



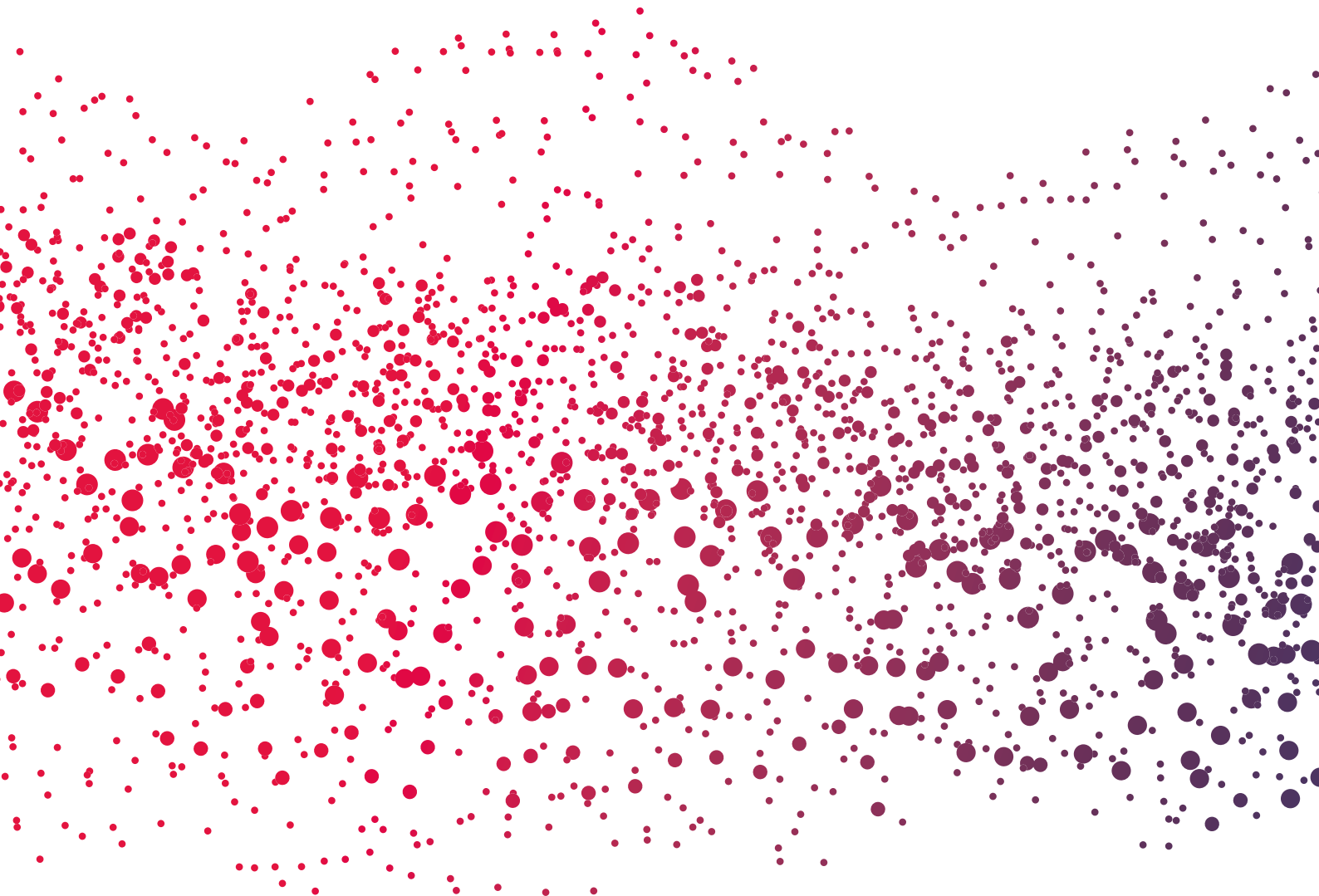
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CRS SCIENTIFIC JOURNAL

Otology & Audiology Article Review

Volume 7
September 2024



Over-The-Counter
Hearing Aids: Are They
Safe and Effective?

Contribution of Tinnitus
and Hearing Loss
to Depression.

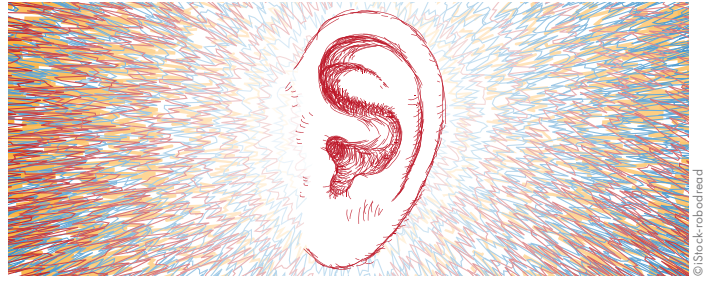
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EDITORIAL



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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 Otolaryngology 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 ten interesting articles published in the second quarter of 2024. Three reviews cover the accessibility and/or the effectiveness of various hearing devices, such as Over-The-Counter Hearing Aids, Hearing Aids and Implantable Hearing Devices. Two articles explore the emotions and perceptions in Audiology and Hearing Health Care. Understanding these emotional and perceptual factors is crucial for delivering person-centred hearing care, which could be a key driver in improving patient satisfaction. The topic of speech audiometry in noise is covered in two different articles. The first looks into the potential of Automatic Speech Recognition, while the second investigates the impact of the Number of Digits Used in the Digit in Noise Test. The findings suggest that two digits seems optimal for a screening test across all age groups. Increasing the number of digits poses greater challenges for older individuals, as it consumes more cognitive resources. In the article titled 'Contribution of Tinnitus and Hearing Loss to Depression,' the severity of tinnitus is found to be directly correlated with an increased risk of depression, with hearing loss further exacerbating the depressive symptoms when tinnitus is the primary condition. Lastly, two reviews focus on asymmetric hearing loss: the first one looks into the outcomes in patients with bilateral cochlear implants and the second investigates the Auditory capacity of the better-hearing ear.

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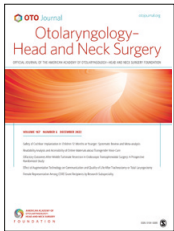
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The authors have sole responsibility for the content of their articles.



OVER-THE-COUNTER HEARING AIDS: ARE THEY SAFE AND EFFECTIVE?



Shah R., Wilkins SG., Panth N., et al.
Otolaryngol Head Neck Surg. (2024): 20
doi: 10.1002/ohn.817. Epub ahead of print.
PMID: 38769863.

By Mark Laureyns – Italy – Belgium

This study aims to evaluate the safety and efficacy of over-the-counter (OTC) hearing aids (HAs) compared to prescription HAs by measuring the variance in testbox output results, comparing the default settings of both types of HAs against the NAL-NL2 target at three input levels, as well as the Verifit estimated UCL for the three types of audiogram profiles.

CRITICAL NOTE

Regrettably, this study and accompanying article lack the necessary rigour; which is disappointing. Given the limited sample of devices examined, it is unsurprising that only few significant differences were observed. Additionally, the study's reproducibility is compromised by the omission of specific details regarding the three audiogram types evaluated.

Regarding safety, the finding that the default maximum output for OTC HAs significantly exceeds the Verifit-estimated UCL at 8000 Hz – by 30, 32, and 22 dB for the gradual high-frequency sloping, sharp high-frequency sloping from 2 kHz, and low-frequency inverse sloping audiograms, respectively – is a serious concern. This is particularly troubling given that OTC HAs are not equipped with a maximum output control to mitigate this issue. Furthermore, since the authors present only averaged results across the three devices, it is likely that at least one of the devices exceeds these limits by an even greater margin. Another important consideration is accuracy. Figure 2 illustrates that the average OTC results deviate by up to 10 dB or more from the NAL-NL2 targets, particularly at high frequencies. Contrary to the authors' claims, these discrepancies are also evident at soft and average input levels.

Concerning noise reduction, it is perplexing that the results are not addressed, despite being detailed in the methodology. It remains unclear whether the omission was due to disappointing findings or another reason.

Finally, attempting to demonstrate that OTC HAs are as safe and effective as prescription HAs solely by evaluating the default first fit on a Verifit Testbox is fundamentally flawed. Prescription HAs are accompanied by audiology support services, including essential components such as verification and fine-tuning processes. The fact that the study focused on the most advanced OTC HAs while comparing them to lower-end prescription models, resulting in default maximum outputs exceeding the Verifit-estimated UCL at 8000 Hz by more than 20 dB across all audiogram types, raises serious concerns.

INTRODUCTION

In the United States, hearing aids (HAs) are not covered by basic Medicare, as they were classified as 'routinely needed and low-cost medical devices' when this scheme was first launched in 1965. According to the authors, only 20% of adults with hearing loss (HL) in the U.S use HAs, with stigma and cost identified as the main barriers to HA adoption. In 2022, the FDA ruled that patients aged 18 and older no longer require an audiological diagnosis or medical evaluation to obtain OTC HAs. The intention of the article

under review is to establish a foundation for determining the safety and efficacy of OTC devices.

METHODOLOGY

The authors selected the four best-performing OTC HAs from a range of devices they had analysed, along with two prescription HAs offering comparable features and fitting options to the chosen OTC models.

The manufacturer's default fit for three different audiogram profiles – gradual high-frequency sloping; sharp high-

frequency sloping from 2 kHz; and low-frequency inverse sloping – were evaluated for the six devices, using 2cc coupler measurements in a Verifit Testbox. These measurements were conducted at input levels of 55, 65, and 75 dB SPL and compared against the NAL-NL2 fitting targets. The maximum power output (MPO) was verified against the Verifit-estimated uncomfortable loudness levels (UCL) for the three audiogram types. Lastly, noise reduction capabilities were assessed by measuring the attenuation of a broadband 60 dB SPL multi-talker babble signal in the testbox. Results for each condition were averaged between the left and right HAs.

RESULTS AND DISCUSSION

Regarding efficacy, the authors assessed the difference between the NAL-NL2 fitting rule and the actual testbox results for input levels of 55, 65, and 75 dB SPL across three distinct audiogram profiles. They concluded that OTC HAs are comparable in effectiveness to ‘minimally adaptive and basic forms of prescriptive hearing aids’, as no significant differences were observed. However, in the discussion, the authors state that OTC devices tend to show a greater deviation from the fitting rule (target) compared to prescription aids, across all types of HL, particularly at higher frequencies and higher input levels. Despite this trend, the authors expressed reassurance when considering previous findings on user satisfaction between OTC and prescription HAs.

