**Electronic Journal of General Medicine**
2024, 21(1), em563
e-ISSN: 2516-3507
https://www.ejgm.co.uk/

MODESTUM

**Review Article**

**OPEN ACCESS**

# Speech perception and parameters of speech audiometry after hearing aid: Systematic review and meta-analysis

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**Citation:** Suatbayeva R, Toguzbayeva D, Taukeleva S, Mukanova Z, Sadykov M. Speech perception and parameters of speech audiometry after hearing aid: Systematic review and meta-analysis. Electron J Gen Med. 2024;21(1):em563. https://doi.org/10.29333/ejgm/14041

**ARTICLE INFO**

Received: 09 Jun. 2023

Accepted: 22 Nov. 2023

**ABSTRACT**

**Background:** One of the greatest difficulties of the hearing impaired is understanding speech, especially in the presence of competitive noise. Speech perception issues are a common difficulty for those who have hearing loss. Poor speech perception is the most frequent cause of seeking hearing treatment. The most extensively used treatment to enhance speech perception is hearing aids or other assistive devices.

**Aim:** To evaluate the effect of hearing aid methods on the speech perception of patients with hearing loss.

**Methods:** We conducted our study based on PRISMA recommendations and guidelines. We searched Cochrane, PubMed, Scopus, and Web of Science for relevant clinical trials and prospective observational studies. Clinical trials were assessed according to Cochrane's risk of bias tool, while observational studies were evaluated according to the National Heart, Lung, and Blood Institute. We involved the following outcomes: speech recognition thresholds, word recognition score (WRS) in noise, and WRS in quiet.

**Results:** Six studies met the eligibility criteria for our meta-analysis. We found that hearing aids can cause an increase in WRS in noise (mean difference [MD]=18.32 [3.08, 33.55], p=0.02) and WRS in quiet (MD=45.13 [7.79, 82.46], p=0.02). In addition, hearing aids lead to a decrease in speech recognition thresholds (MD=45.13 [7.79, 82.46], p=0.02).

**Conclusions:** Hearing aids are an effective treatment for patients with hearing loss. They can significantly improve speech perception (WRS) in quiet and noisy environments and provide other benefits, such as improved communication, increased safety, and better cognitive function. If you or someone you know has hearing loss, it is essential to speak with a healthcare professional about the benefits of using hearing aids.

**Keywords:** speech perception, speech audiometry, hearing aid, hearing loss, conductive hearing loss

## INTRODUCTION

Cognitive and language development are delayed and disrupted due to hearing loss. Oral communication is necessary for social engagement; however, those with hearing loss have worse speech comprehension than those with good hearing [1-3]. Additionally, the ability to perceive noise in the environment is impaired. Adults are more likely to acquire sensorineural hearing loss (SNHL), while children are more likely to develop conductive hearing loss (CHL) [4, 5]. Children's CHL may develop as a result of inherited or acquired defects and can be unilateral or bilateral [6]. The verbal, educational, and psychological development of children with various sorts of hearing problems may be impaired. Early hearing restoration is crucial for appropriate speech and language development [7, 8].

One of the most common and rapidly developing disabilities affecting people's quality of life is hearing impairment [9]. In general, hearing loss may cause a breakdown in communication, making daily functions more challenging. The effect on verbal communication and other crucial parts of life will increase as hearing loss progresses [10, 11]. The degree and the cause of the hearing loss determine how people with CHL should be managed. Children who have CHL may benefit from surgical or medical treatments. The external auditory canal or middle ear surgical repair is still challenging in infants with congenital CHL [12, 13]. Implants for the middle ear and bone conduction hearing are an alternative to surgical repair. The deformity, preoperative imaging, and patient age all play a role in the choice of implant type. All kinds of implants can improve directional hearing, signal-to-noise ratio, and speech perception [14, 15].

