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## Otology & Audiology Article Review

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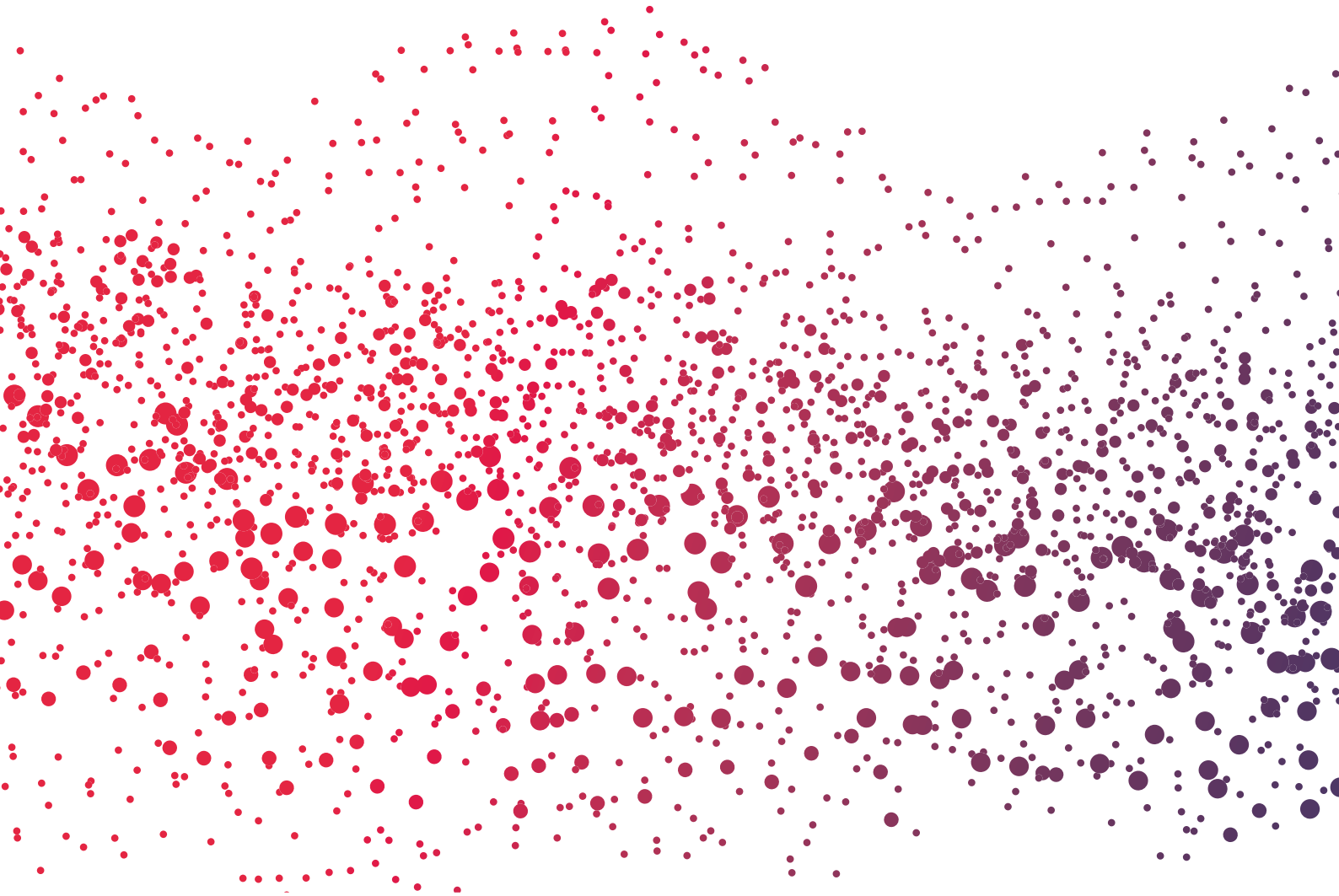

Association between hearing aid use and all-cause and cause-specific dementia

Telemedicine in Otolaryngology During COVID-19

Plasticity After Hearing Rehabilitation in the Aging Brain

# CONTENT




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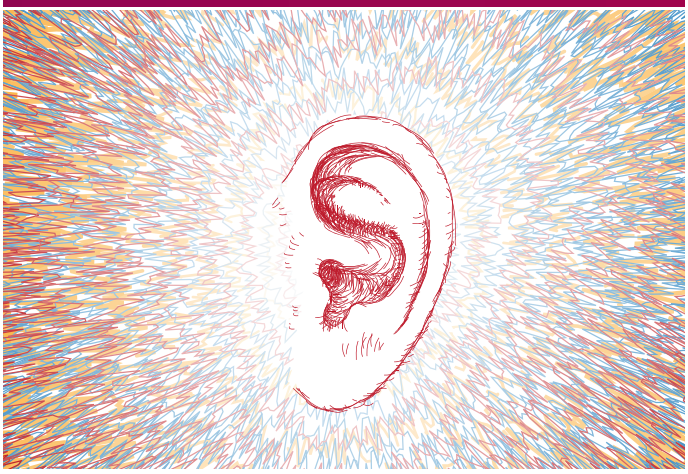
# EDITORIAL



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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 Otology 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 10 interesting articles published in the first quarter of 2023.

We kick off this new issue with a review on the Lancet article, which has raised a lot of interest and led to many discussions, on the association between hearing loss, hearing aid use and all-cause dementia and the different types of dementia. We then offer a review which addresses a key topic: the use of Cochlear Implants or Hearing Aids for children with severe, profound, or total deafness, and what these new findings might imply for performance over time in terms of speech perception, speech understanding and/or executive function. On a different note, one of our reviews offers insight into the position of Otolaryngology with regard to telemedicine, which has been a hot topic since the COVID-19 pandemic. This issue also features two articles that pay a tribute to the late Dr Patricia Stelmachowicz, who was a changemaker in the field of paediatric audiology. Our other reviews are varied such as the relation between self-reported understanding in noise and results of speech audiometry in noise; the use of hearing protection for musicians; the impact of age related hearing loss for people with different profiles; and the importance of the earmold design for the occlusion effect. This issue concludes on a review of the impact of hearing rehabilitation on brain plasticity.

We hope you enjoy this issue of our CRS Scientific Journal

**Mark Laureyns**
Global International CRS & Medical Scientific Research Manager

# ASSOCIATION BETWEEN HEARING AID USE AND ALL-CAUSE AND CAUSE-SPECIFIC DEMENTIA: AN ANALYSIS OF THE UK BIOBANK COHORT


*Jiang F., Mishra SR., Shrestha N.,* et al.
*Lancet Public Health (2023): 13, e329–338*
*doi: 10.1016/S2468-2667(23)00048-8. PMID: 37062296*
*By Mark Laureyns, Italy, Belgium*

**The paper explores the correlation between hearing aid use and dementia. The results showed that subjects reporting hearing difficulty had a 42% increased risk of all-cause dementia compared to the group not reporting hearing difficulty. The subjects using hearing aids did not show such an increased risk.**

## INTRODUCTION:

The Lancet Commission report from 2020 stated that hearing loss (HL) was one of the modifiable risk factors for dementia and that treating HL, such as the use of hearing aids (HAs), might be a way to reduce this risk. Multiple studies have demonstrated that the use of HAs reduces the risk of cognitive decline However, most of these studies were based on a sample size of HA users which was too small, or failed to investigate the relation with specific types of dementia.

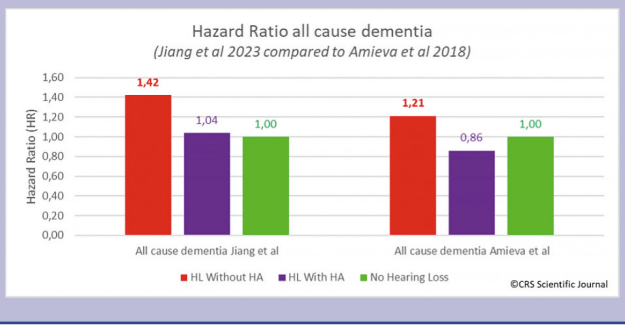
## METHODOLOGY:

This study is based on data retrieved from the UK Biobank, a large long-term population-based prospective study. The study population included a total 437,704 subjects who met the inclusion criteria (i.e. who answered the questions related to HL and dementia) aged between 40 and 69 years at the start of the study over a time period ranging from 2006 to 2010. Of the total group, 57% were female, 26% had self-reported hearing difficulty, 3% were using HAs (i.e., 12% of subjects reporting hearing difficulty). The mean duration of the follow up in this longitudinal study was 12 years.

The criteria of HL was based on self-reported difficulty with hearing, and the possible answers were: "no", "yes" or "I am completely deaf".
Only patients who had responded "yes" to the former question where further asked about HA use, and was based on self-report, confirming the use a HA most of the time.
Dementia and its subtypes were based on the ICF classification in the NHS patient files.
The Biobank also compiled additional data, such as: age; education; level of salary; tobacco and alcohol use; diabetes; cardiovascular information; weight and length; Apolipoprotein E Genotype (genetic risk factor for Alzheimer's disease); feelings of loneliness; social isolation; or depression status.