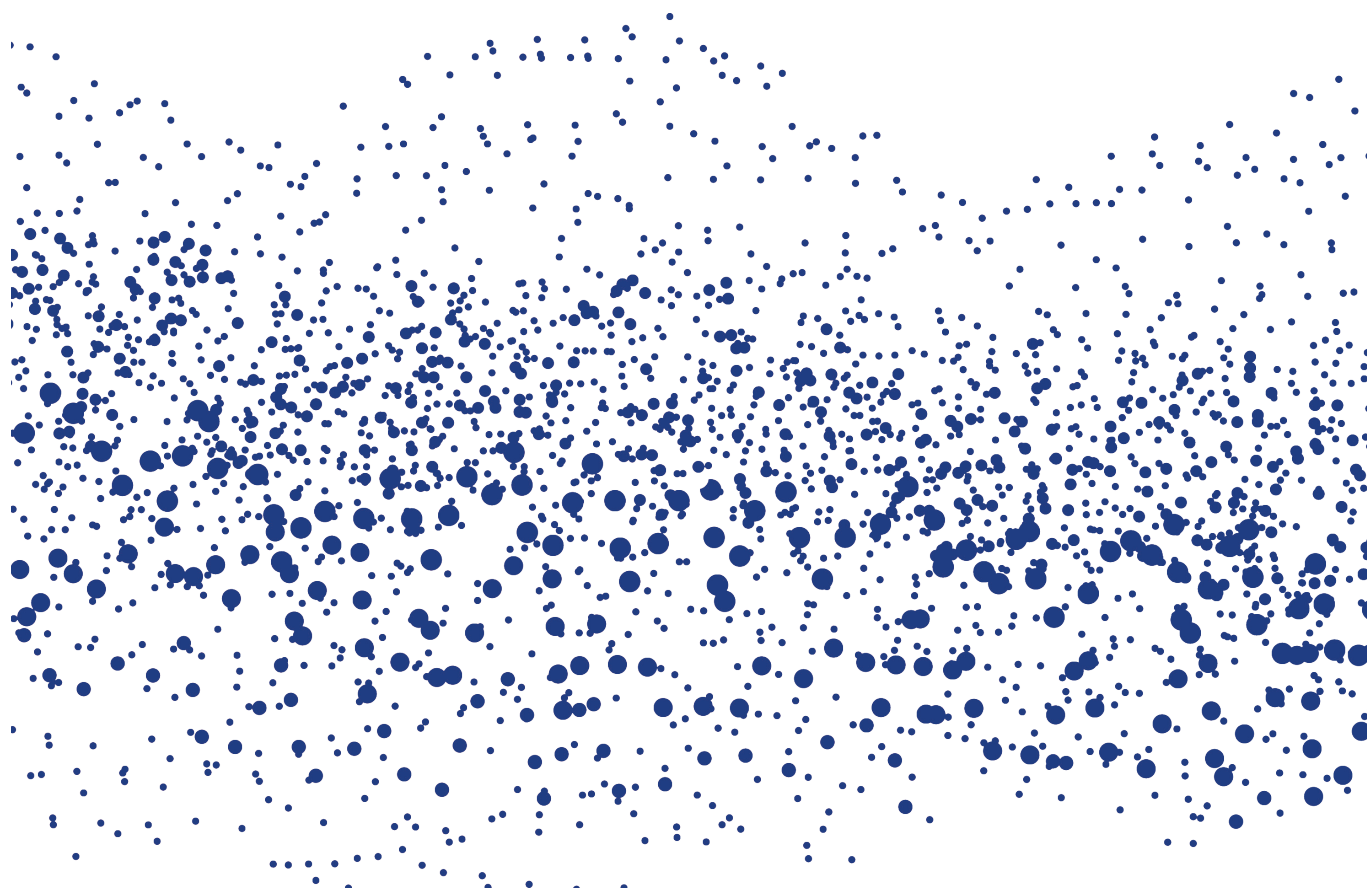
In terms of safety, the authors evaluated the difference between the Verifit-estimated UCL and the default maximum output measured in the testbox. Both OTC and prescription HAs significantly exceeded the estimated UCL at 8000 Hz. The authors conclude that, given the human speech frequency spectrum is typically defined up to 5000 Hz, this overamplification at 8000 Hz poses only a minimal safety risk during normal conversations. They therefore concluded that OTC devices are largely as safe as prescription HAs. Remarkably, despite the methodology mentioning ‘noise reduction’, no results or discussion on this aspect are provided in the article.

STUDY LIMITATIONS

The authors acknowledge several limitations in the studies, including the small sample size of both prescription and OTC HAs and the decision to average the results within each category. They also note that their evaluation was restricted to the most advanced OTC HAs, which may not fully represent the broader range of devices available.

CONCLUSIONS

The authors conclude that their data suggest OTC HAs are safe; however, they emphasise the need for further studies to assess their efficacy across a broader range of HL types. •





FACTORS IN THE EFFECTIVE USE OF HEARING AIDS AMONG SUBJECTS WITH AGE-RELATED HEARING LOSS: A SYSTEMATIC REVIEW



Morvan, P., Buisson-Savin J., Boiteux, C., et al.

J. Clin. Med. (2024): 13, 4027

doi: 10.3390/jcm13144027.

By Perrine Morvan - France

This review aims to determine the factors which contribute to the successful adoption and continued use of HAs among elderly individuals with ARHL

INTRODUCTION

Age-related hearing loss (ARHL) is a progressive, bilateral, and symmetric decline in hearing, primarily affecting high frequencies. It results from a combination of intrinsic factors (such as genetic predisposition and biological aging) and extrinsic factors (including noise exposure and medication use). ARHL can precipitate social isolation, depression, and cognitive decline; however, hearing aids (HAs) hold significant promise in mitigating these effects and improving quality of life. While hearing tests, including pure tone thresholds and speech tests, are valuable, they do not fully capture the benefits of HAs, nor do they address the daily challenges and individual needs of patients. Treating individuals with hearing impairment is complex and must be tailored to each individual, with no universally accepted treatment plan or definitive tools for maximising the effectiveness and success of HA fittings. This review aims to identify the factors which contribute to the successful adoption and continued use of HAs among elderly individuals with ARHL.

METHODOLOGY

Search Strategy

The study used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for systematic reviews, with its protocol registered in the PROSPERO database. Research was conducted across Scopus, PubMed, Web of Science, and Cochrane databases from November 2022 to May 2024. Searched keywords included 'age-related hearing loss,' 'presbycusis,' 'hearing aids,' and 'patient satisfaction' among others. In order to ensure the relevance of the technologies discussed, only articles published from January 2005 onward were considered.

CRITICAL NOTE

This systematic review provides a comprehensive analysis of the factors contributing to the effective use of hearing aids (HAs) among individuals with age-related hearing loss (ARHL). While the review highlights the importance of patient-related outcome measures (PROMs), it fails to provide detailed strategies for their implementation. Future research should focus on developing practical guidelines for incorporating PROMs into clinical practice to improve patient engagement and satisfaction.

Data Extraction

Inclusion criteria focused on adults with bilateral sensorineural hearing loss (SNHL) using conventional HAs. Studies were selected based on subjective and objective evaluation methods. Excluded were articles addressing non-hearing-related communication disorders, cognitive impairments, or other comorbidities, as well as studies not published in English.

RESULTS

Initial research yielded 278 articles, of which 54 studies were ultimately selected for inclusion in the review following a series of elimination steps. The review identified three main factors contributing to the effective use of HAs among ARHL subjects.

The first factor analysed the impact of various signal processing features in HAs, including compression, frequency processing, microphone directionality, and noise reduction. It was found that the use of adaptive directionality significantly improved speech comprehension

in noisy environments. Additionally, features like wide dynamic range compression (WDRC) and noise reducers were shown to significantly enhance user satisfaction and understanding in such settings.

The second factor addressed HA fitting. Despite significant advancements in HA technology, the National Acoustic Laboratories (NAL) fitting methods are still widely used. Evidence indicates that bilateral HA fittings yield superior outcomes compared to unilateral HAs, particularly in variables such as spatial localisation, sound detection, and speech-in-quiet intelligibility.

