known risk factors for hearing loss. Consequently, the authors conclude that COVID-19 does not appear to be independently associated with SNHL in and unvaccinated cohort of patients with pre-existing HL.

The main strength of this study lies in the use of objective hearing assessments, rather than self-reported assessments as in the majority of existing studies. The authors also contend that the timing of the study, prior to the rollout of vaccines or the emergence of new COVID-19 variants, is beneficial in that it minimises the influence of other variables that could affect hearing. The authors, however, acknowledge that the generalisability of these findings may be limited to do the subsequent rollout of vaccines and the emergence of newer COVID variants. Moreover, the generalisability of the results may not extend to individuals who report HL as a new symptom following infection, as opposed to those with pre-existing HL. •





TINNITUS FOOTPRINTS IN THE COCHLEA



Tinnitus Footprints in the Cochlea

Oliveira CA., Kehrle HM., Granjeiro RC., et al.

Int Tinnitus J (2023): 27(1), 54–57

doi: 10.5935/0946-5448.20230009.

By Lawrence Sim –Australia

This article examined how temporal bone histopathology could provide new information on the origin of tinnitus in the cochlea.

Tinnitus is a commonly reported symptom among otologic patients. However, only a small percentage, approximately 1%, experiences severely disabling tinnitus requiring targeted treatments. In this paper, the authors examined clinical records of temporal bones of patients who reported tinnitus as the main complaint in medical consultations, in order to identify possible histopathologic correlations for tinnitus.

The authors selected 83 temporal bones from patients who met the criteria and documented their main histopathologic diagnosis. For comparison, the authors used a control group, made up of an additional set of 33 temporal bones from patients with the same histopathologic diagnosis but who did not report tinnitus. From the selected temporal bones, the authors identified 11 histopathologic diagnoses:

- Bacterial and viral infection
- Sudden deafness
- Drug ototoxicity
- Acoustic trauma
- Sensorineural hearing loss
- Endolymphatic hydrops
- Otosclerosis
- Normal histopathology
- Developmental or hereditary disorders
- Paget's disease
- Degenerative disorders including presbycusis

The authors did not find any statistically significant distinction in the histopathologic diagnosis between the tinnitus and non-tinnitus group. Among the 83 temporal bones in the tinnitus group, approximately 49% exhibited normal histology, endolymphatic hydrops, or otosclerosis.

The authors discussed a previous study they conducted in 2007, in which they assessed the severity of tinnitus in 48 otosclerosis patients using the Visual Analog Scale

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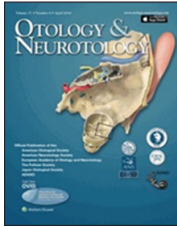
Among otologic patients who reported tinnitus, only a small 1% experience the severe and disabling form of this condition. When analysing the temporal bone diagnoses, the authors observed a greater occurrence of endolymphatic hydrops and otosclerosis among patients who reported significant tinnitus. Although otoacoustic emissions results implied a correlation between outer hair cell dysfunction and tinnitus, the authors did not find any correlation between outer hair cells dysfunction with tinnitus annoyance, anxiety or depression.

(VAS). It revealed that 19 of those patients reported Severe Disabling Tinnitus (SDT) on the VAS pre-operatively. Based on these results, the authors inferred that the prevalence of SDT in otosclerosis patients was considerably higher than in the general population. They proposed a hypothesis that the increased incidence of endolymphatic hydrops and otosclerosis in the histopathological diagnoses of temporal bones from patients with significant tinnitus may be attributed to both conditions causing tinnitus through alterations in cochlear fluid homeostasis.

In another previous study, the authors established a relationship between tinnitus annoyance and dysfunction in outer hair cells as measured by otoacoustic emissions. The results suggested that there was some degree of cochlear dysfunction involved in the generation of tinnitus. Further, they established a correlation between the degree of tinnitus annoyance and the presence of anxiety and depression disorders in patients with tinnitus but otherwise normal hearing. However, no significant correlation was identified between outer hair cell dysfunction and the levels of tinnitus annoyance, anxiety or depression. •



ASSOCIATION BETWEEN CANNABIS USE AND TINNITUS IN U.S. ADULTS



Reyes Orozco F, Lin M., Clark B., et al. Otol Neurotol (2023): 44(6), 611–618 doi: 10.1097/MAO.0000000000003895. Epub 2023 May 31. PMID: 37254263. By Michael Joseph – US

The objective of the researchers was to assess the association between cannabis use and tinnitus across a sample of U.S. adults.

Background & Introduction:

Tinnitus, i.e. the perception of sound without an external source, presents in two forms: objective and subjective. Objective tinnitus is quite uncommon, whereas subjective tinnitus affects a significant portion of the global population, leading to substantial healthcare costs and reduced productivity. Existing treatments primarily focus on alleviating the condition's impact but often lack robust scientific validation. Given the changing legal landscape and increased accessibility of cannabis, it has become an area of exploration for managing tinnitus. In other medical domains, studies have indicated that cannabis might enhance overall wellbeing and alleviate discomfort by modulating stress responses. Research on the relationship between cannabis and tinnitus is ongoing. While some studies show promise in reducing tinnitus symptoms, others raise concerns about potential exacerbation. Further investigation is needed to understand the full potential and risks of using cannabis as a tinnitus management strategy.