## CRITICAL NOTE

*This high-quality retrospective longitudinal study offers sound findings as it is based on a large sample and analysed all subtypes of dementia. One limitation, however, is that, since hearing difficulty is based on self-report, the use of the term "hearing loss" in the article, in both the body and the tables, can be misleading. The self-reported HA use is very interesting, unfortunately there is no information on the hours of use per day or subjects' level of satisfaction with HA fitting. Moreover, the HA use criteria was based on registration at baseline. Many subjects could have started to use HAs during the average 12 years of follow up in the study. The results of this study are in line with the findings of Amieva et al 2018.*




## RESULTS:

When correcting for age, gender, ethnicity, socio-economic aspects, smoking, alcohol use, physical activity, BMI, cardiovascular aspects, diabetes and genetic risk factors, the group with self-reported hearing difficulty not using HAs

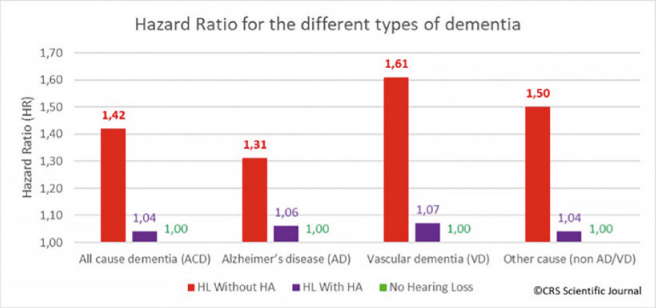
had significantly increased risk *(Hazard Ratio (HR) 1.42)* for all-cause dementia, as compared to subjects without hearing difficulty. There was no significantly increased risk for subjects reporting hearing difficulty and using HAs *(HR 1.04)*.

The risk was higher for the female subjects reporting hearing difficulty not using HAs *(HR 1,56)* than for male subjects *(HR 1,35)*.

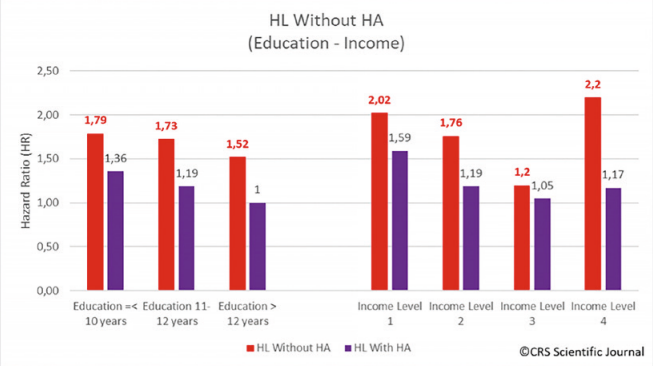
HA use impacts factors which may in turn have an influence on dementia. The authors coined this phenomenon "mediation effect". The mediation effect was 1.5% for social isolation, 2.3% for loneliness, and 7.1% for depression. Consequently, 11% of the influence of HA use on the reduction of risk for all-cause dementia can be attributed to this mediation effect.

The supplemental material provides further information on the following:

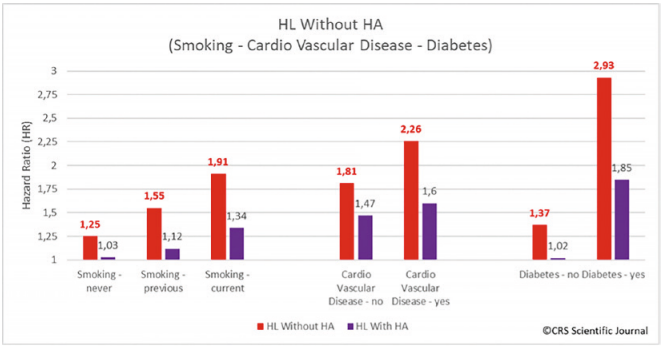
- The different types of dementia. The risk was higher for Vascular Dementia (HR 1,61) than for Alzheimer's disease *(HR 1,31)*.



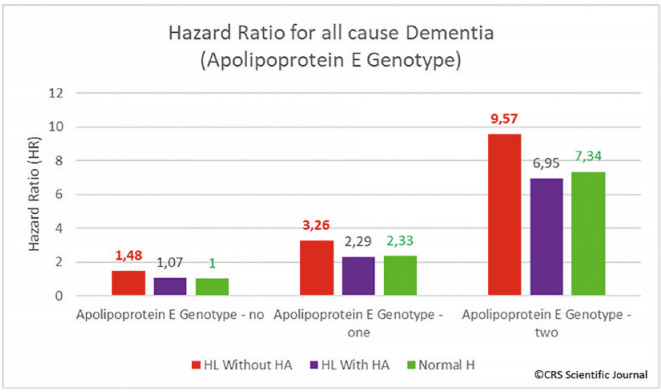

- The socio-economic factors for all-cause dementia. The risk was greater with shorter education *(Education =< 10 years = HR 1.97 - Education > 12 years = HR 1.52)* and lower income *(Income level 1 = HR 2.02 – Income level 3 = HR 1.20)*. However, in the highest income bracket, the risk increases again *(Income level 4 = HR 2.20)*. The authors stress that the income level factor ought therefore to be interpreted with caution, since this could have evolved over the time period of the study.




- Smoking, Cardiovascular Disease (CVD) and Diabetes also increased the risk for all-cause Dementia. *(Current Smokers = HR 1.91; Non-Smokers HR = 1.25 // CVD = HR 2.26 vs No CVD = HR 1.81 // Diabetes = HR 2.93 vs no Diabetes = HR 1.37)*




- Apolipoprotein E Genotype (genetic risk factor for Alzheimer's disease) was found to be correlated to a significantly increased risk for all-cause dementia, for all subjects. However, the group reporting hearing difficulty with no HAs presented a higher risk compared to the other two groups.




## CONCLUSIONS:

The subjects reporting HL had a 42% increased risk of all-cause dementia compared to the group with no self-reported HL. The subjects using HAs did not show this increased risk. This finding was confirmed across the various types of dementia. •

# COCHLEAR IMPLANTS OR HEARING AIDS: SPEECH PERCEPTION, LANGUAGE, AND EXECUTIVE FUNCTION OUTCOMES


*Boerrigter M., Vermeulen A., Benard M.,* et al.
*Ear & Hearing (2023): 44, 411–22*
*doi: 10.1097/AUD.0000000000001300*
*By Cristina Muntane, Spain*

**The authors address whether the selection of Cochlear Implants or Hearing Aids for children with severe, profound, or total deafness entails improved operation over time in terms of speech perception, speech understanding and/or executive function.**

It is acknowledged that almost 80% of learning is incidental for both hearing-impaired children and their normal-hearing peers. This includes life-determining skills, such as vocabulary availability, emotional capabilities, planning and other executive functions, as well as general wellbeing. The authors posit that the ability to overhear conversations in daily circumstances such as noisy environments or third-part conversations might be related to further language, emotional and behavioural development.

As reported in previous literature, both children with moderate hearing loss (HL) with HAs and profound or total HL with CIs have appropriate language and behavioural development compared to normal-hearing peers. It should be noted that in the case of CIs, it has been extensively demonstrated that early implantation, i.e. before 12 months of age, improves conversational and behavioural outcome as opposed to later implantation.
However, for children with severe HL under 12 months, it is yet unclear whether HAs or CIs are the best option. It is indeed suggested in literature that children with profound or total deafness implanted before 12 months of age perform better than children with severe HL with HAs in terms of language development, emotional capabilities, and executive function.

The authors compared paediatric HA users (N=27) with mild to severe HL to paediatric CI users (N=43) with profound to complete deafness in terms of their ability to perceive speech and subsequent language level and executive function. Since noise speech data was only available for CI patients, the authors gathered data from both normal conversation (speech at 65dB) and third-party conversation (soft speech at 45dB). The authors also compared combined HA and CI groups to their normal hearing peers in terms of executive function.

**CRITICAL NOTE**
*The early stimulation of auditive cerebral structures is key not only for language but for emotional and cognitive development in human individuals. Due to preliminary research results, some countries are already lowering the threshold criteria for early CI adaptation.*
*Considering the possible impact this could have in the development of the affected individuals, compounded by the uncertainty of outcomes, particularly for the severely hearing-impaired population, further research would be valuable with more comparable groups.*

**Participants**
The selection criteria followed the World Health Organisation hearing-level classification from 2020:
- Children with severe or profound HL with the best unaided ear average tone being ≥60dB for 1000, 2000, and 4000Hz frequencies (mean PTA 69dB, range 60-97dB).
- Children with profound or total HL with the best unaided ear average tone being >90dB.
- There was no significant difference between both groups for language, education, intelligence, or cognition.

**Data collection**
The authors took advantage of annual follow-up visits to gather data for the study and complement it with additional tests. For this reason, noise test results were only available for CI patients. Data regarding speech perception in quiet at 45 and 65dB was collected by an audiologist for both groups; data regarding vocabulary range was assessed by a psychologist or language specialist; executive function tests were administered by a psychologist.
The authors used a variety of tests to assess the three parameters in randomised order.

**Limitations**

The main limitations of this study are: the late age for cochlear implantation (34 months); the differences in unilateral and bilateral adaptation, with 51% unliteral adaptation for the CI group as opposed to 100% binaural rate for the HA group; and the difference in educational settings across the comparison groups. All these can lead to overestimation of performance in the HA group.