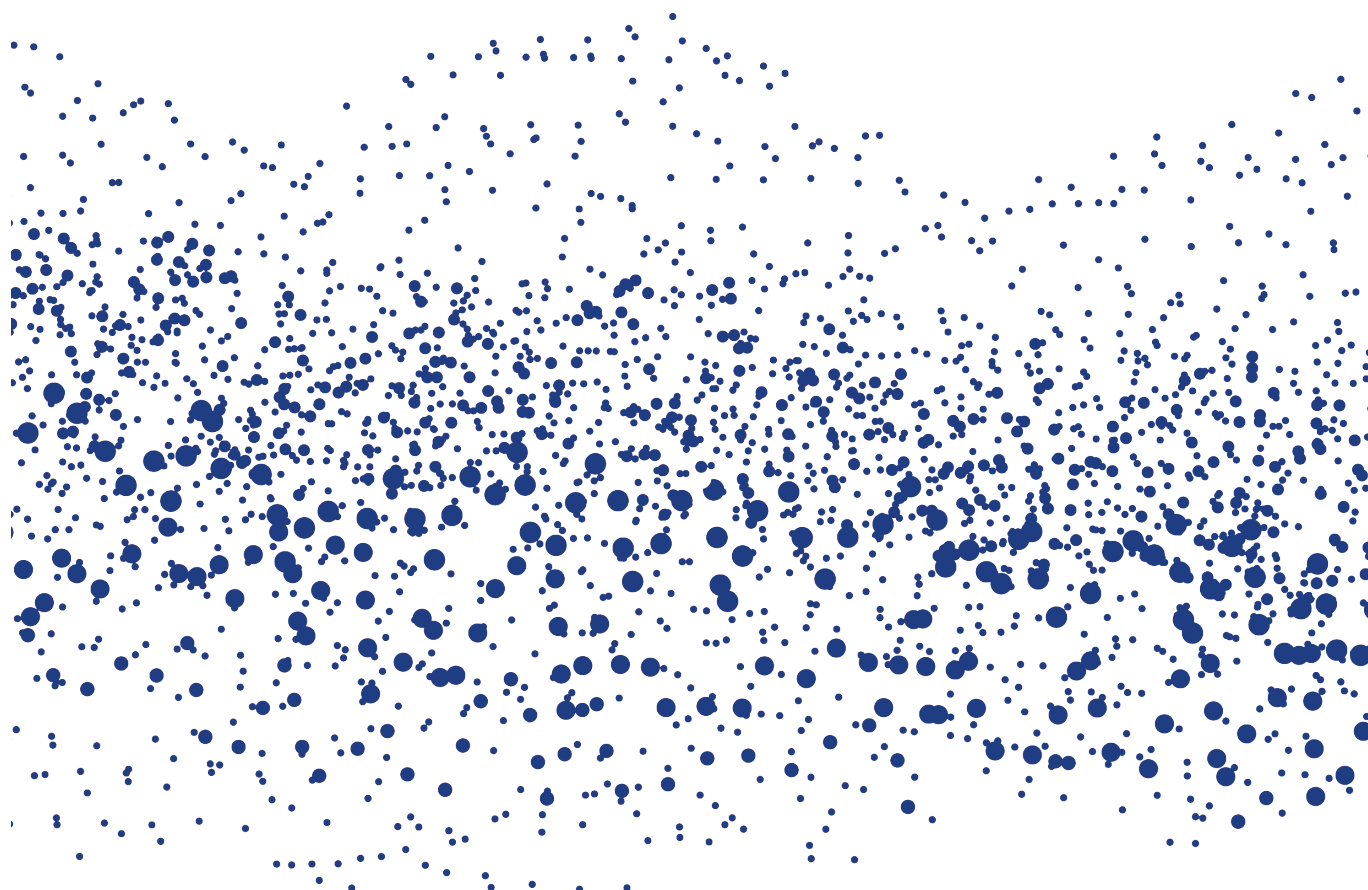
The final factor focuses on a patient-centred approach, which is broadly supported in the reviewed literature. This study's findings highlight how essential it is to consider patients' needs from the outset of the HA fitting process and throughout regular long-term follow-ups, using questionnaires and regular assessments, along with patient-related outcome measures (PROMs) is crucial for involving patients in their rehabilitation, setting personalised goals, and monitoring progress. This approach is a priority in audiology and warrants increased emphasis.

STUDY LIMITATIONS

The authors identified a number of limitations in the reviewed studies. Firstly, the small sample sizes, often fewer than 30 participants, limited the generalisability of the findings. Moreover, in the study design, the exclusion of systematic reviews, meta-analyses, and non-English-language articles introduced potential biases related to publication and language. Thirdly, the heterogeneity in study methodologies and outcome measures complicated the synthesis of results and precluded meta-analysis. Finally, the focus on moderate hearing loss limited the applicability of the findings to other types of hearing impairment.

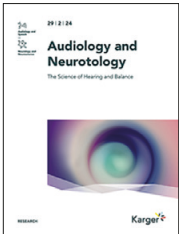
CONCLUSIONS

The review underscores the importance of actively involving patients in the fitting and adjustment process of their HAs to enhance satisfaction and therapeutic outcomes. Future research should prioritise the evaluation of specific signal processing features and the implementation of modern pre-setting methods. Additionally, larger-scale studies are needed to increase statistical power and facilitate robust meta-analyses. •





IMPLANTABLE HEARING DEVICES IN ONTARIO: A POPULATION-BASED STUDY OF ACCESS TO CARE AND ACCESS TO DEVICES



Kirubalingam K., Nguyen P., Kang A., et al.
Audiol Neurotol. (2024): 29(2), 136–145
doi: 10.1159/000534384. Epub 2023 Nov 20.
PMID: 37984348.
By Angela Ryall–Canada

This longitudinal study was conducted to quantify the number of implantable device (cochlear implants and bone anchored devices) dispensed in Ontario, Canada from 1992 to 2021 in order to analyse patients’ access to these devices, including factors such as distance to hearing healthcare facilities.

This longitudinal study examines the number of implanted hearing devices, specifically cochlear implants (CIs) and bone-anchored hearing aids (BAHAs), in the province of Ontario, Canada, from 1992 to 2021, with a focus on patients’ proximity to implantation centres. Using datasets from the Ontario Ministry of Health, the authors found that between April 1, 1992, and March 31, 2021, a total of 1,125 patients received BAHA devices; and 4,720 patients received CIs. All patients underwent a hearing and vestibular assessment at least one year prior to implantation surgery. The median age at implantation was 42 years for the BAHA recipients; and 51 for CIs. However, patients aged 0–19 exhibited the highest implantation rates, at 29.5% receiving BAHA surgeries, and 25% receiving CI surgeries.

The study showed an increase in implantation services for patients located geographically closer to the medical centres providing these surgeries. Approximately 90% of BAHA patients and 89% of CI recipients resided in urban/suburban areas. On average, BAHA patients travelled a median distance of 46.4 km, against 36.6 km for CI patients. However, the analysis did not reveal a significant association between the distance to the hospital and BAHA implantation. In contrast, for CI implantation, distance was positively correlated with age, chronic obstructive pulmonary disease (COPD), and audiometric testing; and negatively correlated with dementia and vestibular function.

CI surgeries increased 17-fold, from 27 surgeries in 1992/1993 to 421 surgeries in 2020/2021. Similarly, BAHA surgeries rose sixfold, from 21 surgeries in 1992/1993 to 64 surgeries in 2020/2021. This surge in implantation surgeries may be attributed to increased government funding over the years. Despite this growth, the geographical area these hospitals serve is still relatively limited. Individuals residing within the catchment area of these centres are more likely to undergo implantation surgeries compared to those outside this region,

CRITICAL NOTE

As a resident of Ontario, Canada, it is encouraging to observe the growth in implantation services over the past 30 years, leading to increased patient access. The expansion in services may be attributed to both increased government funding, as noted in the study, and advancements in technology. Ontario is a large province, it is therefore understandable that travel distance might affect patients’ willingness to pursue implantation. I concur with the researchers’ assessment that additional service centres could be established to address the needs of individuals in rural areas, or alternative support mechanisms could be developed to better serve these populations.

Expanding the focus beyond Ontario to other regions in North America and globally, it is evident that implantation services need to be more accessible to provide patients with viable options for managing their hearing loss (HL). When service centres are too distant or logistically unfeasible, patients may become disinterested in pursuing these treatment options. Presenting this data to government officials can strengthen the case for establishing additional treatment centres, thereby enhancing access to care and improving patient engagement with HL management.

with a more pronounced effect observed for CI surgeries than for BAHA. The findings show reduced accessibility for implantation devices for residents of rural areas, with only 8.4% of BAHA patients and 9.2% of CI patients living in such areas.

Income and socioeconomic status among the patients were relatively uniform, with most falling into a higher income bracket. The researchers posited that financial security might

have facilitated access to care even for patients residing at significant distances from hospitals. The researchers went on to emphasise the need for further efforts to improve accessibility to implantation services. In Ontario, the expansion of BAHA implantation services has enabled patients to receive follow-up care closer to home; similar strategies could benefit patients in rural areas. The researchers also suggested the establishment of smaller CI centres throughout the province, enhanced patient education on implanted

devices, and increased use of virtual care. As the number of implantation surgeries continues to rise, there will be a growing need for additional service centres. Establishing these centres in rural or suburban areas could enhance accessibility for patients who currently reside outside the catchment areas of existing hospitals in Ontario. Finally, the researchers recommend investigating the accessibility of care and implantation services for both pre-lingual and post-lingual CI cohorts. •

DISCUSSING PATIENT EMOTIONS IN AUDIOLOGY: PROVIDER EXPERIENCES WITH THE IMPLEMENTATION PROCESS OF HEARING LOSS PSYCHOLOGICAL INFLEXIBILITY SCREENINGS



Grigsby S., Muñoz K., San Miguel GG., et al.
Am J Audiol. (2024): 33(2), 354–68
 doi: 10.1044/2024_AJA-23-00198. Epub 2024 Apr 2. PMID: 38563702.
 By Anjana Panikkar –Australia

The authors investigated the barriers and facilitators which influenced clinical educators and graduate students of audiology when discussing the challenging emotions and thoughts associated with living with hearing loss in their patients.

CRITICAL NOTE:

In audiology, counselling frequently focuses on providing information and addressing technical aspects related to hearing devices and accessories, with emotional concerns only being addressed if explicitly expressed by the client. The minimal emphasis on the psycho-social aspects of counselling during training often perpetuates this issue in professional settings, regardless of the clinician’s experience. This study offers an interesting approach by addressing this issue both from the perspective of clinicians and clinical educators.

While this study provides valuable insights into a crucial yet frequently neglected aspect of audiology training and practice, several additional research avenues warrant exploration:

- 1. Patient Outcomes: Investigate how addressing patients’ thoughts and emotions regarding their hearing loss impacts their overall outcomes and satisfaction.*
- 2. Screening Tool Scores: Examine changes in patients’ AAQ-AHL or AAQ-MCHL scores throughout the study period and assess their correlation with hearing device usage and acceptance.*
- 3. Patient Demographics: Clarify the number of adult versus child patients included in the study, and analyse whether clinician confidence varies by patient group.*
- 4. Sample Size Expansion: Conduct studies with larger sample sizes to determine whether observed differences achieve statistical significance.*

Living with a chronic condition such as hearing loss (HL) often leads individuals to avoid confronting their condition, resulting in inaction that can hinder overall well-being.

This internal process, termed ‘psychological inflexibility’, prevents individuals from pursuing actions aligned with their health goals. While audiologists are aware of this issue,

many struggle with how to effectively inquire about and address patient emotions. Although counselling in this area is part of audiological practice, there is a pervasive lack of confidence among professionals in handling these sensitive discussions. This lack of confidence is often attributed to insufficient counselling training, unclear role definitions, and limited organisational support.

METHODOLOGY

The study leveraged implementation science methodologies so as to identify barriers and facilitators experienced by clinical educators and graduate students in integrating the findings from two screening instruments for assessing psychological inflexibility – the Acceptance and Action Questionnaire- Adult Hearing Loss (AAQ-AHL); and the Acceptance and Action Questionnaire- Managing Child Hearing Loss (AAQ-MCHL) – into routine clinical care.