In individuals with unilateral hearing loss, including SNHL, mixed hearing loss, and CHL types, bone conduction devices (BCDs) have been employed as effective tools for hearing rehabilitation [16, 17]. When conventional BCD was first created in the early 20$^{th}$ century, it was transcutaneous [18]. Regardless of the degree and type of hearing loss, all implant patients display a broad range of speech perception abilities,

with various variables discovered to determine clinical performance [19].

Our systematic review and meta-analysis aim to evaluate the effect of hearing aid methods on the speech perception of patients with hearing loss.

## METHODS

We conducted our study on PRISMA recommendations and guidelines [20].

### Search Strategy & Information Sources

We developed a search strategy by combining these keywords: (''speech perception'') AND (''speech audiometry'') AND (''hearing aid'' OR ''hearing loss''). Concerning data sources, we utilized Cochrane, PubMed, Scopus, and Web of Science databases until May 2023 for articles that matched our inclusion criteria in the search process.

### Study Selection

First, we performed both title and abstract screenings. After that we conducted a full-text screening. Finally, we selected the eligible articles according to the following eligibility criteria:

- **Population:** Individuals suffering from unilateral or bilateral hearing loss who require hearing aid devices.
- **Intervention:** After the hearing aid parameters of the involved patients.
- **Comparator:** Before hearing aid parameters of the involved patients.
- **Outcomes:** Speech recognition thresholds, word recognition score (WRS) in noise (five dB), and quiet.
- **Study design:** We included clinical trials and prospective observational studies and excluded retrospective observational studies, meta-analyses, surveys, abstracts, and reviews.

### Quality Assessment

Since we involved clinical trials and prospective observational study designs, we used two quality assessment tools to assess the articles' bias risk. Regarding the clinical trials, we utilized Cochrane risk of bias tool, which depends on assessing eight domains in each clinical trial [21]. Each domain could be categorized as having a high, unclear, or low risk of bias. Concerning evaluating the quality of observational studies, we used the National Heart, Lung, and Blood Institute's (NHLB) quality assessment tool [22].

### Data Extraction

We extracted three types of data from involved articles: the first category is the characteristics of the involved articles and the demographic characteristics of the involved patients, such as gender, age, study design, and follow-up period. The second category was extracting data for the following outcomes for analysis: speech recognition thresholds, WRS in noise (five dB), and WRS in quiet. The last category was quality assessment data in both trials and observational studies. The process of data collection was conducted using Microsoft Excel [23].

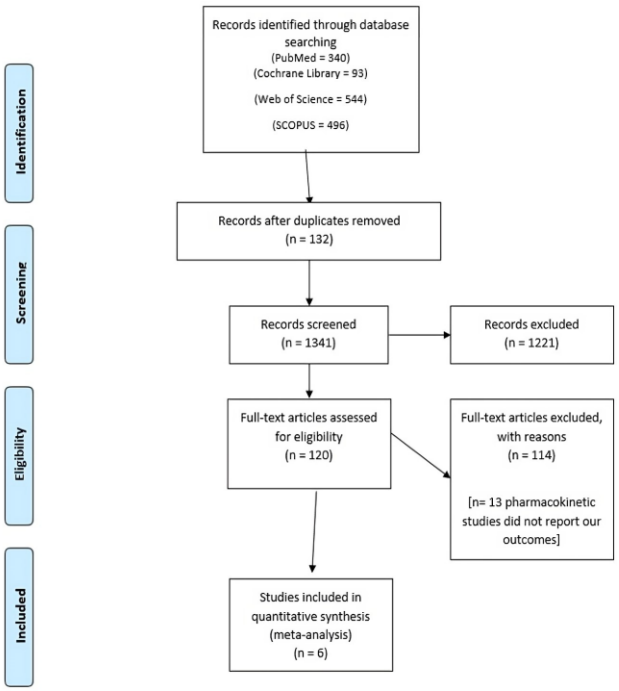


**Figure 1.** PRISMA flow chart of our literature search process (Source: Authors' own elaboration)

### Data Synthesis & Analysis

We used review manager software [24], which we used to conduct the meta-analysis for this research. We used continuous outcomes in our investigation. We used mean difference (MD) and 95% confidence interval to analyze continuous data.