Outcomes for CIs/HAs comparison:

- At 45dB, a statistically significant difference was found between both hearing-impaired groups, with 87% for the CI group and 68% for the HA group for speech perception.
- At 65dB, there was no difference between the CI group and the HA group for speech perception.
- Scores for vocabulary were found to be equivalent.
- Statistical analysis for executive function shows no difference between groups.

Outcomes for variable association:

- No association was found between vocabulary and speech perception at 65dB.
- A correlation between vocabulary and speech perception was found at 45dB in the HA group.

The authors suggest some possible explanations for these results since previous publications show association between speech perception and vocabulary/executive function regardless of the intensity of sound.

Outcomes for impaired/normal hearing comparison

- Vocabulary measurement for CI and HA groups was found to be equivalent to normal-hearing peers.
- Executive function for CI and HA groups was equivalent to normal-hearing peers except for two measured categories: verbal memory in the short and long term; and planning.

When comparing the CI and HA groups, results from the study suggest that perceived speech at 45dB is an element of the skills necessary for developing adequate vocabulary but not sufficient in and of itself. Results from previous studies also highlight that perceived speech at 65dB is sufficient to reach adequate vocabulary level.

When comparing all impaired hearing children to normal-hearing peers, the findings of this study suggest that both planning and memory (short and long term) are reduced for hearing-impaired children. This is consistent with a variety of previous publications and is hypothesised to be related to the reduced development of inner speech in hearing-impaired individuals. Since inner-speech is key in cognitive development and self-regulation, its being impaired could affect executive functions such as planning and memory. However, the authors did not assess expressive vocabulary in this study. Possible correlations with the latter, as they themselves highlight, requires further study. •

# TELEMEDICINE IN OTOLARYNGOLOGY DURING COVID-19: AN EXPLORATORY ASSESSMENT OF PROVIDER AND PATIENT ATTITUDES


*Alwani M., Campiti V., Nesemeier R.,* et al.

*Annals of Otology, Rhinology & Laryngology (2023): 132(2), 155–63*

*doi: 10.1016/j.ijporl.2021.110754*

*By Ryan Johnson-Hunt, New Zealand*

**The article explores behaviours towards telemedicine in otolaryngology. Practitioners at an academic medical center were required to complete a pre-study survey to evaluate their perceptions of telemedicine, followe-up by a post-study survey after a six week telemedicine program to evaluate changes in perception. Patients were also required to provide feedback.**

The modern method of providing healthcare remotely via various means of telecommunications is known as telemedicine. This practice aims to increase the accessibility and availability of healthcare for patients while increasing the effectiveness of healthcare delivery for professionals. Numerous studies have shown how telemedicine may be successfully integrated into a variety of medical specialities, with results demonstrating high diagnostic accuracy, expanded access to doctors, and high patient satisfaction. Despite the lack of research on the role of telemedicine in Otolaryngology—Head and Neck Surgery (OHNS), this subspecialty is suited to telemedicine. Store-and-forward platforms offer true possibilities for sharing exam results (e.g. laboratory studies, audiometric tests, diagnostic imaging, video-endoscopy, etc.) and for the objective assessment of patients remotely.

Problem: Due to social exclusion and quarantine regulations, the COVID-19 pandemic provided a new obstacle for treating patients with safe and ongoing otolaryngologic care.

**CRITICAL NOTE**

*The overall low number of specialists surveyed (especially after the trial period), and the low number of tele appointments conducted make this an area in need of further study. Many of these findings can be extrapolated to the field of Audiological Care and provide the foundation for designing a robust Tele Audiology Program*

Intervention: The Indiana University Otolaryngology Telemedicine Group developed a six-week telemedicine clinic. Surveys: In order to assess overall provider and patient behaviours towards telemedicine in otolaryngology as well as their experience in this pilot outpatient telemedicine clinic programme, provider attitudes were examined before and after the implementation of the programme. Patient attitudes were measured post treatment.

**RESULTS:**

**Provider Pre & Post Intervention Provider Surveys**

**Significant improvement in the following after the six weeks:**

- Physicians feel comfortable communicating with patients when using telehealth services
- Physicians feel at ease in adding telehealth services to their existing clinical workflows

**Telemedicine perceived as suitable for (Percentage of Providers)**

- Triage patients (91.7%)
- Follow-up visits with established patients (83%)
- Diagnosis/management of new patients (66.7%)
- Postoperative visits (41.7%)

**Primary Barriers to Telemedicine use (Percentage of Providers)**

- Inability to perform procedures (58.3%)
- Inability to perform physical exam (41.7%)

**Motivators for Future Telemedicine use (Percentage of Providers)**

- Patient convenience (66.7%)
- Increased patient access (16.7%)
- Improved patient satisfaction (8.3%)
- Triage the need for an in-person visit (8.3%)

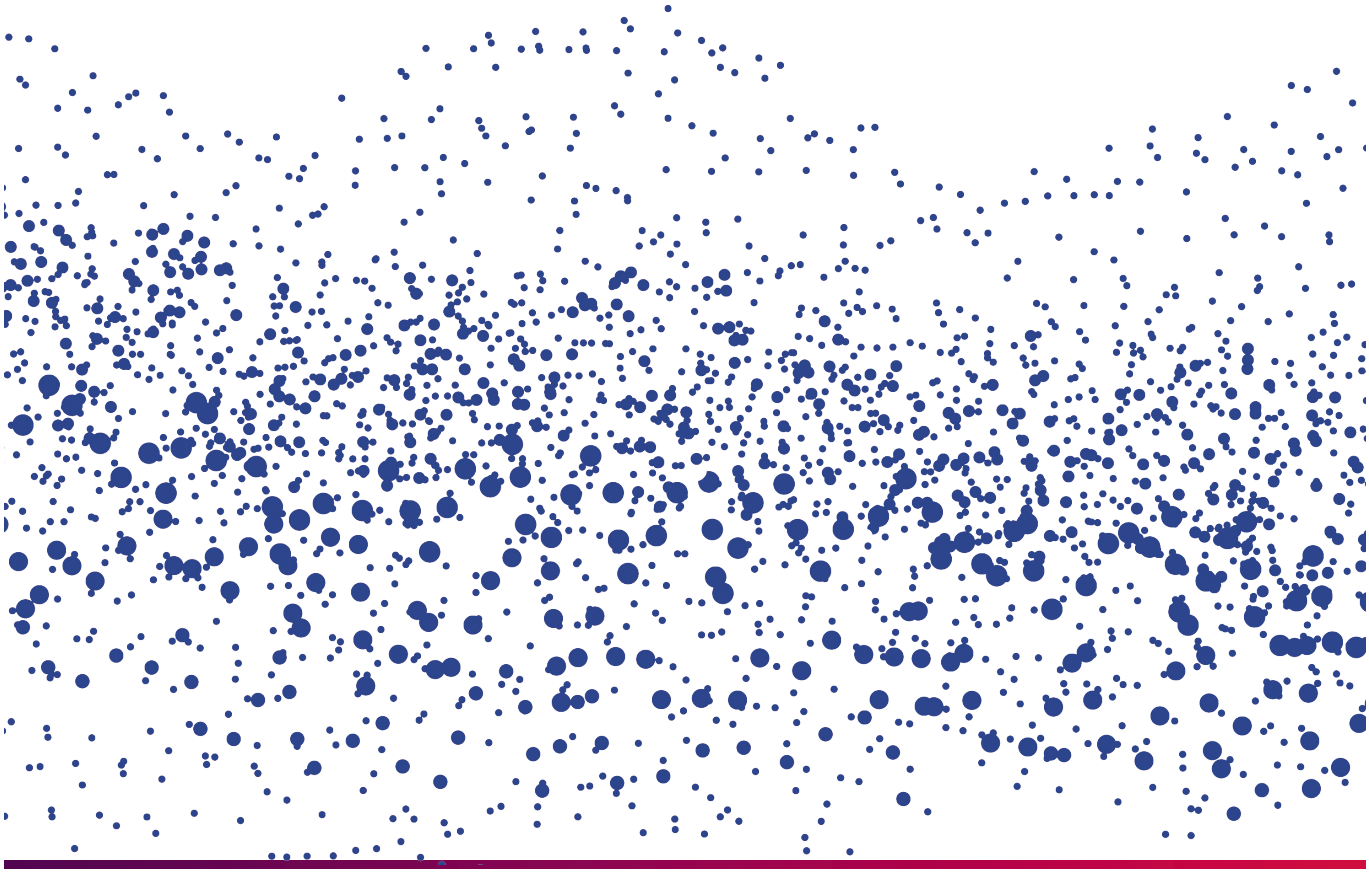
| Provider Individual Encounter Survey | Patient Individual Encounter Surveys |
|---|---|
| • A total of 236 post-visit PrIESQs were completed by faculty members and nurse practitioners over 9 weeks.<br>• 88.1% (208 surveys) were successful virtual encounters, and 11.9% (28 surveys) unsuccessful encounters.<br>• The most common reasons for unsuccessful encounters were audio/visual difficulties and limited server connectivity for the patient.<br>• Providers felt that 11 (5.3%) of the successful encounters were not appropriate for telemedicine. These encounters involved complex cases, where providers felt that an in-person physical exam and procedure were both necessary. | • 101 patients who had virtual doctor visits completed a survey.<br>• 86% (87 patients) reported successful virtual visits, 4% (4 patients) reported unsuccessful ones.<br>• 69% of patients thought that healthcare provided through telemedicine was consistent.<br>• Most patients did not have a strong opinion on whether telemedicine provided better access to healthcare services.<br>• All patients reported that they were satisfied with the quality of service being provided via telemedicine, and none of them disagreed with using telemedicine services again. |

## DISCUSSION

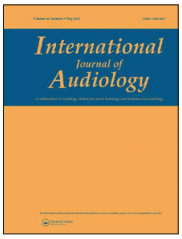
Despite the fact that most providers continued to have medicolegal concerns following virtual appointments, the study revealed favourable attitudes from both patients and providers towards telemedicine in otolaryngology. According to provider reports, the biggest obstacle to the use of telemedicine is the inability to undertake procedures, followed by the difficulty in performing an exhaustive physical examination. Despite the reservations, the study showed that doctors and other healthcare professionals felt much more at ease speaking with patients via telemedicine, and patients also reported that telemedicine gave them better access to care. Of particular note is the significant disagreement among the provider group regarding patients' eligibility for a telemedicine examination and, ultimately, the need for an in-person physical examination to completely address patients' complaints.