The researchers highlight the scarcity of epidemiological studies that have explored the interplay between cannabis use and tinnitus. Through this study, they set out to analyse this association in greater depth, taking into account various aspects of cannabis use, such as quantity and frequency, in order to identify whether there might be a dose-response relationship between cannabis use and tinnitus.

Population:

The study analysed a cohort of 5,927 adults who participated in the National Health and Nutrition Examination Survey (NHANES) in 2011–2012 and 2015–2016. This programme assesses the health, function, and nutritional status of the noninstitutionalised civilian population in the United States, using a complex sampling design.

Tinnitus and Audiometric Measures:

The study compiled data on variables related to tinnitus through questionnaire responses. The primary measure of

CRITICAL NOTE

The authors effectively established an association between cannabis use and tinnitus, but the exact nature of this relationship, including the impact of different levels of cannabis use, remains complex and calls for further investigation. Future research should delve into the effects of varying amounts of cannabis on tinnitus and explore this relationship.

tinnitus was defined as “bothersome tinnitus in the past 12 months”, due to experiencing ringing, roaring, or buzzing in their ears or head that lasted for five minutes or more. Logistic regression analysis was performed to examine the association between tinnitus and cannabis use based on this primary measure.

Secondary measures of tinnitus included criteria such as frequency, sleep disturbance, duration, and severity. “Frequent tinnitus” was defined as experiencing symptoms at least once a day or almost always, whereas “nonfrequent” tinnitus was defined as experiencing symptoms at least once a week, at least once a month, or less frequently than once a month. Sleep disturbance due to tinnitus was defined as experiencing ringing, roaring or buzzing when going to sleep. Duration and severity were assessed thanks to multiple-choice questions.

Audiometric assessments were performed, defining hearing loss (HL) as a Pure-Tone Average (PTA) threshold greater than or equal to 25 dB HL at various frequencies. Severity of HL was categorised as “normal”, “mild”, or “moderate/greater” in line with guidelines from the American Speech Language Hearing Association.

Furthermore, the study examined noise exposure in work and non-work settings, assessing exposure to loud noise for extended periods—whether through employment or outside of work—based on participants’ responses.

Cannabis Use Measures:

The study compiled data on cannabis consumption through self-reported information, which included whether participants had a history of using “marijuana or hashish”, the quantity of joints or pipes they consumed each day, the age at which they initiated regular marijuana use, and their monthly usage frequency.

The primary measure of cannabis usage was divided into three categories: individuals who had never used cannabis; those with low-volume consumption (one to two joints or pipes daily); and those with high-volume consumption (three or more joints or pipes daily).

Additionally, a secondary measure classified cannabis usage based on frequency, resulting in three groups: non-users; nondaily users (fewer than 24 times per month); and near-daily users (25-30 times per month).

Results:

The study examined data from 5,927 participants and identified various factors linked to tinnitus prevalence. Individuals with tinnitus tended to be older, of white ethnicity, with higher levels of education, lower household income, and a history of medical conditions such as hypertension, diabetes, stroke, cardiovascular disease, and major depressive disorder (MDD). They were also more likely to report drug and alcohol use, experience work-related or off-work noise exposure, and use cannabis more frequently.

Tinnitus prevalence was notably higher among heavy cannabis users, at 20.5%, against 12.0% among non-cannabis users. The severity of tinnitus was similar across tinnitus sufferers, regardless of cannabis usage levels.

In univariable models, tinnitus was significantly associated with both low-volume and high-volume cannabis use; however, the association with low-volume use lost significance when accounting for various factors. In multivariable models, high-volume cannabis use remained independently linked to a higher tinnitus prevalence. Major depressive disorder (MDD) consistently showed an association with tinnitus in both univariable and multivariable analyses.

Further analysis regarding the frequency of cannabis use did not show a significant association with tinnitus.

The study also explored the potential influence of MDD on the relationship between cannabis use and tinnitus. It found no significant differences in this relationship between subjects with and without MDD.

In interactions between MDD and cannabis use, no significant interactions were observed. High-volume cannabis use

remained significantly associated with tinnitus even when considering these interactions.

Discussion:

This study identified a higher prevalence of bothersome tinnitus among cannabis users. Importantly, this association remained significant even after adjusting for demographic variables, hearing loss, and noise exposure, and it was not influenced by or interacted with major depressive disorder (MDD).

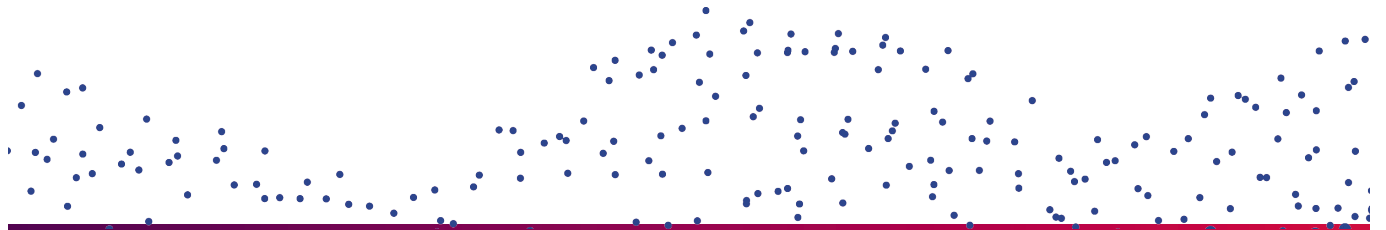
The findings of this study support prior research which also reported a higher prevalence of tinnitus in cannabis users. The present study expanded upon previous findings by exploring various levels of cannabis use and examining the potential role of MDD. However, the precise dose-response relationship between cannabis use and tinnitus remains unclear.