The researchers used a longitudinal observational design over a period of seven months, from September 2022 to April 2023, involving five clinical educators and five graduate students at a single clinical facility. Prior to the study's initiation, the group attended a two-hour workshop designed to familiarise them with the screening tools, address implementation logistics and any concerns or reservations. In addition to a demographic questionnaire, the group completed the Acceptance and Action Questionnaire- II (AAQ-II) and a confidence rating scale at the start and end of the study. Additionally, individual debriefing sessions were conducted throughout the seven-month period to assess clinicians' ongoing experiences with the screening instruments and their approaches to addressing patients' emotions and thoughts during sessions.

RESULTS

The study revealed individual improvements in confidence ratings for all participants, with notable gains observed in five out of ten participants on the Acceptance and Action Questionnaire-II (AAQ-II). However, the group analysis did not show statistically significant differences in either the pre- and

post-AAQ-II scores or the confidence ratings. Thanks to the debriefing sessions, four key themes were identified: 'learning process'; 'clinician confidence'; 'barriers'; and 'supervision' (the latter only being relevant to the clinical educators). The majority of participants considered the monthly debriefing sessions beneficial for evaluating their counselling skills. They expressed a demand for more opportunities to engage with patients who display strong emotions and additional educational resources, e.g. written materials and videos. Participants observed a boost in their confidence when addressing emotional issues with patients, a development they attributed to the use of screening tools and the insights gained during the debriefing sessions.

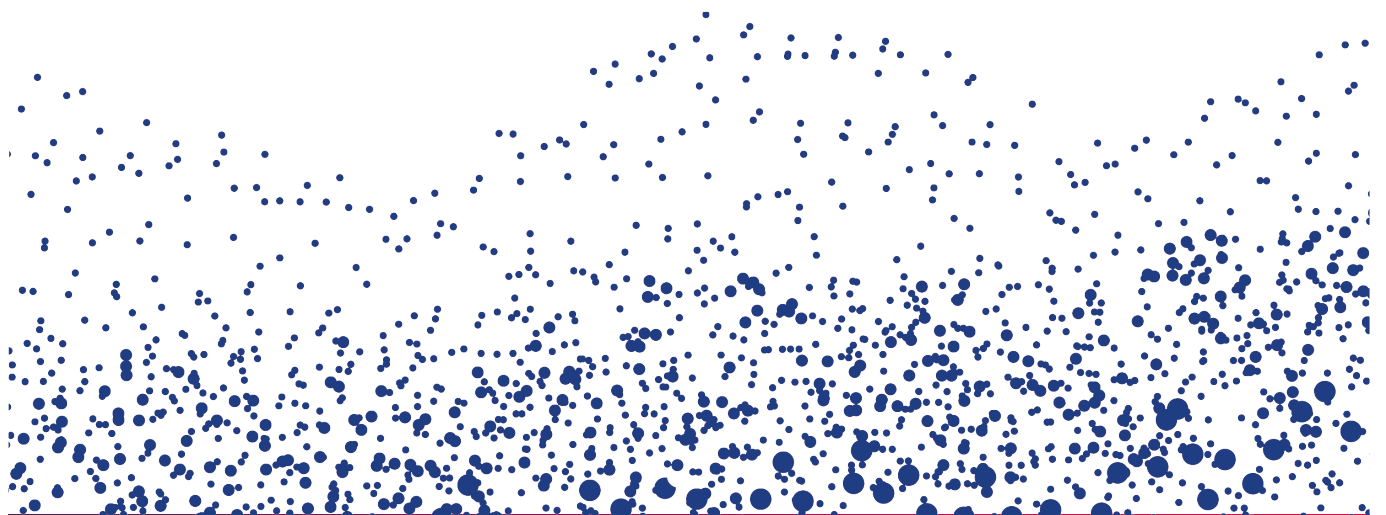
The main barriers reported by participants included time constraints and ambiguity regarding how to effectively question and validate patient emotions. Through supervision, all participating clinical educators addressed these challenges by implementing strategies to improve student learning. These strategies included demonstrating counselling techniques through role playing exercises, offering prompt and clear feedback, and highlighting the importance of addressing patient emotions during the preparation of appointments.

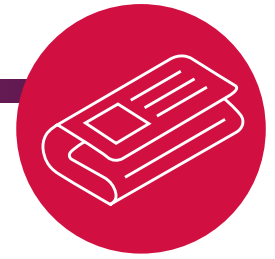
CONCLUSIONS

The findings of this study highlight the benefits of using screening tools to assist clinicians in addressing patients' emotions related to their HL. This research also sheds light on clinicians' reluctance to engage comfortably with patients' thoughts and emotions regarding their hearing impairment, emphasising the need to educate students on recognising and managing patient's inflexibility to promote proactive action towards addressing their hearing health.

LIMITATIONS

The authors also highlight a number of limitations of the study that should be considered when interpreting these findings, e.g. this study is based on only one clinical facility, with one specific context, so the findings cannot be generalised to other facilities, working with a different context. •





AUTOMATED SPEECH AUDIOMETRY: CAN IT WORK USING OPEN-SOURCE PRE-TRAINED KALDI-NL AUTOMATIC SPEECH RECOGNITION?



Araiza-Illan G., Meyer L., Truong KP, et al.

Trends Hear. (2024): 28, 1–13

doi: 10.1177/23312165241229057. PMID: 38483979; PMCID: PMC10943752.

By Gian Carlo Gozzelino – Italy

The research assesses the viability of an automated digits-in-noise (DIN) test utilising the Kaldi-NL automatic speech recognition (ASR) system to facilitate speech audiometry without human intervention.

INTRODUCTION

Speech audiometry plays a pivotal role in diagnosing and managing hearing loss (HL), particularly in evaluating an individual's ability to comprehend speech amid noise. Traditional speech audiometry methods, such as the digits-in-noise (DIN) test, require human supervision in order to evaluate responses accurately, making these approaches resource intensive and reliant on skilled personnel. In this paper, the authors introduce a novel methodology which leverages Kaldi-NL, an open-source automatic speech recognition (ASR) system, to automate the DIN test. This study's core objective is to explore the potential of this automated system in achieving results comparable to those obtained from traditional, human-administered testing methods.

METHODOLOGY

The study was divided into two main phases – Study 1 and Study 2 – both designed to evaluate the reliability and accuracy of the Kaldi-NL ASR system in a clinical context. Study 1 comprised 30 Dutch adults with self-reported normal hearing (NH), aged between 19 and 64. These participants underwent the DIN+Kaldi-NL test, which involved listening to and repeating a sequence of 24-digit triplets. The spoken responses were recorded and subsequently processed by the Kaldi-NL system. The researchers measured the system's accuracy by calculating the word error rate (WER), which indicates the percentage of words incorrectly transcribed by the ASR system.

Study 2 involved a series of bootstrapping simulations designed to assess the effect of ASR system errors on the speech reception threshold (SRT) derived from the DIN test. These simulations compared the variability in SRTs caused by Kaldi-NL's decoding errors against the established within-subject SRT variability in normal-hearing adults, established to be approximately 0.70 dB.

CRITICAL NOTE:

While the study offers a promising outlook, certain limitations should be acknowledged. The participant pool was restricted to normal-hearing adults, which may not fully reflect the efficiency of the system across various populations, including those with varying degrees of hearing impairment. Future research should encompass a broader and more diverse participant base in order to validate the generalisability of the findings.

Additionally, the system's performance in real-world clinical settings – characterised by varying levels of background noise and diverse speaker characteristics – requires further investigation. Continued improvements in ASR technology, coupled with comprehensive validation studies, will be essential for fully realising the potential of automated speech audiometry.

In conclusion, this research marks a significant step towards the integration of ASR technology in audiology, presenting a promising direction for the future of speech audiometry.

RESULTS

The results from Study 1 showed that the Kaldi-NL system achieved an average WER of 5.0%, with individual WERs ranging from 0% to 48%, and a standard deviation of 8.8%. While there was considerable variability in accuracy across individual participants, the overall performance of the system was commendable, with most errors confined to a small percentage of cases.

In Study 2, the simulations demonstrated that variations in SRTs resulting from decoding errors in up to four triplets remained within the acceptable range of 0.70 dB. This finding suggests that the errors from the Kaldi-NL ASR system did not significantly impact the diagnostic accuracy of the DIN

test, thereby supporting the system’s potential for clinical application without necessitating human oversight.

DISCUSSION

The implementation of the Kaldi-NL ASR system in automated speech audiometry marks a significant advancement in the field. By reducing the dependence on human operators, this system improves both the accessibility and efficiency of speech audiometry. The study’s findings suggest that the automated DIN test can reliably generate speech reception thresholds with minimal errors, making it a viable alternative to conventional methods.

The practical implications of this research are significant. By employing an open-source ASR toolkit, the study paves the way for the development of more accessible hearing tests, particularly in areas with limited access to trained audiologists. The use of a laptop-based system further increases the feasibility of administering these tests across various settings, from clinical environments to remote locations. Moreover, the potential cost savings associated with reducing the need for human audiologists could promote the broader adoption of speech audiometry tests, particularly in resource-constrained settings. This democratisation of access to essential audiometric testing could significantly improve public health outcomes by enabling earlier and more frequent hearing assessments.