## CONCLUSION

This study assessed the attitudes of otolaryngology providers and patients toward telemedicine. Providers reported that telemedicine was most appropriate for triaging patients; the primary barrier was the inability to perform a physical exam. Patients generally had positive experiences, feeling comfortable and understood by their healthcare provider. Overall, both providers and patients had a positive attitude towards the use of telemedicine in otolaryngologic care. •



# RELATIONSHIPS BETWEEN BEHAVIOURAL AND SELF-REPORT MEASURES IN SPEECH RECOGNITION IN NOISE.




*Stenbäck V., Marsja E., Ellis R.,* et al.
*Int J Audiol. (2023): 62(2), 101–9*
*doi: 10.1080/14992027.2022.2047232*
*By Catherine Boiteux, France*

**The authors of this paper analyse the relationship between self-reported measures using SSQ (Speech, Spatial and Qualities of Hearing Questionnaire) and the results of speech audiometry (using the Swedish HINT and Hagerman speech-in-noise test).**

This study sets out to explore the relationship between behavioural and self-reported measured of listening in noise. In the introduction, the authors motivate the choice of tools. A table summarizes the use of the SSQ (Speech, Spatial and Qualities of Hearing Questionnaire) in relation to noise test measures (Swedish HINT and Hagerman speech-in-noise test) from 2012 to 2019. They further highlight that few studies have established the correlation between the self-reports and measurements.

There has been extensive research on the relationship between Pure Tone Audiogram (PTA) and the different ranges of the SSQ. However, to date, there is lack of evidence regarding the correlation between these two elements.
This study proposes to explore the links between the SSQ and two different speech-in-noise tests.

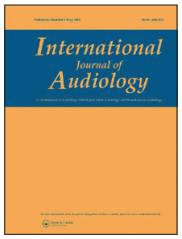
The results show that in normal-hearing people (N = 195 / Average age 62 years) there is indeed a correlation with the HINT (specifically SSQ questions 3, 4, 5 and 12 had a high correlation*), but not with the Hagerman sentence test. This correlation with the HINT suggests that this test has greater ecological viability.

No correlation was found for hearing-aid users (N=191 / Average age 61 years). The authors speculate that this lack of correlation could be explained by the inclusion of subjective assessments that subjects rely on to answer the SSQ and the involvement of cognitive factors. Further research is required to evaluate the impact of such factors.

**CRITICAL NOTE:**
*The group of hearing-aid users was required to perform the speech-in-noise tests with experimental hearing aids with an individual linear gain rule. In contrast, the SSQ was completed without such features (using their own hearing aids). This might explain the lack of correlation between the SSQ and HINT results for this particular group.*

**Question 3: You are in conversation with one person in a room where there are many other people talking. Can you follow what the person you are talking to is saying?*
**Question 4: You are in a group of about five people in a busy restaurant. You can see everyone else in the group. Can you follow the conversation?*
**Question 5: You are with a group and the conversation switches from one person to another. Can you easily follow the conversation without missing the start of what each new speaker is saying?*
**Question 12: Do you have to concentrate very much when listening to someone or something?* •

# OCCLUSION AND COUPLING EFFECTS WITH DIFFERENT EARMOLD DESIGNS – ALL A MATTER OF OPENING THE EAR CANAL?




*Denk F., Hieke T., Roberz M., et al.*
*Int J Audiol. (2023): 62(3), 227–37*
*doi: 10.1080/14992027.2022.2039966*
*By Majda Basheikh, Canada*

**This study offers a review of the factors that lead to occlusion in hearing aid fittings and different earmold designs that can increase patient comfort.**

One of the most common reactions that hearing health care professionals receive from their patients during hearing aid (HA) fittings is that their own voice is too loud. This results from physical and acoustic effects provided by the HA: the physical occlusion of the ear canal increases bone conduction signals at low frequencies, and consequently, the HA's amplification of the user's own voice. Despite the many HA features and software developed to reduce such a perception in wearers, concerns from patients still persist. This study examines venting, earmold design options, and acoustic coupling parameters and their overall effect on the HA user comfort.

This study comprised a sample of ten adult subjects, one of whom had been a HA user since childhood. The remaining nine were normal-hearing (NH) individuals. The choice of relying on a predominantly NH population is explained by the fact that previous studies indicated that the level of hearing had no differential impacts on the occlusion effect. Open and closed jaw impressions were taken of each subject and the length of the impressions went past the second bend. The impressions were scanned for the earmolds to be 3D printed. For each subject, the following six types of earmolds were produced, with each model designed to impact the occlusion effect differently thanks to various physical and acoustic factors:

- Standard Earmold: standard skeleton earmold that reached the second bend of the canal
- Hollow Earmold: same outer shape as standard earmold, but the canal portion was hollowed out to result in a 1.3mm layer in the canal instead of a solid canal
- Skeleton Hollow Earmold: same design as hollow earmold with the addition of three slits into the canal portion touching the canal wall

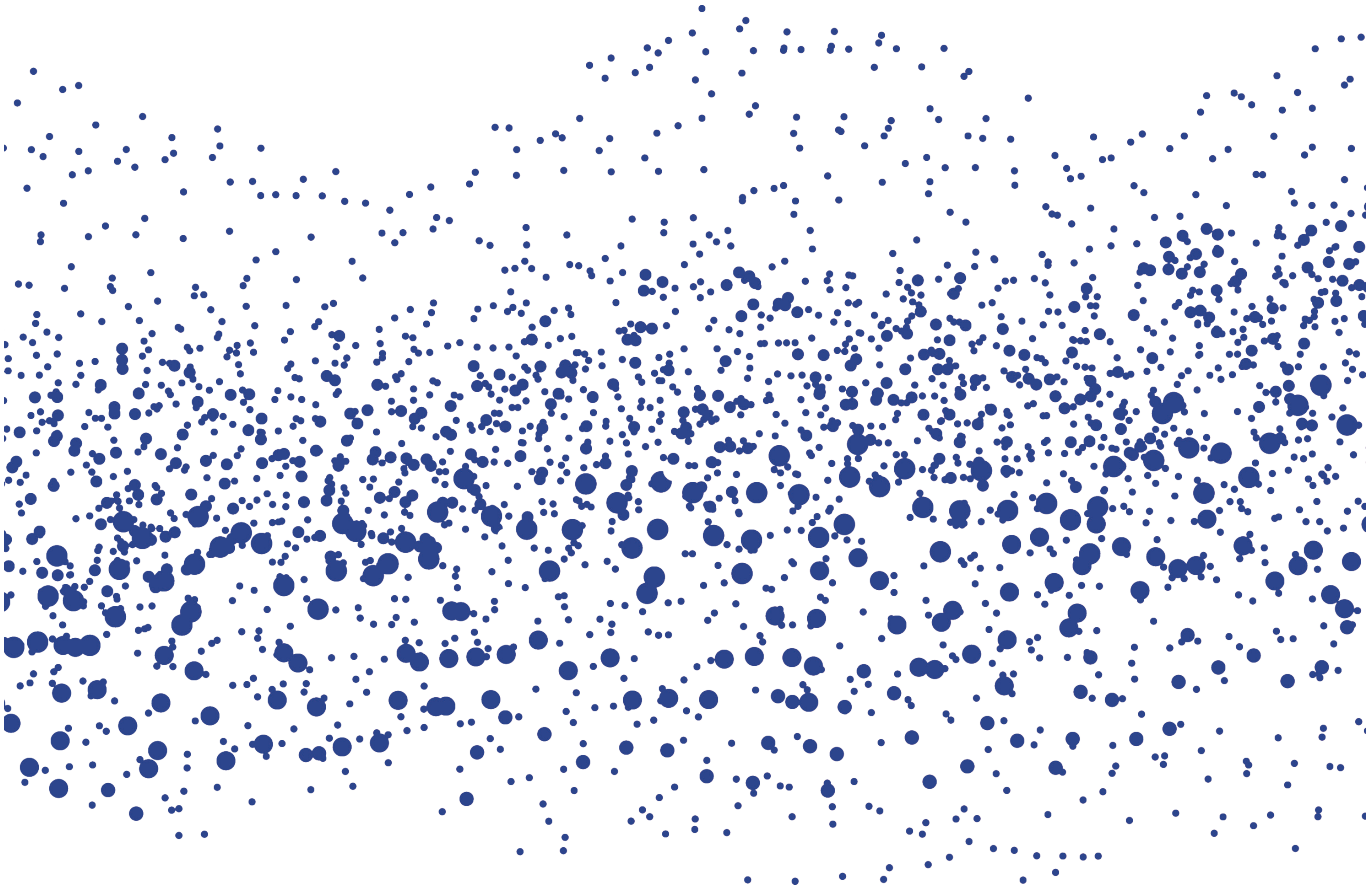
**CRITICAL NOTE:**
*To achieve more natural sound, the vent is not the only consideration that must be made. The overall shape and design of the earmold can have similar effects as vents on own voice quality.*