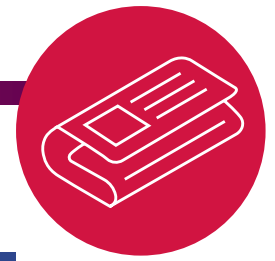
Interestingly, the study revealed a significant link between tinnitus and the volume of cannabis consumption, with individuals who used a higher number of pipes or joints per day presenting a higher prevalence of tinnitus. Daily cannabis use did not show the same association. Although some animal studies had suggested that cannabinoids might exacerbate tinnitus, the relationship between cannabis use and tinnitus appears to be multifaceted. Cannabis could potentially alleviate tinnitus due to its anti-inflammatory properties, but this aspect requires further investigation.

MDD emerged as a significant factor in this study, as it was linked to both cannabis use and tinnitus. People with MDD were more likely to report tinnitus, and it is possible that some of those turn to cannabis as a form of self-medication. However, the study did not find a significant interaction between cannabis use and MDD in relation to tinnitus.

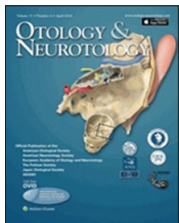
Despite the many insights the study provides, it does have several limitations. Its cross-sectional design makes it challenging to establish the sequence of associations. Underreporting of cannabis use, possibly due to social stigma, might have affected the results. The study did not differentiate between various cannabis products, which could have implications for the findings. Additionally, different criteria for diagnosing MDD could potentially have yielded different results. There may also be residual confounding from unaccounted medical or environmental factors.

In summary, the study established an association between cannabis use and tinnitus, but the exact nature of this relationship, including the impact of different levels of cannabis use, remains complex and warrants further investigation. •





HEALTH INSURANCE COVERAGE OF COCHLEAR IMPLANTATION IN SINGLE-SIDED DEAFNESS AND ASYMMETRIC HEARING LOSS



Sorkin DL., Adunka OF, Westin N., et al.
Otol Neurotol (2023); 44(8), e628–e634
 doi: 10.1097/MAO.0000000000003969. Epub 2023 Jul 25. PMID: 37504974
 By Carrie Meyer – US

This study surveyed cochlear implant clinicians to provide an overview of their experiences with health plan coverage for cochlear implants for single-sided deafness and asymmetric hearing loss.

Introduction:

Single-sided deafness (SSD) is observed in approximately 0.14% of the adult population in the United States. This prevalence tends to rise to 0.25% among individuals aged 60 and older. SSD and asymmetric hearing loss (AHL) are consistently the most challenging hearing impairments to treat. CROS, BiCROS, and bone anchored hearing aids (BAHA) offer limited improvement by offsetting the head shadow effect. However, BAHAs have been demonstrated to provide some benefit in hearing in noise. Early (2003) European studies showed that cochlear implants (CI) used for SSD could provide significant benefits, including relief from tinnitus, improved sound localisation, enhanced speech comprehension in noisy settings, and an overall boost in the quality of life. In the United States, health plans tend to prioritise the adoption of cost-effective non-CI solutions for SSD and asymmetric HL.

In 2019 the Food and Drug Administration (FDA) broadened the criteria for cochlear implantation (CI), allowing for the use of CIs in cases of single-sided deafness (SSD) and asymmetric hearing loss (AHL). Before this change in 2019, employing CIs for SSD was considered “off-label” as it fell outside the established FDA guidelines. As a result, most SSD patients were required to cover the costs of CIs.

The primary aim of this study was to assess whether health insurance coverage has improved to align with the updated FDA guidelines for the utilisation of cochlear implants in patients with SSD and AHL.

Methodology:

A 13-question survey was sent via Survey Monkey to U.S. CI clinicians working at clinics that provide a minimum of 20 CIs per year, with a total of 78 CI centres, from all regions of the U.S.

CRITICAL NOTE

Single-sided deafness (SSD) and asymmetric hearing loss (AHL) pose unique challenges for successful treatment. Established treatment options including CROS, BiCROS and BAHA devices offer limited benefits for SSD. In 2019, the FDA expanded cochlear implant (CI) candidacy criteria to include SSD and AHL. Despite this regulatory change, health insurance coverage for cochlear implantation in the context of SSD/AHL remains disparate in comparison to the coverage provided for CI for bilateral deafness. This survey-based study evaluates the experience of current CI clinicians when seeking insurance coverage for CI for their SSD and AHL patients.

Type of Facility	Percentage of Respondents
Hospital	45 percent
University-based clinics	33 percent
Private practice clinics	15 percent
Schools for the Deaf	4 percent

The survey began by determining how many SSD CI surgeries each facility carried out both prior to and subsequent to the FDA’s 2019 approval of CIs for SSD. The remainder of questions focused on the facilities’ success rates in securing insurance coverage for CI procedures in SSD patients. This included questions about the difference in coverage for SSD in adults compared to coverage for children with SSD, reasons for insurance denial of coverage and whether any denied claims were eventually reversed. The survey also inquired about the insurance policies of specific US insurers concerning SSD coverage and explored any challenges related to reimbursement. The survey used close ended, multiple-choice questions; responses were tallied for each

question. In addition, five respondents agreed to phone interviews, providing additional, in-depth insights.