When the data were homogenous, the fixed-effects model was employed; when the data were heterogeneous, the random-effects model was utilized. We utilized the value of I2 and p-value of the Chi-square tests to assess the degree of consistency across the studies [25]. The existence of heterogeneity was significantly indicated by values of p=0.10 or I2>50%. Using Cochrane's leave-one-out technique, we attempted to resolve the inconsistency of the results [25].

## RESULTS

### Summary of Involved Studies

**Figure 1** shows PRISMA flow chart of our literature search process. A total of six trials [26-31] were involved in our meta-analysis. Our meta-analysis involved 96 hearing-loss patients requiring hearing aid devices. The mean age of the involved patients was 27.9 years. Our study involved 57 (59%) males and 39 (41%) females.

### Results of Risk of Bias Assessment

According to Cochrane's tools, the risk of bias evaluation of randomized clinical trials indicated that they were at low risk of bias as each domain of Cochrane's tools was at low risk [31] (**Figure 2**). NHLB assessed the remaining studies' quality assessments [26-30]. The observational studies' average rating was 10.6 out of 14.

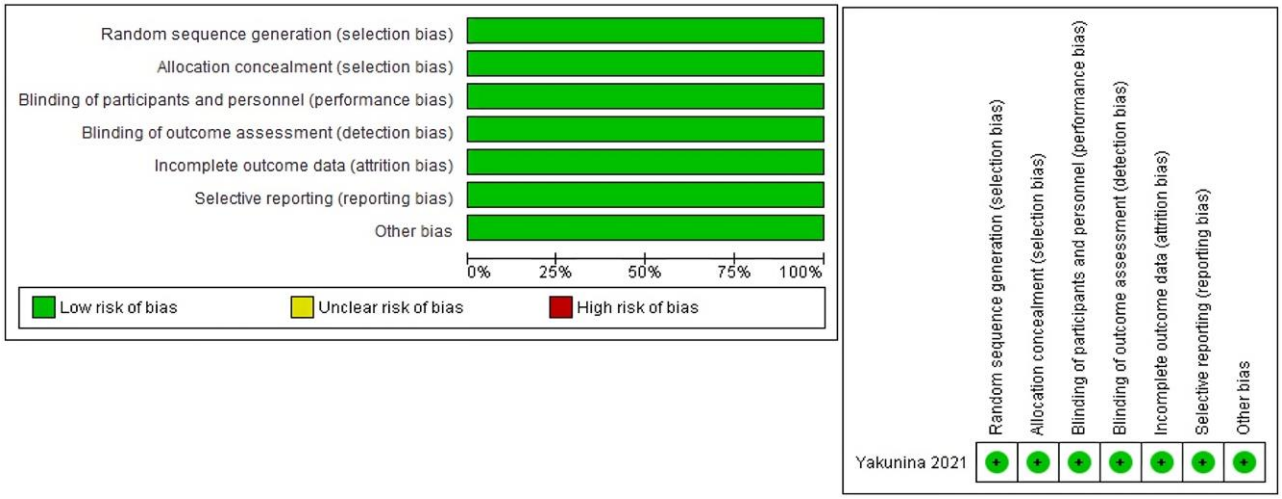


**Figure 2.** ROB (Source: Authors' own elaboration)

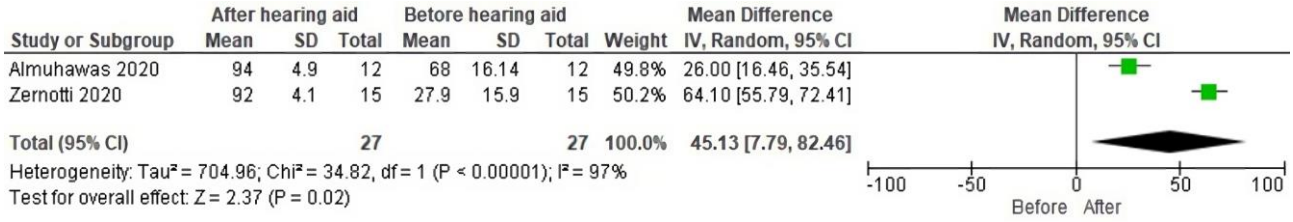


**Figure 3.** Analysis of WRS in quite (Source: Authors' own elaboration)

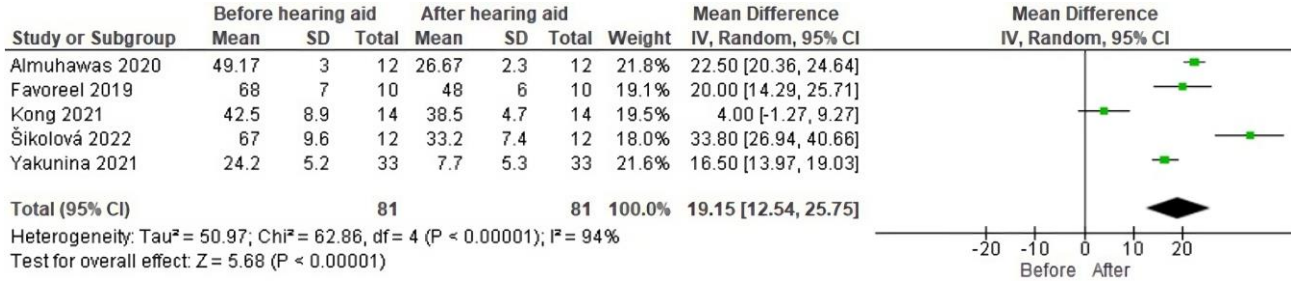


**Figure 4.** Analysis of SRT outcome (Source: Authors' own elaboration)

### Analysis of Outcomes

#### *Word recognition score in quiet*

The studies in [26, 27] reported this outcome. The analysis revealed that WRS was higher after the hearing aid than before (MD=45.13 [7.79, 82.46], p=0.02). The estimated analysis showed heterogeneity (I2=97%, p<0.001) (**Figure 3**).