- Step-Vent Earmold: same features as the standard earmold, with the removal of material at the lower part of the canal and the resulting reduction in length of the canal tip and vent. This also resulted in the formation of a second portion of the vent due to the residual canal volume
- Notched-vent Earmold: same features as the standard earmold with the elimination of the material from the mandibular condyle area, which is expected to contribute to bone conducted generation of acoustic signals that increase low frequencies and own voice perception
- Nugget Earmold: same features as notched-vent earmold, but with the earmold hollowed out further from the notch, further reducing contact with the ear canal walls

Acrylic molds were designed for each type, as well as closed and open vented options for all except the hollow earmold, where it was not possible to offer a closed vent. Sound tubes were attached to the bores and they were coupled to BTE hearing aids. Real-Ear measurements were performed for each condition so as to evaluate the coupling effects of the earmold to the BTE hearing aid (HA) via the Transfer Function Measurement, i.e. the transfer functions from the HA and the loudspeaker to the microphones of the hearing aid. The test subjects were also required to provide an individual rating of the naturalness of their own voice on a scale of 1 ("very unnatural like an earplug") to 10 ("very natural like an open ear").

As expected, the results indicated that the occlusion effect was perceived lowest for the vented earmold versions. The lowest level of occlusion effect was achieved with the Skeleton Hollow earmold; the highest level of occlusion effect were perceived with the Standard earmold. Eardrum responses were vastly different across the different ear conditions at low frequencies. The Standard earmold had the highest response at low frequencies, as it was the most closed option. Furthermore, the earmolds with the highest rated subjective natural perception of own voice (vented Skeleton Hollow earmold) measured as having the worst coupling parameters (i.e. greatest feedback, lowest bass response). A consistent trend was observed with both closed and vent earmolds: coupling quality decreases as own voice quality increases. For vented earmolds, reducing acoustic mass by decreasing contact between the skin and the earmold improved overall comfort. Consequently, heavier molds such as the Standard earmolds, provided less comfort. The Step-Vent earmold features a shortened vent due to the removal of material and therefore has less contact with the canal wall, resulting in a smaller acoustic mass and more overall comfort by opening the ear canal. However, when comparing the Step-Vent to the Standard earmold with equivalent vent diameters, the Step-Vent was reported to have greater feedback.

In conclusion, different earmold conditions provide different perceptions in own-voice quality. More vented options, that essentially open the ear canal, are most optimal for comfort. However, there is a clear trade-off between coupling parameters and own voice quality: improving own voice quality may also reduce overall HA satisfaction by resulting in other detrimental effects such as feedback. •



# SUBJECTIVE IMPACT OF AGE-RELATED HEARING LOSS IS WORSE FOR THOSE WHO ROUTINELY EXPERIENCE BOREDOM AND FAILURES OF ATTENTION


*Crawford CML., Ramlackhan K., Singh G., et al.*
*Ear and Hearing (2023): 44(1), 199–208*
*doi: 10.1097/AUD.0000000000001271*
*By Connie Loi, New Zealand*

**The authors investigate the relationship between subjective experience of age-related hearing loss and psychological factors such as attentional control and trait boredom proneness.**

The relationship between age-related hearing loss (HL) and its impact on the physical and mental wellbeing among the older adults has been investigated at length, as have the benefits of aiding age-related HL. However, HL remains one of the leading untreated conditions among the older-adult population. One of the determining factors for this is believed to be the lack of understanding of the subjective impact of HL.

This study looks into the level of boredom proneness, including state and trait boredom, and the extent to which this might explain why the subjective impact of HL may be worse for certain patients. Research has found that boredom is associated with poorer self-control, impatience, negative self-awareness, narcissism, and attentional difficulties. It is widely known that HL can lead to social isolation. Consequently, it was proposed that loneliness could also be one of the key factors in explaining the relationship between subjective experience of HL and boredom proneness.

The authors posit that individuals who are more prone to boredom would experience greater negative subjective impact of age-related HL due to their poorer attentional control, contributing to difficulties engaging in social situations due to noisy environments.

## PARTICIPANTS:

- A sample of 1,840 adults aged 50 years old and above, recruited from hearing care clinics throughout Canada.
- Most participants were aged between 50–69 years old (34.2% aged 50–59 years; 37.3% aged 60–69 years)
- Most participants had normal hearing (32.9%) or minimal HL (32.9%).
- Women accounted for 57.6% of the total sample, an men for 42%.

Tools and methods:

This study used multiple self-report measures:

**CRITICAL NOTE:**

*This study provides a novel insight into how individuals' experience and perception of hearing loss can be affected by psychological factors such as boredom and attentional control. This offers a reminder to us, as audiologists, to be mindful of providing a holistic patient-centred care approach, not limited by audiological practice standards but establishing hearing rehabilitation that is suitable according to individual differences and needs. This enables us to improve the negative outcomes of long-term HL, including depression and dementia.*

1. Eight-item Short Boredom Proneness Scale (SBPS) to measure individuals' tendency to experience boredom
2. Eight-item Mind-Wandering: Deliberate/Spontaneous Scale (MW-D/MW-S) to assess individuals' tendency to experience mind-wandering
3. Hearing Handicap Inventory for Adults – Screening (HHIA-S) to measure the subjective impact of hearing-related issues
4. Speech, Spatial and Qualities of Hearing Scale to measure the level of listening effort and the strain associated with
5. PROMIS Cognitive Functions and Abilities Scale-Short (PROMIS) to measure self-reported level of cognitive function

Audiometric thresholds were also obtained through pure tone audiometry (PTA) in order to obtain an objective measure of hearing ability.

## RESULTS:

**Hypothesis 1:** To investigate variances in the relationship between long-term exposure to boredom and the subjective impact of age-related HL.

- Significant positive correlations were found between these two factors, where higher levels of subjective impact of

HL and listening effort were associated with higher levels of boredom proneness.

**Hypothesis 2:** To investigate the relationship between boredom proneness and subjective impact of age-related HL mediated by poorer attention control.

- Significant correlations were found between the effect of boredom proneness and subjective impact of age-related HL, which could be mediated by poorer attention control.

No evidence was found to support the relationship between boredom proneness and objective audiometric results. •

# QUANTIFYING ACCESS TO SPEECH IN CHILDREN WITH HEARING LOSS:

## THE INFLUENCE OF THE WORK OF PAT STELMACHOWICZ ON MEASURES OF AUDIBILITY


*Wiseman KB. & McCreery R.*

*Seminars in Hearing (2023): 44(1), S17–S28*

*doi:10.1055/s-0043-1764136*

*By Pierre Devos, France*

**The authors offer an overview of the context and goals of the "PTA calculation", the "Articulation Index" and the "Speech Intelligibility Index" leading to the more efficient index called "Auditory Dosage", designed to evaluate the impact of hearing loss and predict language outcomes of children equipped with hearing aids.**

The authors highlight the contributions of Dr. Stelmachowicz, on establishing the relationship between audibility and outcomes of hearing-impaired children. From the beginning of 20th century, four tools have been used to quantify audibility: PTA calculation; Articulation Index / Audibility Index; Speech Intelligibility Index; Auditory Dosage, which is the most recent. The authors offer an overview of the context and goals of each of these and the scientific contributions of Dr. Stelmachowicz leading to this last more efficient index, designed to evaluate the impact of hearing loss (HL) and predict language outcomes of children equipped with hearing aids (HAs).

**PTA (Pure-Tone Average)** was the first ever test designed to quantify patients' audibility and determine hearing technology candidacy. This test, published by Fletcher in 1929, proposed calculate an arithmetic average of pure tone thresholds at three or four frequencies. However, no universal convention regarding the frequencies to be used. Most often, the average was calculated from three (0.5kHz + 1kHz + 2kHz) or four (0.5kHz + 1kHz + 2kHz + 4kHz) values. It has since been established that this simple index is not sufficient to predict language outcomes, especially for children. Numerous factors influence speech rehabilitation, such as age of diagnosis and hearing technology fitting, time of use etc. We also need to evaluate audibility with hearing instrument and consider higher frequencies that have been proved to be prevalent into speech discrimination in noise process. Adults with prior hearing experiences can compensate for this lack in higher frequencies; children, however, must build his language based on information transmitted by his hearing instruments. This is the basis of Pat Stelmachowicz research!

PTA is limited for quantifying child's access to speech because it does not include information above 4000 Hz.