Results:

All respondents indicated there was a large increase in CI surgeries for SSD and AHL after the release of the new manufacturer criteria by the FDA in 2019. Insurance coverage for SSD CI varied depending on the geographic region and health plan. Most facilities reported they were almost always (30.9%) or often (34.6%) successful in obtaining coverage for SSD CI.

Regarding disparities in insurance coverage between adults and children, clinicians highlighted that the primary reason for insurance denial in paediatric patients under five years of age was the FDA's criteria, which restricted SSD cochlear implants to children aged five years or older. Although 75% of clinics observed no difference in insurance coverage between adults and children, the remaining 25% found it more challenging to obtain coverage for paediatric patients. In terms of reversing coverage denials or winning determination appeals, 67% of respondents stated they were usually successful in getting denials overturned. The most effective strategies for this, as reported by respondents, included requesting a peer-to-peer review or involving a speciality external reviewer, particularly an otolaryngologist. Clinicians found that submitting relevant published research and results from trials involving non-surgical devices played a significant role in supporting appeals and ultimately securing coverage for cochlear implants.

Study Limitations:

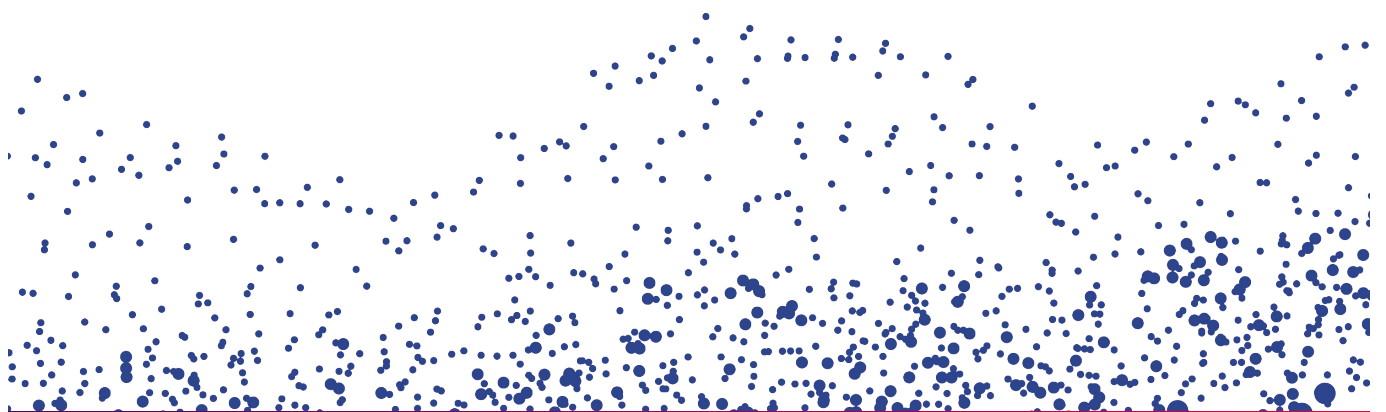
The authors note that research limitations were mitigated by limiting survey distribution only to active clinicians in CI centres.

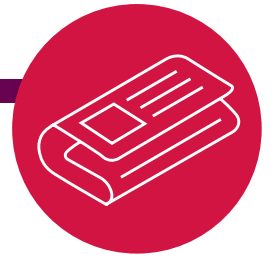
Conclusions:

As CI technology and surgical procedures have advanced, the FDA's patient criteria have expanded to include younger patients and those with less severe HL. In response to these changes, the Centers for Medicare & Medicaid Services (CMS) has extended insurance coverage for CIs to individuals with bilateral deafness. These changes in FDA and CMS policies have had a positive impact on health insurance coverage, both from private/commercial plans and federal programs, and have led to an ongoing expansion of coverage for CI for bilateral deafness.

In 2019, the FDA introduced manufacturer criteria for the use of cochlear implants in SSD and AHL. CI clinics and hospitals specialising in these procedures have reported that health insurance coverage for SSD is not on par with coverage for bilateral deafness. Clinicians have emphasised the challenges in obtaining positive coverage determinations, particularly for children under the age of five. They have also pointed out that most requests for SSD CIs are initially denied, leading to time-consuming appeals and surgery delays.

In light of these findings, the authors of this study recommend expanding healthcare access to CI for SSD, aligning it with the standards set for bilateral deafness. They advocate for disseminating information about the benefits of cochlear implants in SSD to the public, including professionals, parents, and consumer organisations. The authors propose further clinical research into the benefits of CIs in SSD be presented to the FDA to broaden SSD criteria guidelines. They conclude by emphasising the urgent need for more research in CI for SSD in children under the age of five. Health plans are expected to continue requiring approval of less effective, non-surgical options until robust research is conducted and published, clearly demonstrating improved patient outcomes for CI in SSD and AHL. •





EVALUATION OF DEEP MARGINAL FEEDBACK CANCELLATION FOR HEARING AIDS USING SPEECH AND MUSIC.



Zheng C., Xu C., Wang M., Li X., et al.
Trends in Hearing (2023): 27,
 23312165231192290
 doi: 10.1177/23312165231192290. PMID:
 37551089; PMCID: PMC10408330.
 By Joshua Holland–Australia

The authors conducted an assessment of the efficacy of three different iterations of DeepMFC in the context of speech and music, both individually and in combination with conventional feedback methods.