#### *Word recognition score in noise*

WRS in noise outcome was reported by four studies [26, 27, 30, 31]. The overall mean difference proves that WRS in noise was higher after the hearing aid than before (MD=18.32 [3.08, 33.55], p=0.02). The analysis showed heterogeneity (I2=94%, p<0.001) (**Figure 3**).

#### *Speech recognition thresholds*

Five studies [27-31] reported SRT outcome. The overall mean difference revealed that SRT after the hearing aid was lower than before (MD=19.15 [12.54, 25.75], p<0.0001). The analysis showed heterogeneity (I2=94%, p<0.001) (**Figure 4**).

## DISCUSSION

In this meta-analysis, we evaluated the efficacy of hearing aid devices on speech perception in patients with hearing loss. Hearing loss is a common problem among people of all ages, and it can significantly impact their daily lives. One of the most common treatments for hearing loss is the use of hearing aids. Hearing aids are small electronic devices that amplify sound and improve speech perception in patients with hearing loss. In this article, we will discuss the efficacy of hearing aids on speech perception in patients with hearing loss [32]. Hearing aids can significantly improve speech perception in patients with hearing loss. Our analysis showed that hearing aids could significantly improve WRS in quiet and noisy environments. Besides, it significantly improved SRT.

It was examined the effectiveness of a new adhesive bone conduction hearing aid (ADHEAR) system for patients with CHL [27]. The results showed significant improvement in audiological outcomes, as well as high satisfaction rates and improved auditory performance, according to patient surveys.

The system caused no pain or skin irritation for most users. Overall, the study demonstrates the efficacy of using this system as a hearing rehabilitation option for young patients and those who do not wish to undergo surgery for implantable hearing aids.