In 1940's, Bell Telephone Laboratories worked to determine the ideal bandwidth for understanding of speech in communications technologies. They created the **Articulation/ Audibility Index** (AI) that expressed "the proportion of the speech signal that is audible to a listener /../ that is calculated by summing the importance-weighted proportion of the speech signal that is available to the listener at different frequency-bands" using an equation. For the first time, the notion of "critical frequency band" is considered and each frequency is weighted based on its importance in the speech discrimination process. As it is usable with and

without HAs, AI has been largely used in audiology fields for counselling tools for parents. Many studies conducted by Pat Stelmachowicz proved:

- the efficiency of the DSL algorithm (higher AI values)
- the need for higher listening levels for children
- the need for children to access to extended frequency bandwidth (above 4 kHz !)

Subsequently, Killion & Mueller translated AI into a "count the dots" method, the use of this index as a counselling tool has been developed to describe patient's hearing situation and outcomes.

It is on this same basis that the **Speech Intelligibility Index (SII)** was developed: the proportion of the speech spectrum that is accessible to the listener. The spectrum is divided in "dots", 0 means "no access" and 1 means "access".

This new index integrates more parameters related to speech and noise level, speech material, high speech level induced distortions and audiometric curve slope. This approach gave a more realistic index to describe patients' hearing that could more efficiency predict spoken language, literacy and academic outcomes.

As a key player in the Outcomes of Children with Hearing Loss (OCHL) Consortium, Dr. Stelmachowicz contributed to the execution of many hearing-impaired children focused studies, leading to the integration of SII into recommendations for candidacy to HA or cochlear implants and into modern audiological equipment. Together with the assessment of REM / RECD measurements, SII became an efficient, individualized predictor of speech perception, taking into account personalized anatomic characteristics that highly influence the higher-frequency part of the spectrum, especially for children under five years of age.

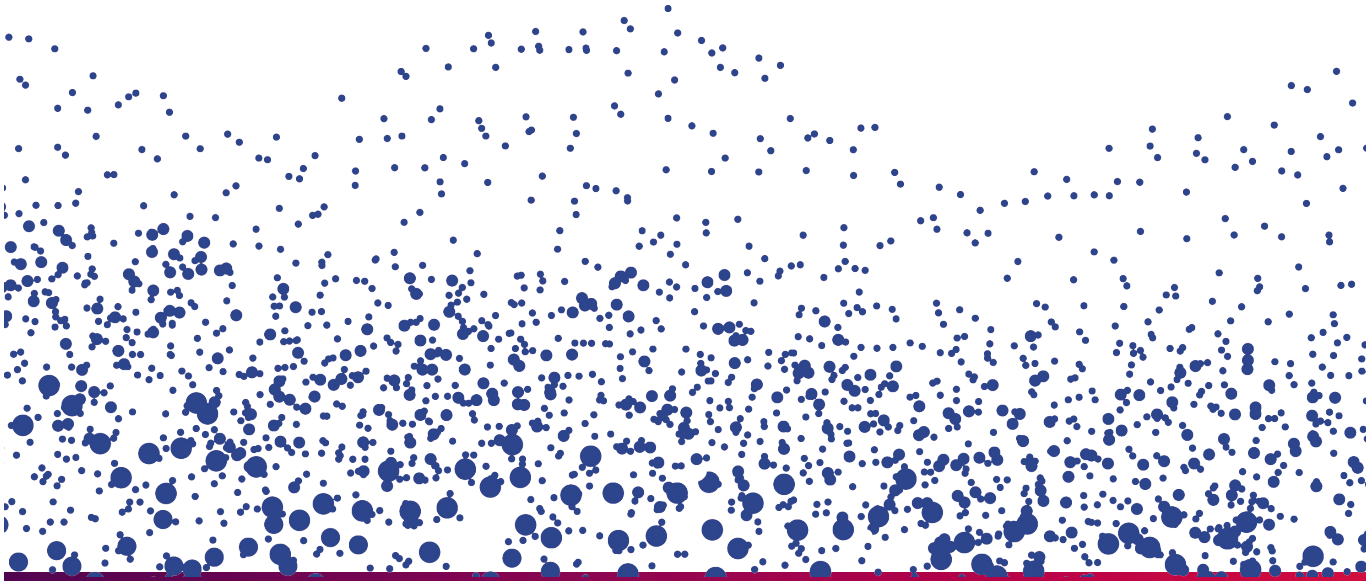
**CRITICAL NOTE:**
*The introduction of Auditory Dosage, where not only the gain and audibility are evaluated, but also the time of stimulation, is ground-breaking.*

Various retrospective studies are currently being carried out, and more recently some authors associated the concept of speech audibility to the cumulative auditory experience of children: how much audibility during how much time?

This is the concept of **Auditory Dosage**, to confront the descriptive aspect of SII to the time of use of the HAs. Without that latter dimension, SII was not efficient enough to predict any language outcome with hearing-impaired children. This new index value provides a more nuanced evaluation of audibility in the long term. Some children have better residual audibility (without HAs) than others; some wear their HAs with more perseverance than other pairs, etc. All these factors lead to different outcomes! Auditory Dosage accounts for intensity and duration of auditory access and quantifies access relative to both unaided and aided audibility and HA use. Auditory Dosage represents the sum of a child's hours of HA use, weighted by their aided SII, and their hours of non-use, weighted by their unaided SII :

$$\text{Auditory Dosage} = \text{HA use}^{\text{Aided SII}} + (24 \text{ hours} - \text{HA use})^{\text{Unaided SII}}$$

Authors concluded saying that "the emergence of auditory Dosage as a new measure audibility demonstrate how Pat's work continues to influence our understanding of the relationship between audibility and outcomes in children with hearing loss". •



# EXTENDING THE HIGH-FREQUENCY BANDWITH AND PREDICTING SPEECH-IN NOISE RECOGNITION: BUILDING ON THE WORK OF PAT STELMACHOWICZ.


*Monson BB. & Trine A.*

*Seminars in Hearing (2023): 44(1), S64–S74*

*doi: 10.1055/s-0043-1764133*

*By Pierre Devos, France*

**This article pays tribute to the late Dr Patricia Stelmachowicz (who passed away in January 2021) and her contributions to the field of paediatric audiology. The authors offer a contextualised overview of her key works during her 30 years of research.**

Many recent studies discuss the (extended) high-frequency tone audiometry as a predictor of speech understanding capacities in noisy environments. High-frequency means > 6kHz, extended high-frequency (EHF) means > 8kHz, until 16kHz. Contrary to what was believed until now, "speech bandwidth" or "Speech bananas" are therefore not limited to 8000Hz.

The first studies focusing on defining the speech bandwidth were conducted by communication technologies engineers with adults subjects, and at a time where transducers (microphones and receivers) were limited. Thanks to technological advances, current transducers offer more capacities. In addition, over time research has demonstrated that children need more level and, above all, more high-frequency speech components than adults to build their language and speech capacities. One of the pioneers in studying the role of high-frequencies in discrimination processes for the youngest population is Dr. Stelmachowicz. She developed the first prototypes of high-frequency audiometers for investigating detection thresholds above 8kHz in children and for further studying the role of audibility in speech discrimination in quiet and noisy environments for this population. The first and most important conclusion was that children need a larger frequency bandwidth than adults to understand speech, especially if the talker is a female or a child. This challenged previous beliefs that frequencies above 4kHz did not contribute in any significant way to speech discrimination.

The findings of Dr. Stelmachowicz led to the following determinations:

- We need a specific approach for testing and fitting children with HL
- We need a child-appropriate Speech Intelligibility Index based on female voice to integrate the 8kHz octave band (spreading from 5.6kHz to 11kHz).

Several studies conducted in 2014, 2015 and 2019 confirmed the contribution of high frequencies until 10 or 13kHz for speech recognition in children. They found that, not only can children detect and use speech energy around 13kHz, these frequencies contribute to ameliorate speech segregation and phonetic cues in noisy environments, particularly when the talker is facing the listener (0° azimuth) because of the directional aspect of higher frequencies.

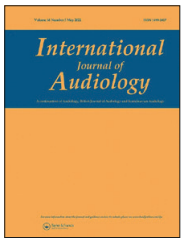
More and more authors continue to correlate high frequency audiometry results to speech in noise discrimination. Consequently, EHF audiometry is regarded as a new diagnostic tool for highlighting "hidden deafness" and objectivate hearing in noise complaints in patients with "normal" hearing. Such hearing difficulties can be attributed to underlying causes such as auditory central processing disorders, cochlear synaptopathy, neuropathies or other lesions to the auditory system. However, high frequency hearing loss may be one of the most common sources of difficulties in noise. Today, we have normalized material to assess patients as well as hearing aids with extended bandwidth (up to 12kHz), meaning high-frequency tone audiometry should become a common test for hearing evaluation. This is particularly true for paediatric patients, who could benefit greatly from this audibility and potential rehabilitation. •

**CRITICAL NOTE**

*This article offers evidence that the time has come for us to focus our HA fittings above 6kHz, with adapted REM material and/or 0,4cc coupler (which is more appropriate than 2cc for higher frequencies). The audiological community must also convince health authorities of the importance of high-quality hearing aids for children, regardless of the degree of hearing loss. Unfortunately, in the current hearing technology landscape, frequency bandwidth is one of the points differentiating high-tech and low-tech hearing devices.*

# EVALUATION OF HEARING PROTECTION DEVICE EFFECTIVENESS

## FOR MUSICIANS




*Crawford K., Willenbring K., Nothwehr F.,* et al.