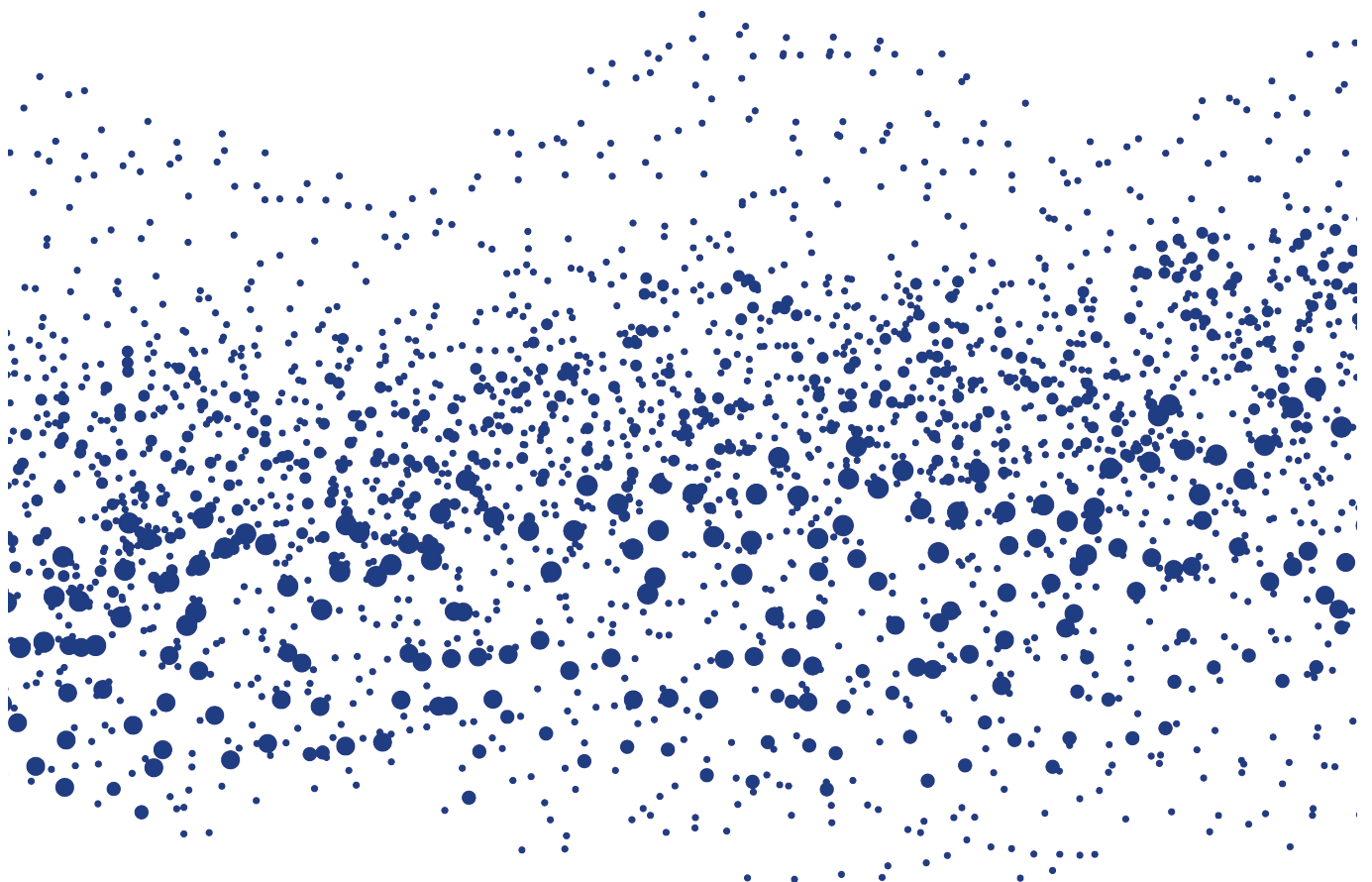
TECHNICAL CONSIDERATIONS

Despite the promising results, several technical considerations warrant further attention. The variability in WER among participants underscores the need for continued refinement of the ASR system to ensure consistent performance across a diverse range of users and acoustic environments. Factors such as background noise, speaker accents, and speech clarity could influence the accuracy of the system and should be addressed in future developments.

The robustness of the Kaldi-NL system in diverse acoustic settings and its adaptability to various languages and dialects are crucial for its broader application. Ongoing research and development in the field of ASR technology will likely enhance the system’s capabilities and extend its applicability to a wider range of clinical scenarios.

CONCLUSION

This study successfully demonstrates the potential of incorporating the Kaldi-NL ASR system into automated speech audiometry. The system’s performance, characterised by a low WER and minimal impact on SRT accuracy, suggests that automated DIN tests could serve as a viable alternative to traditional, human-administered methods. This shift towards automation could lead to more efficient, cost-effective, and accessible speech audiometry testing, carrying significant implications for both public health and clinical practice. •





CONTRIBUTION OF TINNITUS AND HEARING LOSS TO DEPRESSION: NHANES POPULATION STUDY



Chakrabarty S., Mudar R, Chen Y., et al.
Ear Hear. (2024): 45(3), 775–86
 doi: 10.1097/AUD.0000000000001467. Epub
 2024 Jan 31. PMID: 38291574.
 By Jan De Sutter - Belgium

This study investigates the interaction between tinnitus and hearing loss as predictors for depression.

Both tinnitus and hearing loss (HL) are both widely prevalent conditions and have the potential to adversely affect sufferer’s emotional well-being. While previous research has investigated the impact of HL and tinnitus on depression separately, there is limited information on the interaction between these potentially inducing factors. The authors used data from the United States National Health and Nutrition Examination Survey (NHANES), which ran in 2011–2012 and 2015–2016, to examine whether HL and tinnitus have a combined effect on depression, while also accounting for other potentially moderating factors. The findings reveal that the presence of HL exacerbates depressive symptoms in individuals already experiencing tinnitus. Conversely, tinnitus emerges as the sole predictor of depression when it occurs in conjunction with pre-existing HL.

CRITICAL NOTE:

Although this study primarily investigates the prediction of depression based on presence of tinnitus and/or hearing loss (HL), it highlights the importance of multidisciplinary approach in treating HL combined with tinnitus. The fitting of hearing aids (HA) or cochlear implants (CI) compensates HL and can potentially alleviate tinnitus symptoms. Given the comorbidity with depression, would a more comprehensive strategy, starting with thorough counselling and timely referral to mental healthcare professionals, help in preventing depression?

DESIGN

The study analysed NHANES survey data from a cohort of 5,845 U.S. Adults (20–69 years). The following findings were extrapolated from the dataset:

- Patient Health Questionnaire-9 (PHQ-9) score to measure depression

The score was dichotomised into two categories - ‘not depressed’ and ‘depressed’ - using a cutoff score of nine.

- Tinnitus-related questionnaire

Tinnitus duration was categorised into three durations: ‘non-chronic’ (less than 3 months); ‘new-onset chronic’ (three months to one year); and ‘chronic’ (more than one year).

Tinnitus frequency was categorised as ‘occasional’ (less than once a month); ‘intermittent’ (once a month to once a day); ‘constant’ (more than once a day).

The severity of tinnitus-related problems reported by participants was classified into ‘none’; ‘moderate’; and ‘big’

- Audiometry measures

Puretone audiometry results were used to calculate the ‘speech frequency PTA’ (pure tone average of 0.5kHz, 1kHz, 2 kHz and 3 kHz) and ‘high frequency PTA’ (pure tone average

of 4kHz, 6kHz and 8kHz). Both PTA values were categorised in ‘no hearing loss’ (≤ 25 dB); ‘mild hearing loss’ (26–40 dB); and ‘moderate to severe hearing loss’ (≥ 41 dB).

- Other factors

Demographic, lifestyle and health factors were also considered in this study.

RESULTS

In comparison with the general population, the study identified several subpopulations with a higher prevalence of depression, speech frequency HL, high frequency HL and tinnitus. The analysis further revealed that demographic, lifestyle and health variables considered in this study also proved to be influencing factors.

This study established a significant correlation between PHQ-9 score and high frequency PTA. Depression exhibited a strong association with both speech frequency and high frequency HL as well as with tinnitus frequency. However, tinnitus duration and the extent of problems caused by tinnitus showed a weaker correlation with depression. Depression, along with HL and tinnitus, demonstrated at

least a moderate association with demographic, lifestyle, and health covariates.

Based on the crude odds ratios (COR), several measures of HL and tinnitus exhibited significant interaction effects in predicting depression. Interestingly, these measures demonstrated both amplifying and attenuating effects on depression, contingent upon their specific combination. Although the inclusion of demographic, lifestyle and health covariates attenuated or, in some cases, suppressed the significance of the predictor, both speech frequency HL and general tinnitus issues consistently emerged as predictors of depression.

This study corroborates prior research indicating a strong comorbidity between tinnitus and depression, highlighting the exacerbating impact of tinnitus severity on depressive

symptoms. Additionally, it reinforces the well-established finding that HL affects depression, with speech frequency HL showing a consistent link to depression, irrespective of covariates. These nuances underscore the potential benefit of amplification through HAs as a preventive measure against depression in people with HL.

When tinnitus was considered in conjunction to HL as a primary condition, the impact of that HL on depression diminished significantly, to the point where the risk of depression could almost entirely be predicted by the tinnitus severity. The authors propose that the persistent nature of tinnitus, even in isolation, accounts for this finding.

Interestingly, HL was found to have an amplifying effect on depression when tinnitus was considered a primary condition. •



DEVELOPMENT OF THE MANDARIN DIGIT-IN-NOISE TEST AND EXAMINATION OF THE EFFECT OF THE NUMBER OF DIGITS USED IN THE TEST



Wang S. & Wong LLN.
Ear Hear. (2024): 45(3), 572–82
 doi: 10.1097/AUD.0000000000001447
 Epub 2023 Nov 22. PMID: 37990396.
 By Julin Teo –Italy–Australia

This study sought to develop a Mandarin version of the Digit-in-Noise (DIN) test, using four sets of digit sequences (i.e. two-, three-, four-, and five-digit). The test underwent rigorous validation to assess its test-retest reliability, criterion validity, and the influence of the number of digit sets on speech reception threshold (SRT) results, as well as its correlation with working memory.

CRITICAL NOTE

The development and validation of the Mandarin Digit-in-Noise (DIN) test presented in this study offer significant potential for enhancing the outcomes of hearing aid (HA) users. This test enables hearing care practitioners to assess aided speech intelligibility outcomes, overcoming challenges related to literacy, dialect diversity, and varying degrees of hearing loss (HL). Despite the high inter-list test-retest reliability demonstrated, future research should incorporate digits with an equal probability of occurrence in each list to avoid any bias from uneven digit distribution. Furthermore, since all participants in the older test group were free from cognitive impairments, future research should investigate the relationship between digit sequences, speech reception threshold (SRT), and working memory capacity in older adults with cognitive decline.

In China, there is a growing demand for the development of a test to measure speech intelligibility outcomes, which would enable hearing health professionals to more accurately

evaluate the benefits of hearing aids (HAs). Existing Mandarin versions of the hearing-in-noise (HIN) test and the Mandarin Chinese Matrix sentence tests are not widely used due to

their difficulty for individuals with severe HL or cognitive impairments. Additionally, these tests inadequately address the great diversity of spoken dialects and the low literacy levels prevalent among the older population throughout China. The Mandarin Digit-in-Noise (DIN) test was developed using 11 monosyllabic digits (0 to 10) spoken by a female speaker. Individual recordings of these digits were combined into four sets of digit sequences (two-, three-, four-, and five-digit). These sets were evaluated using both fixed Signal-to-Noise Ratio (SNR) measurements and an adaptive procedure in 2dB steps. The average digit recognition probabilities and estimated psychometric function curves for the 11 digits were plotted, leading to the exclusion of digit three from the final set due to suboptimal performance in the optimisation process.