ADHEAR audio processor is a new bone-conduction hearing aid system that has recently gained attention for its effectiveness in treating CHL. Unlike traditional implantable hearing aids, ADHEAR system uses an adhesive attachment to transmit sound waves through the skull bone directly to the inner ear, bypassing any blockages in the outer or middle ear. This innovative approach has shown promising results in improving audiological outcomes and patient satisfaction, making it a viable option for those who are not candidates for surgery or prefer a non-invasive solution. In this article, we will explore the efficacy of ADHEAR audio processor as a hearing rehabilitation option and its potential benefits for patients with CHL.

It was aimed to assess the effectiveness of the ADHEAR system as a treatment option for children with CHL, both unilateral and bilateral, over a three-week period [28]. The study also compared ADHEAR system to a traditional bone conduction hearing aid on a softband. Additionally, the study aimed to evaluate the improvement in quality of life and patient satisfaction with ADHEAR system. ADHEAR audio processor has been found to be an effective treatment option for children with CHL, according to a short-term study. The device has shown significant improvements in hearing thresholds, speech perception in silence, and quality of life. Although subjective experience should be considered, especially for children with unilateral CHL, the device has a fast adaptation time and reliable results over time. The improvements seen with ADHEAR are comparable to those of a bone conduction hearing aid on a softband, making it a valuable alternative for children with CHL.

Identifying combined impacts of electrocochleography, angular insertion depth, and array design on speech perception outcomes was goal of the current investigation [33]. The study found that measuring the total response before cochlear implant (CI) insertion significantly predicted speech perception outcomes for adult CI recipients. However, the total response did not accurately predict performance for all types of CI arrays. A model that involved the total response, array design, and the interaction between array design and the auditory periphery accounted for a large portion of the variance in postoperative speech perception scores. These results suggest that the relationship between insertion depth and speech perception may vary depending on the type of CI array used and highlight the important role of the auditory periphery in speech perception for adult CI recipients.

It was reported that after examining the mapping strategy for CIs at various target thresholds, the researchers discovered that optimal speech recognition occurred when the target threshold was set between 25 and 35 dB [34]. When the target threshold was raised, there was an increase in dynamic range and better speech recognition. The key to achieving the best perception is finding a balance between reducing the hearing threshold and maximizing the dynamic range, which allows for appropriate speech recognition.

It was evaluated the speech perception of adult CI recipients as a result of residual speech and auditory loss [35]. They examined the effects of residual hearing, speech perception, and auditory deprivation on post-CI word recognition performances and found that patients who experienced shorter periods of auditory deprivation as well as measured speech perceptions and residual hearing may have performed better with CI. Individual speech perception abilities should be considered while choosing ears in unilateral CI instances.

### Limitations

One of our main limitations is the heterogeneity of the analysis. However, we managed to trace out the attributing factors, which are the use of different types of aid devices and different study designs.

## CONCLUSIONS

Hearing aids are an effective treatment for patients with hearing loss. They can significantly improve speech perception (WRS) in both quiet and noisy environments, as well as provide other benefits such as improved communication, increased safety, and better cognitive function. If you or someone you know has hearing loss, it is important to speak with a healthcare professional about the benefits of using hearing aids.

**Author contributions:** All authors have sufficiently contributed to the study and agreed with the results and conclusions.

**Funding:** No funding source is reported for this study.

**Ethical statement:** The authos stated that the study adheres to ethical principles, with a commitment to responsible publishing, transparency in research through open data practices, and the ethical treatment of subjects, ensuring no violations of ethical standards. The study did not require approval from an institutional ethics committee since it was based on existing literature.

**Declaration of interest:** No conflict of interest is declared by authors.

**Data sharing statement:** Data supporting the findings and conclusions are available upon request from the corresponding author.