Both speech and music have been widely used in studies of auditory perception and are of significant importance to hearing (HA) users. However, hearing devices, such as HAs, are primarily designed to enhance speech perception and with less emphasis placed on improving music perception, even though music contributes to social interactions, pleasure, and emotional expression.

The distinct characteristics of speech and music present a challenge in developing a unified signal processing approach which can effectively enhance both speech and music perception. Employing diverse feedback systems may provide limited benefits for both domains, potentially impacting music perception. In this study, the authors explore the application of a deep learning framework for feedback control known as DeepMFC. Their goal is to evaluate its effectiveness in simulated closed-loop systems which incorporate measured feedback paths for both music and speech, utilising various training materials and employing both objective and subjective evaluation measures. The study also aims to estimate the stable gain introduced by DeepMFC in enhancing the quality of speech and music, while elucidating the mechanisms behind DeepMFC's operation.

Method:

The authors used three different DeepMFC models, each tailored to specific scenarios: DeepMFC(1), for speech feedback control; DeepMFC(2), for music feedback control; and DeepMFC(3), for handling both speech and music. These models were compared with traditional methods, such as Frequency Shifting (FS) and Prediction Error Method–Adaptive Feedback Cancellation (PEM–AFC) as well as combinations of these with DeepMFC.

During training, simulated feedback paths were used; whereas testing measured feedback paths from HAs. In order to assess signal quality, objective quality measures, such as Perceptual

CRITICAL NOTE

The perception of both speech and music is crucial for individuals with hearing impairments. While hearing aids can partially address this issue by employing frequency-dependent amplification and compression, they may lead to feedback when higher gains are needed to compensate for hearing loss, especially at lower sound levels. The authors conducted an investigation into the utilisation of the deep-learning method DeepMFC and assessed its performance in enhancing both speech and music perception. The results were promising, suggesting that further training of the deep-learning model could provide a solid foundation for future advancements in this field.

Evaluation of Speech Quality (PESQ) and Hearing-Aid Speech Quality Index (HASQI)-V2 for speech and Hearing-Aid Audio Quality Index (HAAQI) for music, were used. Additionally, subjective preference scores were gathered through paired comparisons for different conditions and gain margins.

The study aimed to assess and compare the performance of these approaches in controlling feedback, with a focus on speech and music signals, using both objective and subjective evaluation methods.

Participants: 15 individuals, with ages ranging from 20 to 42 years old, all with self-assessed normal hearing.

Results:

Speech Quality for Simulated NH Listeners: DeepMFC(1) showed the highest added stable gain among the individual feedback approaches, whereas a combination of both DeepMFC(1) and PEM-AFC showed the highest added stable gain of 13 dB to 14 dB.

Speech Quality for Simulated Hearing-Impaired Users: DeepMFC(1) alone effectively increased the added stable gain to over 14 dB; when combined with PEM-AFC, it resulted in slightly improved performance.

Music Quality for Simulated NH Listeners: Of the single approaches PEM-AFC scored the highest with a combination of PEM-AFC and DeepMFC(3) scoring slightly higher.

Music Quality for Simulated Hearing Impaired Listeners: Highest added stable gain values were seen with a combination of PEM-AFC and DeepMFC(3).

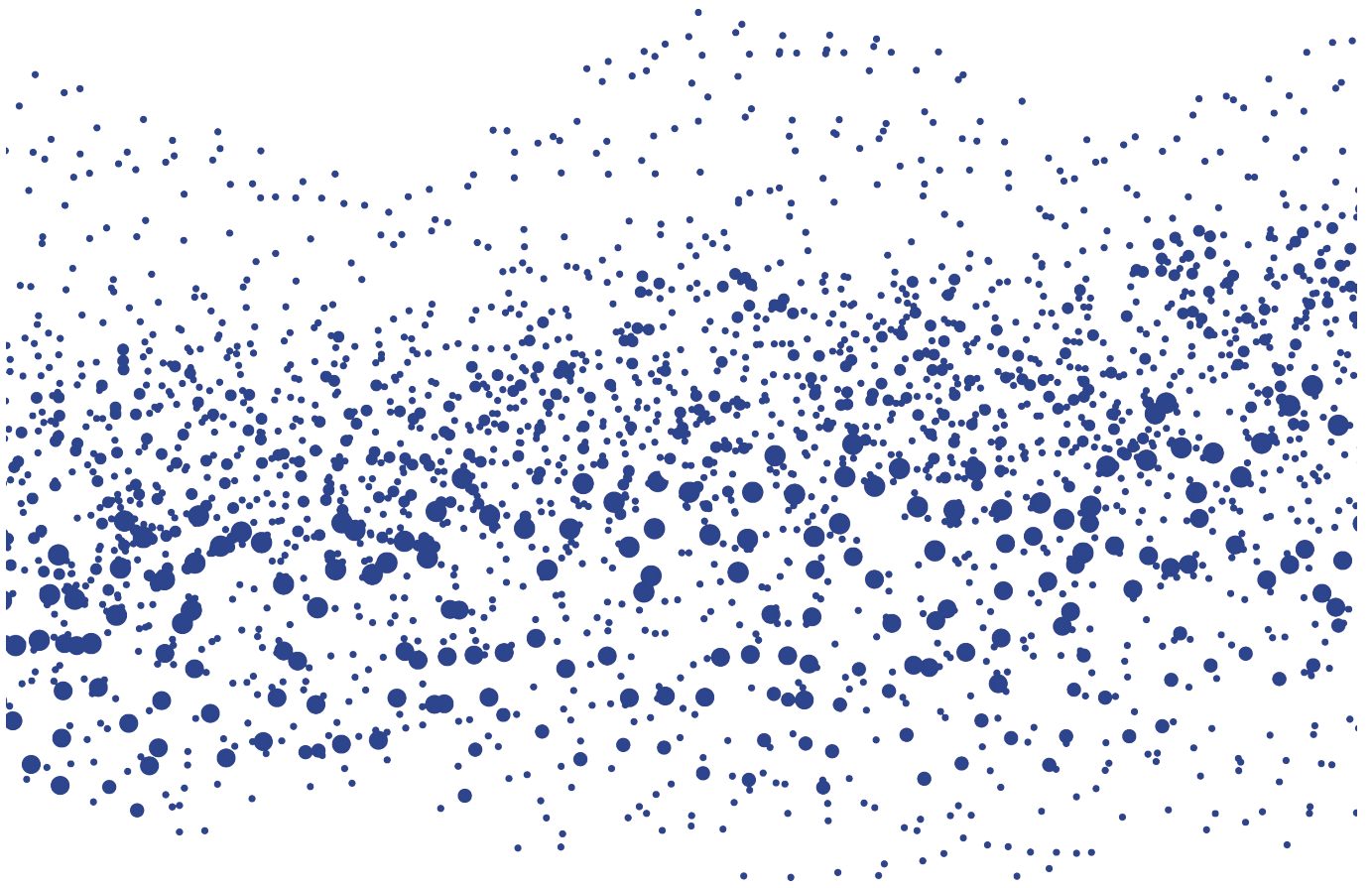
Results of the Listening Test for Speech: With gain margins set to 0 dB both PEM-AFC and DeepMFC(1) were preferred over the unprocessed signals and a combination of PEM-AFC and DeepMFC(1) scored the highest HASQI-V2 scores.