Test time to complete a two-digit, a three-digit, a four-digit, and a five-digit was approximately 1:30, 2:00, 2:25, and 2:55 min, respectively.

The psychometric functions and test-retest reliability for the two- to five-digit sequences were evaluated among 54 young normal hearing (NH) listeners (aged 21–29 years), and 56 older (60–87 years) HA wearers with moderate-severe SNHL. Additionally, the study also explored the relation between digit recognition and working memory capacity for the older test subject group.

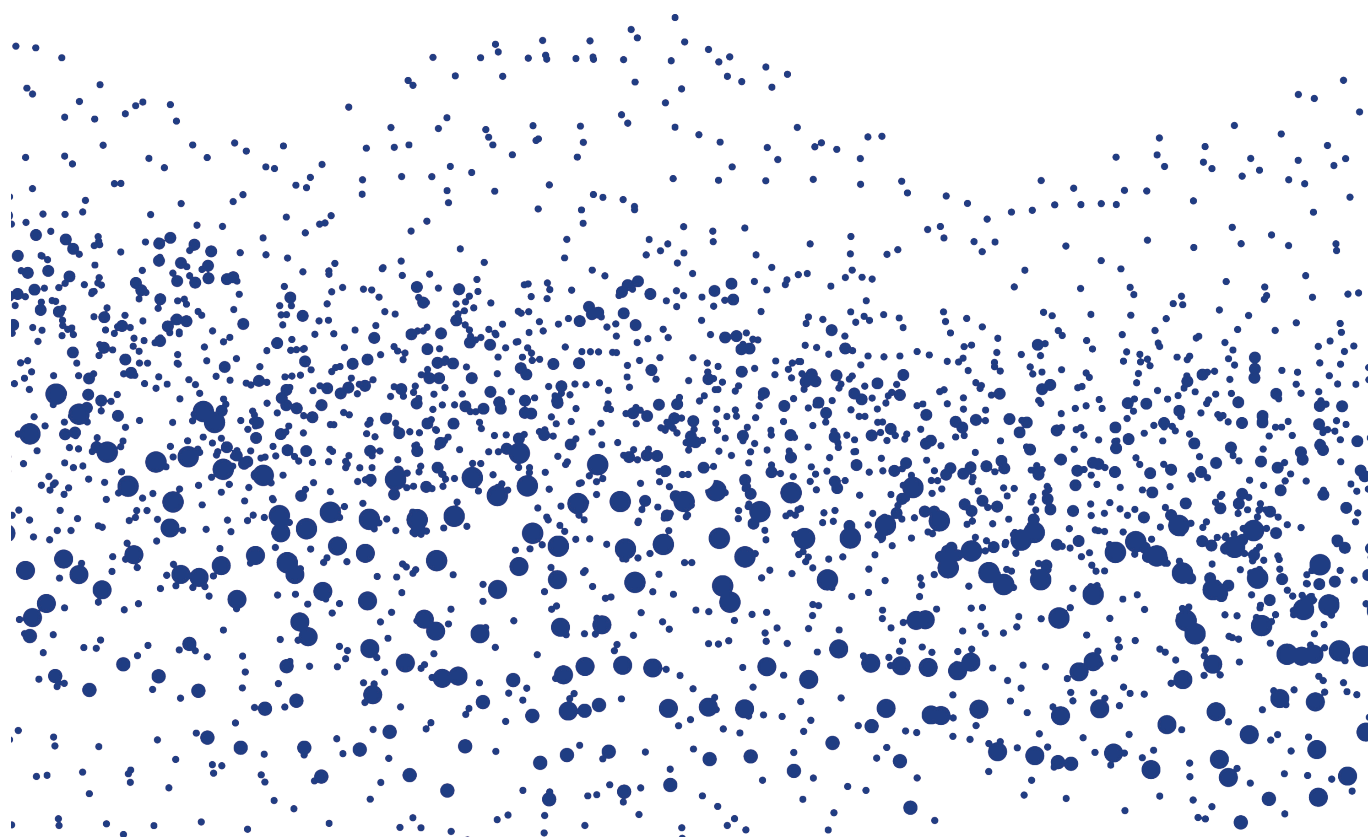
In both test groups, results indicated that the Speech Reception Threshold (SRT) worsened (i.e. increased) as the number of digits increased. For young NH adults, the mean SRT increased from -11.11dB to -10.02dB as the digit sequence length increased from two to five digits. In contrast, for

older adults with HL, it increased from -2.94 dB to -1.25 dB SNR over the same range. The DIN test slope in Mandarin is shallower compared to that observed in other languages, possibly due to Mandarin's greater reliance on spectral rather than temporal information.

Test-retest reliability was consistently high across all digit sequences in both test groups, although it was lower in older adults. The SRTs for all digit sequences correlated well with SRTs measured using the Mandarin Hearing in Noise Test (HINT) and the Mandarin Chinese Matrix test.

In older test subjects with HL, working memory capacity correlated specifically with the SRT for the five-digit sequence, but not with the SRTs of the other sets of digit sequences. This suggests that two- to four-digit sequences primarily reflect auditory perception, whereas the five-digit sequence requires a higher working memory capacity to reconcile the mismatch between speech input and phonological representations stored in long-term memory.

These findings highlight the reliability of the Mandarin DIN test and its strong correlation with SRTs obtained from standardised sentence tests. However, the choice of digit sequence is crucial for accurate assessment. The authors recommend the use of the three-digit sequence for clinical assessment of auditory perception and the two-digit sequence for hearing screenings, given its shorter administration time and acceptable test-retest reliability. The five-digit sequence test, which may present challenges for older HA users, warrants further investigation to assess its suitability for evaluating speech perception. •





REVIEW OF BINAURAL PROCESSING WITH ASYMMETRICAL HEARING OUTCOMES IN PATIENTS WITH BILATERAL COCHLEAR IMPLANTS



Anderson SR., Burg E., Suveg L., et al.

Trends Hear. (2024): 28, 1–25

doi: 10.1177/23312165241229880. PMID:
38545645; PMCID: PMC10976506.

By Karen Lovelock - Australia

This study reviews existing research on binaural processing and the implications of interaural asymmetry, and proposes a model to help understand the variability in outcomes associated with hearing asymmetry in individuals with bilateral cochlear implants.

The benefits of binaural hearing for sound localisation and hearing in background noise are well documented. However, the benefits for users of bilateral cochlear implants (CI) can vary significantly, potentially due to interaural asymmetry. Interaural asymmetry may occur at many levels of the auditory pathway, including, but not limited to, differences in hearing thresholds, loudness growth, speech recognition, place of stimulation, neural health and cortical representation.

BOTTOM UP CODING AND BRAINSTEM STRUCTURES

In the early stages of auditory signal processing, the primary interaural cues are interaural loudness or level difference (ILD) and interaural time difference (ITD). Several brainstem structures, including the lateral superior olive, the inferior colliculus, and the medial superior olive, are involved in encoding ILD and ITD by integrating information from both ipsilateral and contralateral auditory pathways. However, the characteristics of CIs – such as insertion depth of the electrode array, resulting in stimulation of the higher frequency neurons; the rate of stimulation; and lack of coding for fine temporal cues in the processing strategies – all contribute to a difference in the coding for these early binaural cues compared with normal hearing (NH) listeners.

AUDITORY DEPRIVATION

In addition, auditory deprivation, associated with delay of implantation, as well as sequential implantation, can adversely impact binaural processing of the auditory signal. Prolonged auditory deprivation may lead to neural consequences such as nerve fibre death, deterioration of dendrites, and demyelination of nerve pathways. In cases where the delay extends beyond critical developmental periods, the pathways

CRITICAL NOTE:

This comprehensive review provides an excellent summary of recent human and animal research into the factors and mechanisms underlying both binaural hearing and interaural asymmetry. The incorporation of these findings into a model to assist with explaining the impacts of asymmetry on the variability of binaural hearing benefits obtained by people who receive bilateral CIs, is also especially valuable.

for binaural processing may fail to develop adequately or be irreversibly compromised.

CHARACTERISTICS OF COCHLEAR IMPLANTATION

The variety in electrode arrays, their translocation into adjacent scalae, and their positioning within the cochlea can significantly influence the distance from the spiral ganglion cells, which are the intended targets of electrode stimulation. Additionally, the processing strategies of cochlear implants – such as simultaneous stimulation of multiple electrodes – coupled with interaural placement discrepancies in bilateral implant users, can lead to spectro-temporal smearing of the auditory signal and degrade binaural processing.

TOP-DOWN PROCESSING

Predictive coding assumes that listeners leverage previous knowledge of the world and language structure to help interpret auditory signals, with this type of processing occurring in higher-order brain structures, such as the auditory cortex. Processing strategies at this level utilise binaural fusion of spectro-temporal information, combined with predictive knowledge, to facilitate the identification and spatial localisation of sound sources. Once sound sources

are organised in space, the brain can focus attention by inhibiting neural responses to background sound sources and amplifying responses to foreground sound sources. In bilateral CI users, indistinct object identification associated with asymmetric spectral fusion may disrupt the ability to segregate and prioritise objects into foreground and background, important prerequisites for focusing on a sound source in the presence of noise.

Cortical specialisation can also play a role in top-down processing, with NH listeners exhibiting a right-ear advantage for speech and language tasks. Bilateral CI wearers often show an advantage for the ear implanted first. Moreover, animal studies suggest that unilateral implantation can induce a reorganisation of contralateral cortical areas to respond more effectively to the unilateral auditory input. In contrast, children and adults receiving simultaneous CI show no ear advantage.