*Int J Audiol. (2023): 62(3), 238–44*

*doi: 10.1080/14992027.2022.2035831. Epub 2022 Feb 10. PMID: 35143376*

*By Julin Teo, Italy, Australia*

**This study evaluates hearing protection devices (HPDs) effectiveness and uniformity in attenuation across three types of HPDs and across various frequencies. They further explore the correlations between a range factors and frequency of use.**

Over the last 30 years, three main types of Hearing Protective Devices (HPD) have been developed and marketed to musicians for reducing risk of exposure to loud sounds: formable foam earplugs; non-custom; and custom Uniform Attenuation ear plugs (UAEs).

However, despite the widespread availability of HPDs, the uptake of these devices amongst musicians continues to be low because of a number of factors, such as comfort, sound perception, ease of use and users' own attitude towards the risks and consequences of hearing loss.

This study aims to evaluate the quality and consistency of sound attenuation for each of the three HPDs, and to determine the relationship between measured effectiveness and self-perceived advantages and disadvantages over a six-month period.

A total of 24 musicians were enrolled in this study, with ages ranging from 20 to 60 and over , as well as varying experience with HPDs, hearing levels and tinnitus. These participants were presented with an overview of hearing conservation topics at the initial visit and were then trained on proper HPD insertion technique at fittings.

Participants' hearing was assessed at baseline, and the authors subsequently measured the personal attenuation of each participant with each of the three HPDs was thanks to audiometric testing across 125Hz to 8000Hz frequencies. In addition, their attitude towards hearing loss and conservation was assessed thanks to the Health Belief Model (HBM) survey. Participants were asked to fill in follow-up surveys on frequency of use and perception of each HPDs at various timepoints: week 1; month 1; month 3; and month 6.

For all three HPDs, personal attenuation varied across frequencies, but was greatest with the foam earplugs. The least variation in the attenuation from manufacturer rating was with custom UAEs, which is likely due to the fact that they are seated in one fixed position in the ear. However, it should be noted that despite UAEs ability of remaining in a stable position, their effectiveness is affected by anatomical differences in the individual ear, and the eventual position of where the UAE seats in the ear. Some users found it challenging inserting custom UAEs and therefore did not manage to achieve the seal required for effective attenuation. Appropriate sizing of the non-custom UAEs was also a factor influencing the effectiveness of attenuation and hence should be taking into consideration when selecting or fitting them to individual ears. Foam earplugs can provide uniform attenuation response if they are inserted deep into the ear canal.

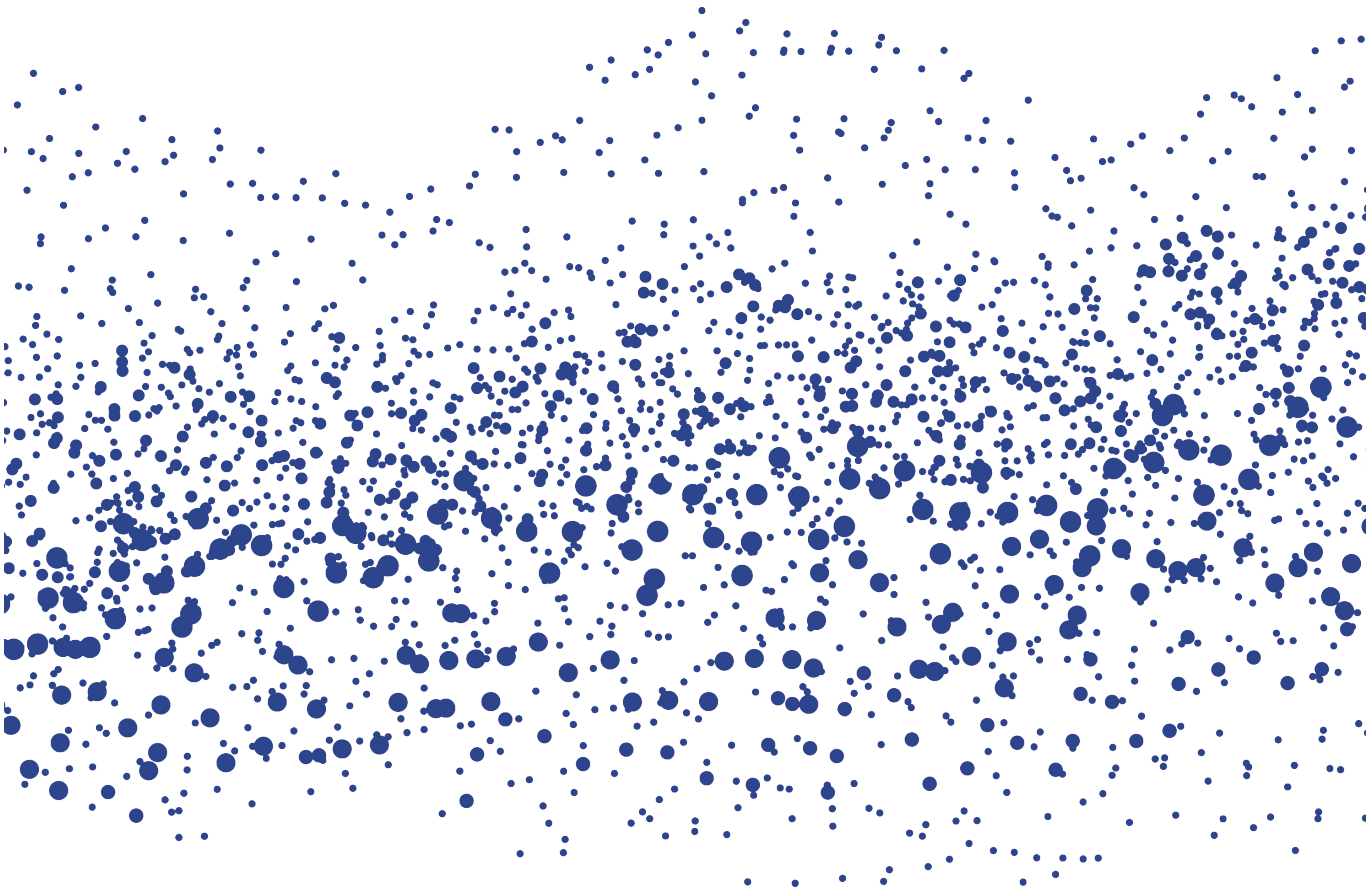
**CRITICAL NOTE**

*Uniform Attenuation Ear Plugs (UAEs) can be effective in reducing the risk of exposure to loud sounds for musicians, regardless of whether they use custom or non-custom forms. However, the effectiveness of attenuation for both forms of UAEs are dependent on appropriate sizing/ fitting and user insertion technique. The comfort and sound perception are also important factors to consider as these are perceived as barriers to users which then affect the frequency of Hearing Protective Device (HPD) usage. It should be noted that the sample size of this study is limited and the self-reported rating survey forms that were used had not been validated even though it was constructed and modelled based on the Health Belief Model and other previous studies. Further studies should include different models of each of the three forms of HPDs, and investigate the most effective way to assess UAE performance in a clinical setting.*

These results demonstrate the need for proper fitting of all HPDs regardless of custom or non-custom forms. This study further recommends validating HPD fittings with a fit check system for foam earplugs if available, or the use of Real-Ear Attenuation at Threshold (REAT) measurements.

The authors highlight that the frequency of use of HPDs tends to decline after three to six months. This indicates the possible need for re-engaging users at the three-month mark.

The findings of this study concur with similar results in previous studies on the correlation between frequency of HPD use and the perceived barrier of reduced auditory perception during musical activities. There is no one best type of HPD for all study participants. Instead, HPD preference was influenced by various factors such as the type of musical activity performed. As a result, the authors recommend that Audiologists should discuss the pros and cons of each type of HPD for different musical activities. •



# PLASTICITY AFTER HEARING REHABILITATION IN THE AGING BRAIN.


*Lazard DS., Doelling KB. & Arnal LH.*

*Trends Hear. (2023): 27, 1–12*

*doi: 10.1177/23312165231156412. PMID: 36794429; PMCID: PMC9936397*

*By Sofie Peeters*

**The authors explore plasticity after hearing rehabilitation post cochlear implantation. The majority of subjects (regardless of age) increased speech intelligibility between six and 24 months after implantation. Based on findings, patients were grouped into one of three plasticity profiles. The second largest maintained speech intelligibility after two years. The smallest group showed a decline of speech audiometric results after two years, correlated to a higher representation of older subjects.**

The statistical association between presbyacusis and dementia, demonstrated in many studies also suggests that, by corollary, rehabilitation and interventions for the auditory system could result in reactivating or maintaining the cognitive activity of the aging brain.

In this study a dataset of 2,251 unilateral cochlear-implant recipients (17–93 years, implanted between 2003 and 2011) was reanalysed (Blamey et al., 2013, 2015; Lazard, Vincent, et al., 2012). All participants received auditory training, however, no information on the number and length of sessions was provided. The researchers collected results of the best aided speech audiometry in quiet pre and post implantation (two timepoints). In addition, postoperative testing was conducted on average after six months and two years. The same speech material and test conditions were used.

In order to investigate the influence of age, the investigators divided the population into two subgroups: one 'older' group, with a cut off age of 70 years at implantation; a 'younger' group. The study design used the cut-off age of 70 years because earlier studies (Blamey 2012, Lazard 2013) had demonstrated that from that age onward, the results on the aided speech audiometry in quiet with cochlear implants was poorer and declined faster.