Results of the Listening Test for Music: Mixed results with gain margins of 0 dB, PEM-AFC preferred method but with negative gain margins combination of DeepMFC and PEM-AFC being the preferred.

Characterisation of How DeepMFC Works for Speech & Music: DeepMFC(1) exhibited strong performance across various types of simulated HL and also performed well in subjective

listening tests with speech signals, showing up to 14 dB of added stable gain. DeepMFC 2&3 demonstrated smaller added stable gains, even though they were trained using both music and speech data (for DeepMFC(3)). This could be attributed to the inherent complexity and variability of music signals compared to speech signals when processed by the deep-learning model. It is possible a more powerful deep-learning architecture could enhance performance for both speech and music.

The testing found that the performance of DeepMFC is influenced by the source material and the gain margin. A combination of DeepMFC with other methods was preferred in subjective evaluations for both speech and music. While DeepMFC effectively mitigated excess gain, it exhibited some shortcomings when used in isolation. With more training of the deep-learning model and implementation with other hearing aid processing this paper forms a good base for future research. Further training of the deep learning model and integration with other hearing aid processing techniques are areas that hold promise for future research, making this paper a solid foundation for subsequent studies. •





DIAGNOSING NOISE-INDUCED HEARING LOSS SUSTAINED DURING MILITARY SERVICE USING DEEP NEURAL NETWORKS



Diagnosing Noise-Induced Hearing Loss Sustained During Military Service Using Deep Neural Networks

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By Ryan Johnson-Hunt – New Zealand

This study introduced a novel approach using a type of deep neural network called multilayer perceptrons (MLPs) to classify individuals with noise-induced hearing loss, achieving higher accuracy than conventional methods, and highlighted the promising potential of MLPs in audiogram-based diagnostics.

The diagnosis of noise-induced hearing loss (NIHL) hinges on three criteria: documented noise exposure, exclusion of other causes, and audiogram characteristics. Traditional diagnostic methods involve the analysis of audiograms and rule-based diagnostic procedures. This study introduces an innovative approach using multilayer perceptrons (MLPs) to classify individuals based on their audiograms and ages. Prolonged exposure to noise is a well-established cause of NIHL, prompting the establishment of safety standards and regulations. Accurate diagnosis is crucial, particularly for issues such as compensation claims.

Traditional diagnostic methods typically employ audiograms to identify deviations in hearing threshold levels (HTL) that exceed age-related expectations. For military-related NIHL (MNIHL), an alternative approach has been suggested, which emphasises notches or bulges in the audiograms, primarily around the 4 kHz range. In 2020, Moore introduced the M-NIHL method, focusing on notches, bulges, and high-frequency hearing loss (HL), although it lacked specificity. In 2022, Moore and colleagues introduced the rM-NIHL method, specifically designed for enhancing specificity.

This article proposes an alternative approach using MLPs, to automatically identify M-NIHL characteristics in audiograms based on age. Databases of individuals with noise exposure and control subjects were used to train and test MLPs. The approach strikes a balance between sensitivity and specificity, which is essential for ensuring fair compensation decisions, while also considering alternative causes for HL. In this article, the authors developed the MLP(18) model, characterised by

CRITICAL NOTE:

Despite the many strengths of this article, it does present some limitations which should be taken into account. It is possible that the military group exhibited an overestimation of hearing loss due to their increased likelihood of experiencing M-NIHL. Factors such as alcohol consumption, smoking habits, socioeconomic status, and education, which might vary between the noise-exposed and control groups, were not taken into account. Moreover, the extent of noise exposure beyond military service was not comprehensively addressed within the noise-exposed group.