AUDITORY EXPERIENCE AND TRAINING

Following implantation, patients undergo an adaptation phase as they learn to interpret and utilise the signals from the implant. In terms of pitch perception, individuals learn to recalibrate their pitch map to accommodate the new stimulation patterns. Recent animal studies, in which animal subjects were deafened early in life and subsequently fitted with CIs after a period of auditory deprivation, showed that

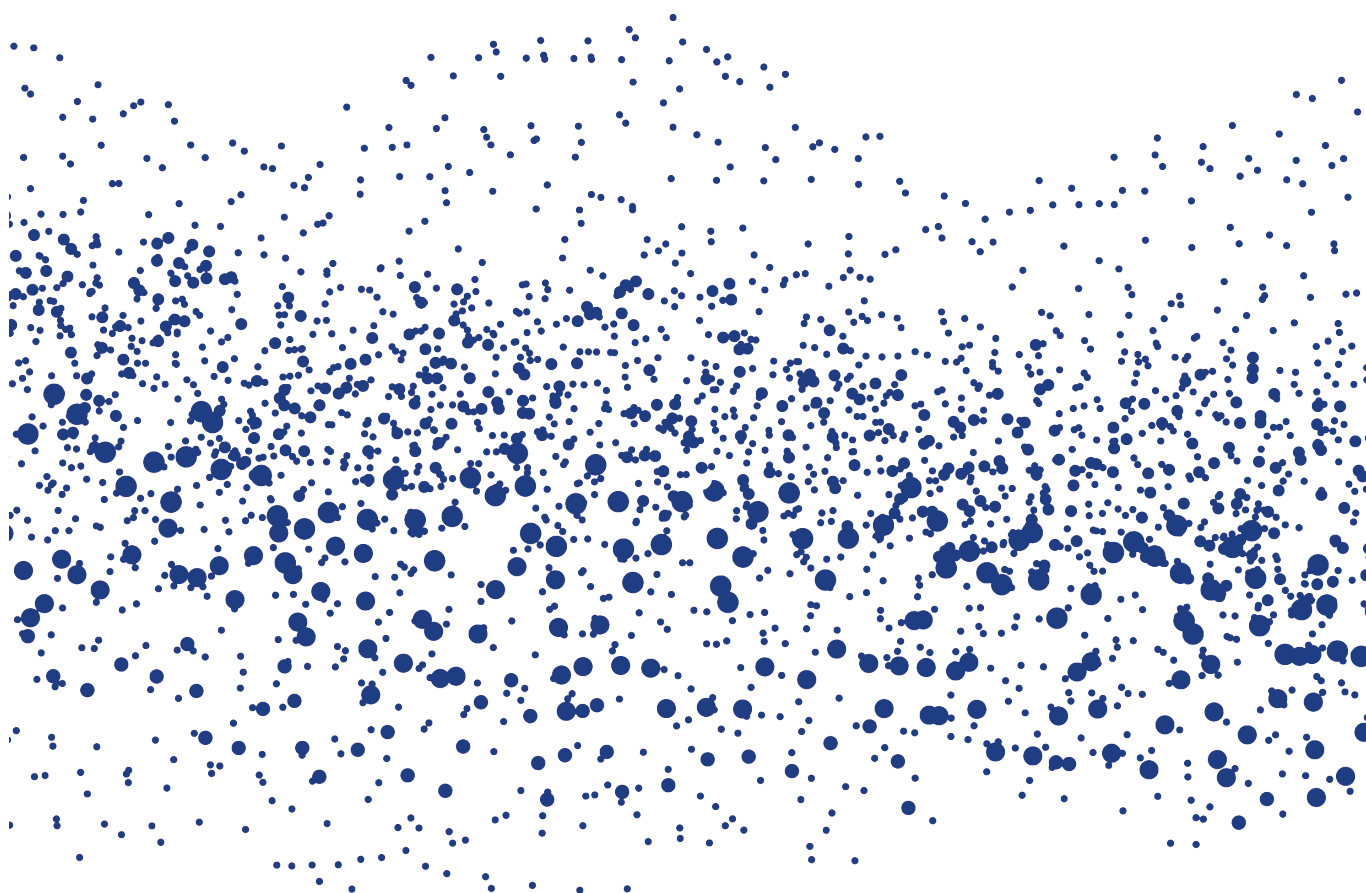
operant conditioning could be used to train users' ability to use interaural timing differences. These findings suggest that auditory training could be instrumental in improving listening in noise for individuals with CI.

SUMMARY

Interaural asymmetry resulting from degradation of auditory signals and binaural pathways can interfere with binaural processing for individuals with bilateral CIs. Nonetheless, it is important to recognise that, despite significant interaural differences post implantation, most implantees perform better on SIN tasks in the binaural condition, meaning it would be uncommon for second-ear implantation to result in poorer performance. However, the degree of improvement in binaural function can vary among recipients.

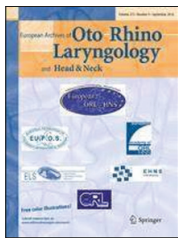
IMPLICATIONS FOR CLINICIANS

Minimising auditory deprivation and providing auditory training following cochlear implantation may play an important role in leveraging the neural plasticity of auditory pathways. In addition, robot-assisted surgeries could reduce electrode translocations, and minimise trauma associated with electrode insertion. Advances in imaging techniques could lead to more precise interaural electrode placement, or help in refining pitch-matching techniques. •





AUDITORY CAPACITY OF THE BETTER-HEARING EAR IN ASYMMETRIC HEARING LOSS



Speck I., Gundlach E., Schmidt S., et al.
Eur Arch Otorhinolaryngol. (2024): 281(5), 2303–12
 doi: 10.1007/s00405-023-08342-w. Epub 2023 Nov 25. PMID: 38006462; PMCID: PMC11024001.

By Melissa Babbage – New Zealand

This study documented the course of changes in hearing in the better ear over time in patients with single-sided deafness (SSD) and asymmetric hearing loss (AHL).

In a previous study, the authors demonstrated that patients with single-sided deafness (SSD) referred for cochlear implantation (CI), exhibited a significantly higher average air-conduction threshold (at 0.5, 1, 2, 4 kHz; AC PTA4) in the better ear compared to age- and gender-matched thresholds from ISO 7029:2017. This ISO standard defines hearing thresholds for female and male otologically normal persons between 18 and 80 years of age. The authors suggest that the higher PTA in the better ear could result from additional strain on the only hearing ear, potentially due to heightened noise exposure from orienting towards the sound source and/or stretching of the cervical vessels resulting in reduced blood flow. It is proposed this might manifest as a progressive high-frequency threshold increase in the better ear. The present study built on the existing body of work by including thresholds up to 8 kHz, recruiting patients both with and without referrals for CIs, and including measurements of tinnitus burden.

METHOD

The authors conducted a comprehensive review of 2,086 pure-tone audiograms PTAs from 323 adult patients, including 277 with SSD and 46 with asymmetric hearing loss (AHL), from four hospitals and 156 private otorhinolaryngology practices. SSD was defined as severe to profound HL in one ear and a PTA of no more than 30 dB HL in the other. AHL was characterised by a PTA between 30 and 60 dB HL in the better ear. Collected data included the following variables: age; gender; aetiology of HL; CI use; and duration of deafness (measured either to the date of assessment or to the time of cochlear implantation). Aetiologies were classified into eleven categories: 'sudden loss'; 'trauma'; 'vestibular schwannoma'; 'Meniere's Disease'; 'infectious disease'; 'chronic otitis media (COM)'; 'congenital HL'; 'otosclerosis'; 'postoperative'; 'other'; and 'unknown'.

The primary dependent variable was the difference between the AC PTA4 of the better ear of SSD participants and the

CRITICAL NOTE

This study presents compelling evidence that patients with SSD are at an elevated risk of experiencing hearing loss (HL) in their better or only hearing ear. This finding is crucial for clinical practice, where it should inform patient counselling regarding expectations as well as the importance of ongoing hearing monitoring and conservation strategies. Although the research seeks to compare HL in the better ear across different aetiologies of SSD, the conclusions are somewhat limited by the relatively small sample sizes within each aetiological group. It is likely that the mechanisms underlying HL in the better ear vary significantly across different pathologies, such as chronic otitis media (COM) versus postoperative HL or sudden SNHL. Additionally, the study does not clearly explain the timespan over which the audiograms were obtained, leaving open the question of whether the observed patterns would shift with longer observation periods. Nonetheless, this data is of significant relevance for both clinicians and patients dealing with SSD.

age- and gender-controlled AC PTA4 from ISO 7029:2017. A positive difference (AC PTA4 > 0) indicates that the AC PTA4 for SSD participants is greater than the normative values from ISO 7029:2017.

Additionally, the study evaluated number and monosyllabic speech, assessed tinnitus intensity using a numerical rating scale, and administered the Goebel and Hiller tinnitus questionnaire.

RESULTS

The primary finding of the study was that patients with SSD had significantly higher pure-tone thresholds at each

measured frequency from 0.125 to 8 kHz compared to age- and gender-matched normative data from ISO 7029:2017. This relationship held when including only audiograms with nonsignificant air-bone gaps (<10 dB).

A weak but significant correlation ($r = 0.08$) was observed between the duration of deafness in the poorer hearing ear and the difference in AC PTA4. However, no significant correlations were found between the AC PTA4 difference and either of the tinnitus measures employed in the study. Except for Meniere's disease (MD), patients with aetiologies commonly presenting bilaterally, and particularly in patients with COM, exhibited greater AC PTA4 differences for the better ear. In the case of COM, this increase in better ear AC thresholds was at least partially attributable to conductive components, as evidenced by higher PTA4 air-bone gaps in this group.

Of the 277 patients with SSD assessed in the initial audiogram, 104 developed AHL during the study period. The mean interval between the first recorded instance of SSD and the diagnosis of AHL was 5.19 years ($SD = 5.91$ years).

No significant associations were found between the duration of SSD diagnosis and the onset of AHL, or between AHL and the aetiology of the poorer ear. Additionally, age, gender, and CI treatment were not correlated with developing AHL.