The impact of age at implantation was only minimal for the speech audiometric results at six months post implantation, and these results improved further for all subjects at the second session, 24 months post implantation. However, this relative gain was negatively correlated with age and declined further from 67 onward.

**CRITICAL NOTE**

*Although this study is based on a large sample of 2,251 cochlear implant users, and despite the value of the hypothetical profiles developed in the article, the findings should be taken with caution. It is challenging to interpret such results without first reading the multicentric study the authors reference (Blamey et al, 2013)*. Indeed, it provides more insight into the inclusion criteria, the distribution of the different brands and types of cochlear implants, the fact that the data collection includes recipients with the date of implantation from 2003 onward and how speech audiometry was conducted in different languages (in 15 different international centres in total eight different countries) and on different presentation levels. Since 2003, cochlear implants and fitting procedures have evolved Moreover, comparing speech audiometry results across different speech lists and different languages may also influence the results. Consequently, the results detailed here should not be generalised.*

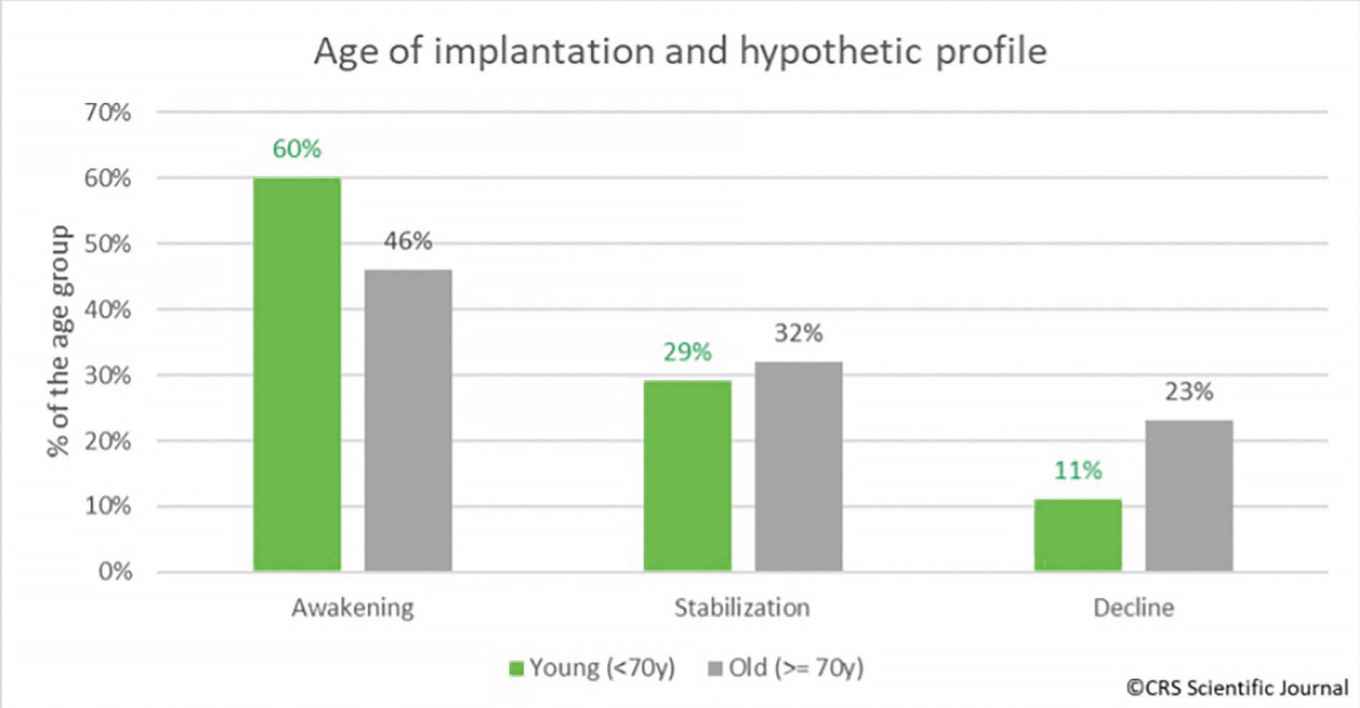
A secondary analysis enabled the authors to define three hypothetic profiles based on the plasticity effects found in each subgroup after implantation:

1. the Awakening profile: this group improves most on the speech audiometry results between the first (six months) and second point (24 months) post implantation (> 15% improvement on intelligibility). The 'younger' group was more represented (60%) then the older group (46%) in this profile. The auditory system is reactivated after implantation.

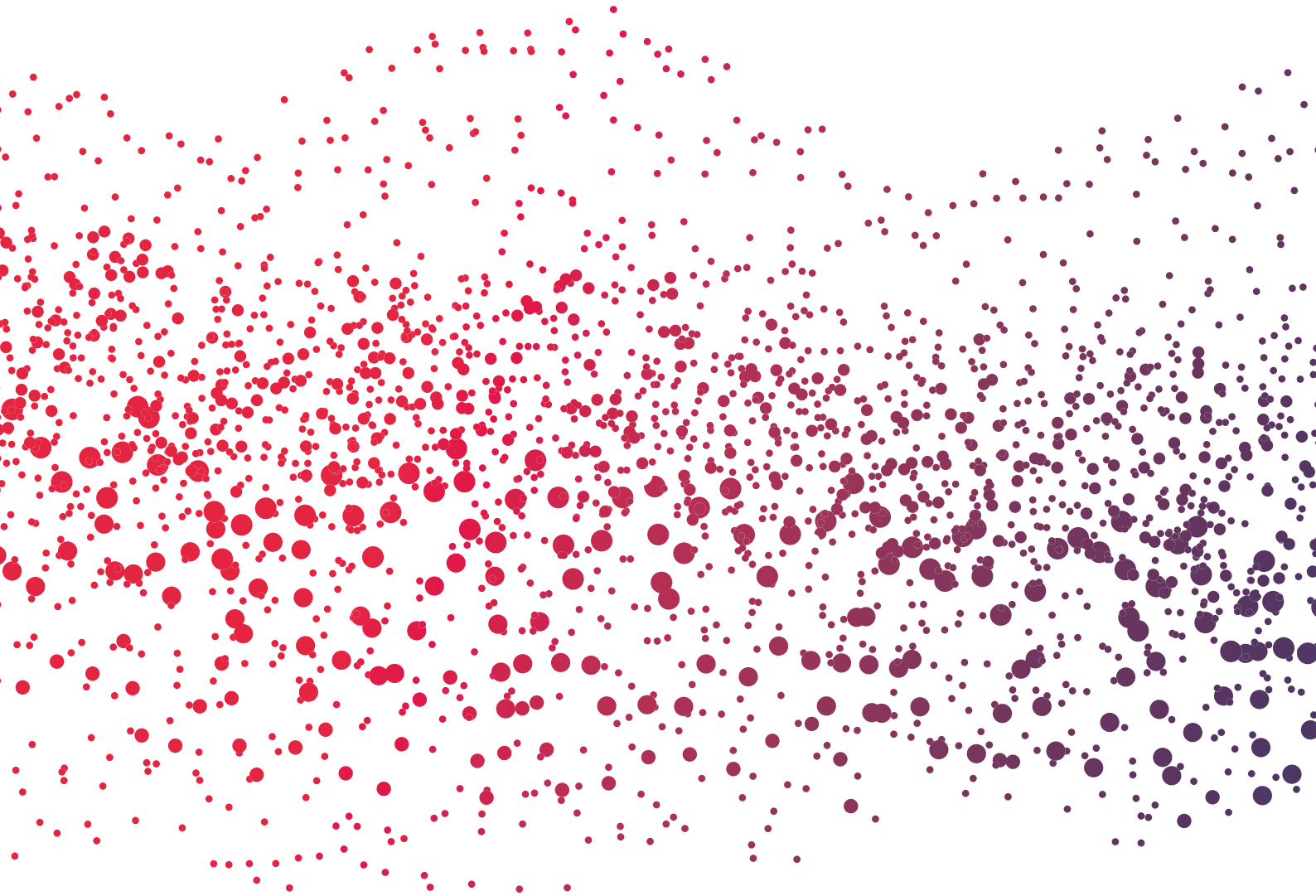
*Blamey P, Artieres F, Başkent D, *et al.* Factors affecting auditory performance of postlinguistically deaf adults using cochlear implants: an update with 2251 patients. Audiol Neurootol. 2013:18(1), 36–47. doi: 10.1159/000343189.

2. the Counteracting profile: this group maintains or slightly improves the speech audiometry results (0 to 15% improvement on intelligibility) between the first and second post implantation timepoints. The 'younger' and 'older' group were equally represented (respectively 29% and 32%) within this profile. The auditory system is stabilized after implantation.

3. the Decline profile: this group shows a decline of the speech audiometry results between the first, and second point post implantation. The 'older' group accounted for 23% of this profile, as opposed to only 11% for the 'younger' group. The functionality of the auditory system declines after implantation.




A combination of factors could potentially lead to poorer plasticity in the auditory system and cognitive decline, resulting in the deterioration of speech audiometry scores post implantation. One of the risk factors could be cardio-vascular problems, which negatively impact white brain matter. On their part, white matter lesions have been found in other studies to be correlated with degraded cochlear implant speech scores. Further studies could use neuroimaging in order to obtain a clearer image of the impact of auditory rehabilitation and the factors responsible for cochlear implant outcome decline. •



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