18 input features, one hidden layer, and two hidden units, chosen for its strong performance in diagnosing military service-related NIHL (M-NIHL).

Method:

This study utilised two datasets, MiIDB1 and MiIDB2, for MLP training and testing. MiIDB1 consisted of 143 individuals seeking compensation for M-NIHL; MiIDB2 consisted of 142 individuals with similar compensation claims. Both datasets showed exposure to intense impulsive sounds during military service. In addition, two control datasets, ContDB1 and ContDB2, were used totalling 93 and 92 individuals, respectively, were used as control populations without significant noise exposure. The input features used in this study were z-score normalised, including age-corrected hearing threshold levels (ACHTLs). Various MLP configurations were

assessed for sensitivity and specificity. The best-performing MLP in terms of validation accuracy was selected for further analysis.

Results:

The results section provides valuable insights into the performance of multilayer perceptrons (MLPs) in diagnosing NIHL. The validation accuracies of various MLP configurations were examined. Interestingly, the study found that altering the number of hidden layers and units had a negligible impact on accuracy. Furthermore, a comparative analysis was conducted between the MLP(18) method and existing diagnostic approaches. The results showed that the MLP(18) method outperformed the others, particularly in terms of specificity and overall diagnostic accuracy. The study also assessed Positive Predictive Values (PPV), which emphasised the robustness of the MLP(18) method, even under low prevalence scenarios. In summary, the MLP(18) method demonstrated improved diagnostic accuracy, making it valuable for M-NIHL diagnosis in medicolegal contexts.