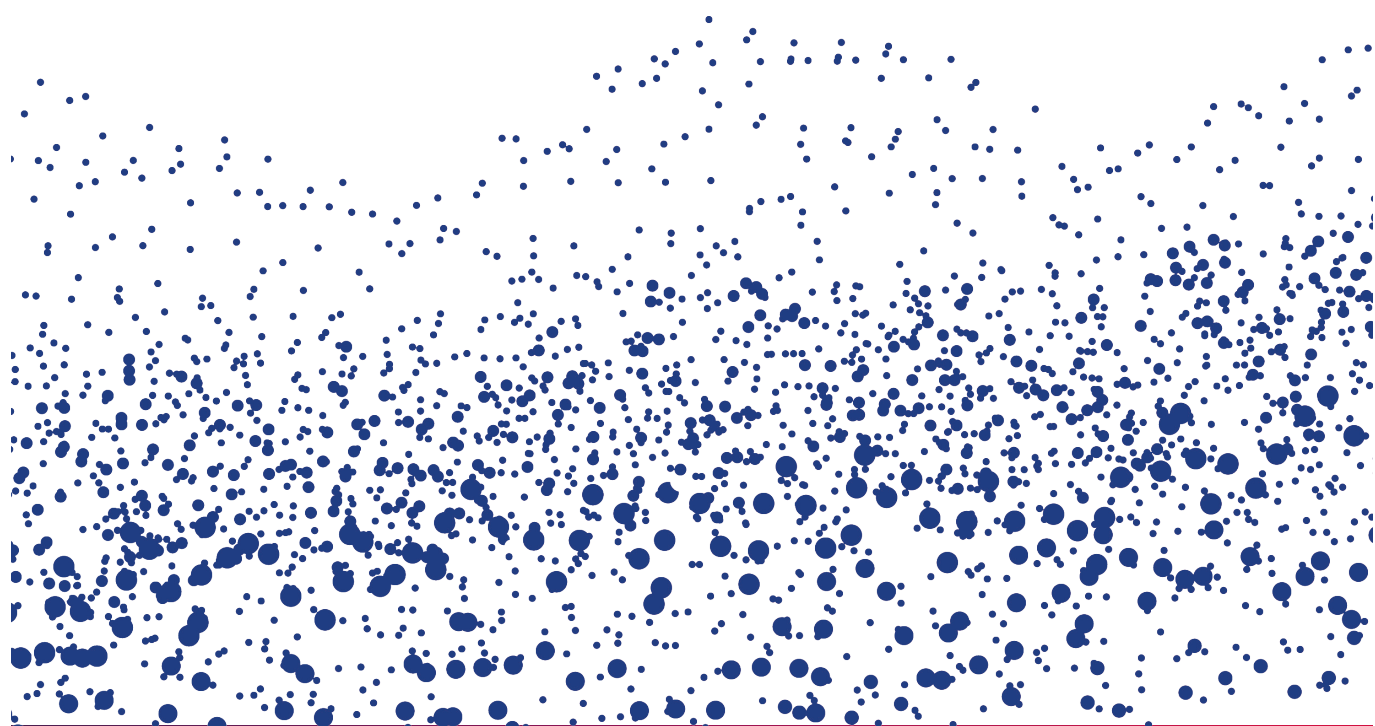
DISCUSSION

Overall, the results provide evidence supporting the conclusions from the authors' previous study that hearing thresholds in the better ear of patients with SSD are poorer than those of average age- and gender-matched controls from ISO 7029:2017. Although the discrepancy between SSD and ISO thresholds was greater in the high frequencies, it was statistically significant across all tested frequencies. A weak

correlation was observed between the duration of deafness and AC PTA4 difference. These findings do not support the hypothesis that the HL is attributable to increased strain of the better ear, which the authors posited would result in significantly more pronounced loss in the high-frequencies and greater HL over time. Instead, it is proposed that the observed mechanism could instead be sympathetic HL in the better ear, similar to sympathetic ophthalmia, which causes vision loss in the better eye due to an autoimmune response. The significant influence of the aetiology on HL indicates that the underlying causes of the PTA4 difference may vary depending on the pathology affecting the poorer ear. This effect persisted even when excluding audiograms with air-bone gaps. Notably, patients with COM exhibited the greatest AC PTA4 difference and the largest air-bone gap in the better ear, likely due to reduced middle ear ventilation bilaterally. Similarly, subjects from the otosclerosis showed elevated AC PTA4 differences, consistent with the known tendency for bilateral development in 62–80% of those initially presenting with unilateral otosclerosis. Interestingly, the AC PTA4 difference was no higher in patients with MD than in other aetiology groups, despite the fact that this pathology often progresses to a bilateral condition over time.

While there was a clear variance in AC PTA4 differences across aetiologies, it is interesting that among the 38% of SSD patients who progressed to AHL, no significant impact of aetiology, age, or duration of deafness was observed.

The authors conclude that there is clear evidence that, in many pathologies leading to SSD or AHL, there is a greater risk of hearing deterioration in the better or only hearing ear. This risk is greater in cases of COM, otosclerosis and congenital SSD, underscoring the importance of appropriate patient counselling. •





PERCEPTIONS OF HEARING HEALTH CARE: A QUALITATIVE ANALYSIS OF SATISFIED AND DISSATISFIED ONLINE REVIEWS



van Bruggen S., Bennett R.J., Manchaiah V., et al.

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doi: 10.1044/2024_AJA-23-00180. Epub 2024 Mar

14. PMID: 38483218.

By Tali Bar-Moshe–Israel

The analysis of 500 five-star and 234 one-star reviews across various clinical settings in 40 U.S. cities offers detailed insight into the factors affecting patient-centred care and patient satisfaction. This collaborative effort underscores the crucial role of consumer feedback in improving healthcare services.

Technological advancements have significantly altered the behaviour of healthcare consumers, particularly in their pursuit of online information, interactions, and service reviews. These transformations influence not only consumers but also healthcare providers.

This qualitative study sought to explore online reviews and consumer feedback regarding their experiences with hearing services. The researchers collected Google both recent and older reviews about audiology clinics across various clinical settings in 40 U.S. cities. After applying inclusion criteria, the study analysed a dataset comprising 500 five-star reviews and 234 one-star reviews.

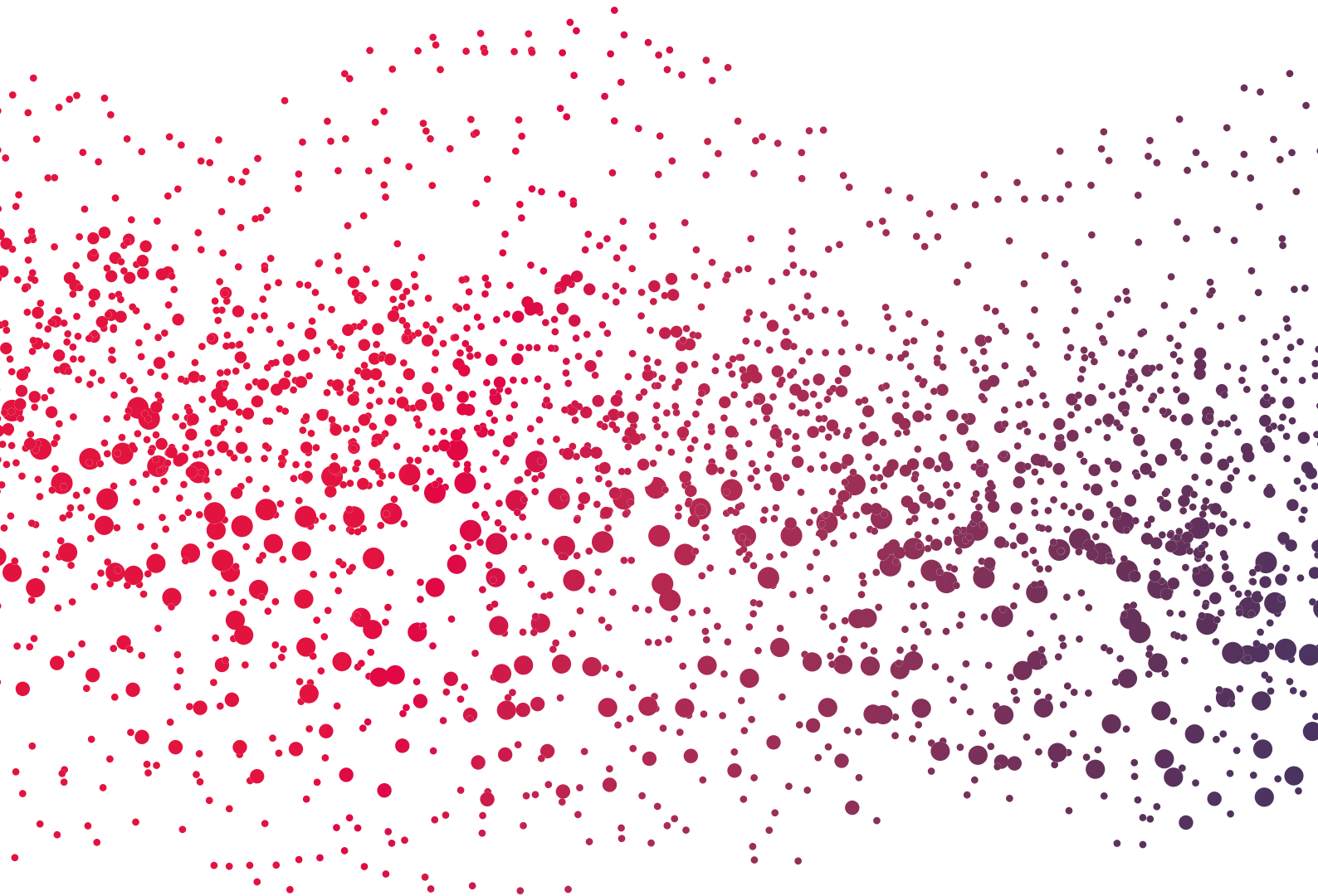
The data collected was subjected to inductive thematic analysis, revealing six domains with 23 themes for satisfied consumers; and seven domains with 26 themes for dissatisfied consumers. The experience of consumers as expressed across these domains presented a wide spectrum of emotions. The 'overall experience' domain capturing sentiments from deep appreciation and satisfaction to pronounced dissatisfaction and diminished loyalty. The 'standard of care' domain highlights consumers' expectations for person-centred care, professionalism, and effective relationships and communication. The 'clinical outcomes' domain emphasises the critical role of hearing outcomes in consumers' well-being. The data also points to the importance of audiologists'

CRITICAL NOTE:

Audiologists must navigate not only technological advancements in their field but also the evolving expectations and experiences of consumers of audiology service. By gaining a deeper understanding of these expectations and experiences, audiologists can improve patient-centred care, strengthen the audiologist-consumer relationship, and ultimately improve patient satisfaction.

professional competence, facility quality, and inclusive care, all of which were recurrently mentioned in both positive and negative reviews.

The study's findings shed light on consumers' experiences with hearing healthcare, offering valuable insights into areas needing improvement in both service delivery and audiologist-consumer interactions. It emphasises that effective communication is a cornerstone of the consumer-audiologist partnership and plays a significant role in every in-clinic interaction with other service providers. Other key factors contributing to consumer satisfaction included personalised care and service, inclusion and accessibility, economic considerations, and the magnitude of hearing outcomes on consumers' well-being. •



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