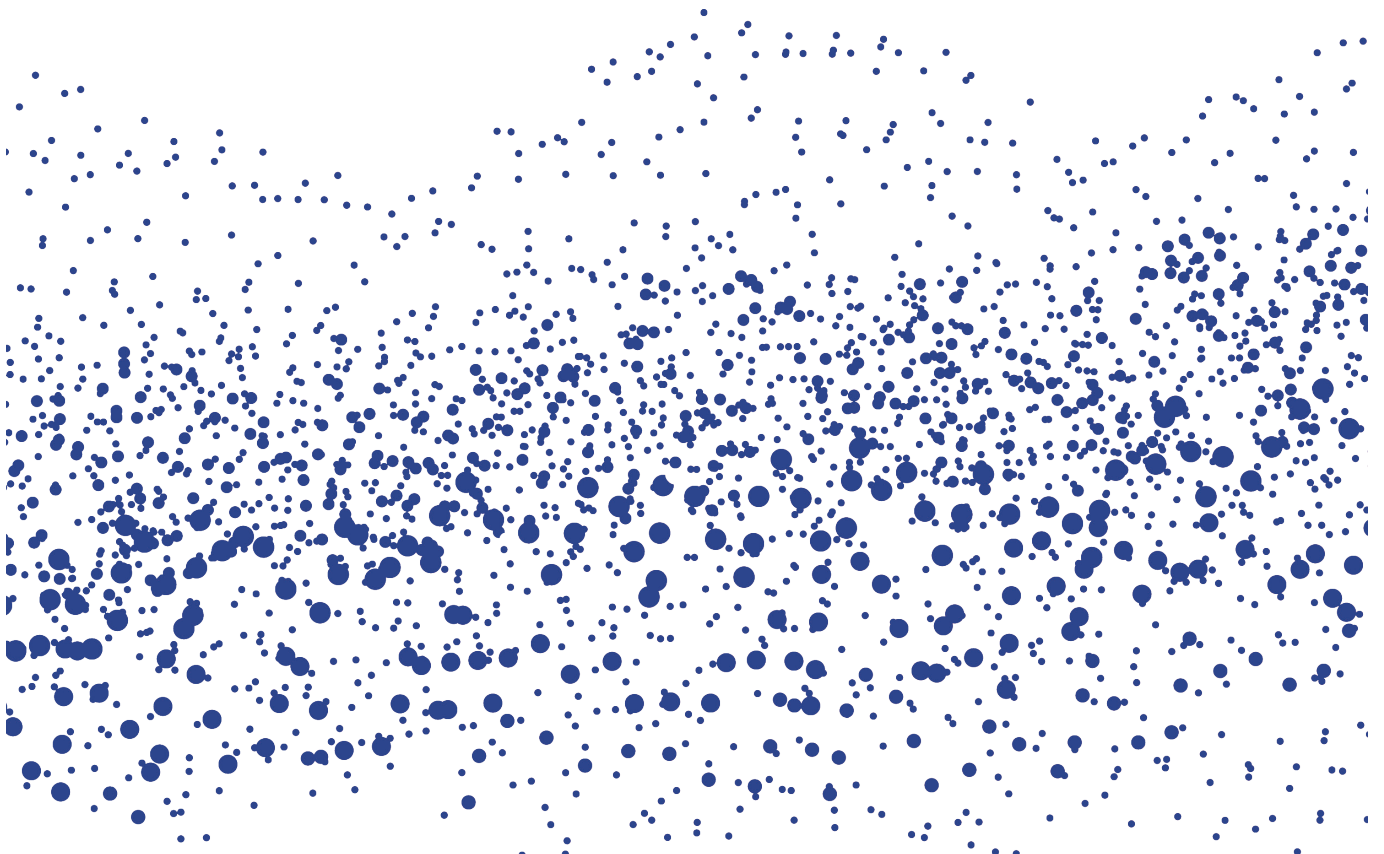
Discussion

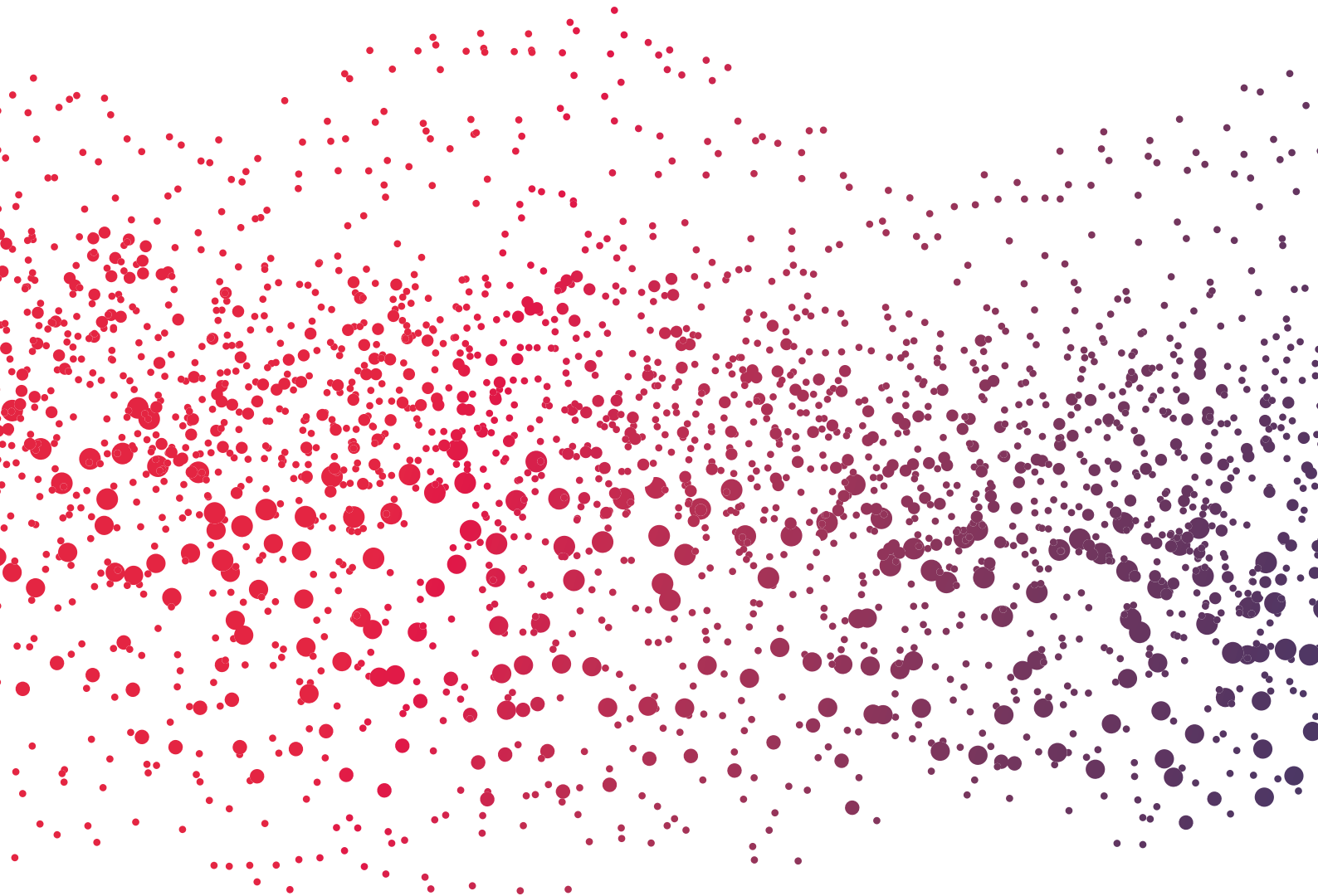
The discussion section highlights the superior performance of the MLP(18) method when compared to the M-NIHL (2020) and rM-NIHL methods in diagnosing M-NIHL. This enhanced performance is likely attributed to the MLP(18) method’s ability to capture distinct data patterns. Using data from both ears contributed to MLP(18)’s accuracy, in

contrast to the ear-specific approach of M-NIHL methods. However, interpreting the results obtained from MLP(18) can be challenging, as specific frequencies and ear asymmetry play a role in its diagnostic outcomes. The study also examined the individual application of MLPs to each ear, which yielded higher sensitivity and specificity compared to previous methods, underscoring their effectiveness in recognising data patterns. Implementing MLPs in Excel makes them accessible to a broader audience. Nevertheless, some limitations remain, including the potential overestimation of HL in the military group, variations in individual factors, and disparities in noise exposure assessments.

Conclusion

A novel diagnostic approach for military service-related noise-induced hearing loss (M-NIHL) was developed and tested. This method leveraged Multilayer Perceptrons (MLPs) to analyse audiogram and age data from individuals filing compensation claims for M-NIHL as well as a control group with no history of significant noise exposure. Among the MLP configurations, MLP(18) stood out as the best performing, considering audiometric data and age for both ears. It achieved a sensitivity of 0.99 and a specificity of 0.90, outperforming previous diagnostic methods. MLP(18) also displayed robust positive predictive values, under low assumed M-NIHL prevalence, making it a more specific diagnostic tool for this condition. •





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