## REFERENCES

1. Šlapák I, Urík M, Hošnová D, Kruntorád V, Šikolová S, Bartoš M. Hearing loss in children. Pediatrie Pro Praxi. 2022;23(5):339-43.
2. Samocha-Bonet D, Wu B, Ryugo DK. Diabetes mellitus and hearing loss: A review. Ageing Res Rev. 2021;71:101423. https://doi.org/10.1016/j.arr.2021.101423 PMid:34384902
3. van Beeck Calkoen EA, Engel MSD, van de Kamp JM, et al. The etiological evaluation of sensorineural hearing loss in children. Eur J Pediatr. 2019;178(8):1195-205. https://doi.org/10.1007/s00431-019-03379-8 PMid: 31152317 PMCid:PMC6647487
4. Jafari Z, Kolb BE, Mohajerani MH. Hearing loss, tinnitus, and dizziness in COVID-19: A systematic review and meta-analysis. Can J Neurol Sci. 2022;49(2):184-95. https://doi.org/10.1017/cjn.2021.63 PMid:33843530 PMCid:PMC8267343
5. Vos B, Noll D, Pigeon M, Bagatto M, Fitzpatrick EM. Risk factors for hearing loss in children: A systematic literature review and meta-analysis protocol. Syst Rev. 2019;8(1):172. https://doi.org/10.1186/s13643-019-1073-x PMid: 31315672 PMCid:PMC6637473

6. Wagatsuma Y, Daimaru K, Deng S, Chen JY. Hearing loss and the COVID-19 pandemic. BMC Res Notes. 2022;15:228. https://doi.org/10.1186/s13104-022-06120-1 PMid: 35761410 PMCid:PMC9235250
7. Morgan A, Gasparini P, Girotto G. Hearing loss. In: Patrinos GP, Lázaro C, Lerner-Ellis J, Spurdle A, editors. Clinical DNA variant interpretation: Theory and practice. Cambridge (MA), USA: Academic Press; 2021. https://doi.org/10.1016/B978-0-12-820519-8.00016-8 PMid:34964090 PMCid: PMC9021055
8. Chandrasekhar SS, Tsai Do BS, Schwartz SR, et al. Clinical practice guideline: Sudden hearing loss (update) executive summary. Otolaryngol Head Neck Surg. 2019;161(2):195-210. https://doi.org/10.1177/0194599819859883 PMid: 31369349
9. Powell DS, Oh ES, Reed NS, Lin FR, Deal JA. Hearing loss and cognition: What we know and where we need to go. Front Aging Neurosci. 2022;13:769405. https://doi.org/10.3389/fnagi.2021.769405 PMid:35295208 PMCid:PMC8920093
10. Irace AL, Armstrong NM, Deal JA, et al. Longitudinal associations of subclinical hearing loss with cognitive decline. J Gerontol A Biol Sci Med Sci. 2022;77(3):623-31. https://doi.org/10.1093/gerona/glab263 PMid:34516645 PMCid:PMC8893253
11. Gouveia FN, Jacob-Corteletti LCB, Silva BCS, et al. Perda auditiva unilateral e assimétrica na infância [Unilateral and asymmetric hearing loss in childhood]. CoDAS. 2020;32(1). https://doi.org/10.1590/2317-1782/20192018280 PMid: 31994593
12. Silvola JT. Endoscopic findings and long-term hearing results for pediatric unilateral conductive hearing loss. Int J Pediatr Otorhinolaryngol. 2020;133:109983. https://doi.org/10.1016/j.ijporl.2020.109983 PMid: 32200311
13. Neumann K, Thomas JP, Voelter C, Dazert S. A new adhesive bone conduction hearing system effectively treats conductive hearing loss in children. Int J Pediatr Otorhinolaryngol. 2019;122:117-25. https://doi.org/10.1016/j.ijporl.2019.03.014 PMid:31004837
14. Okada M, Welling DB, Liberman MC, Maison SF. Chronic conductive hearing loss is associated with speech intelligibility deficits in patients with normal bone conduction thresholds. Ear Hear. 2020;41(3):500-7. https://doi.org/10.1097/AUD.0000000000000787 PMid: 31490800 PMCid:PMC7056594
15. Kindzer B, Saienko V, Diachenko A. Ability of kata "Sanchin" Kyokushinkai karate to quickly restore the bodies of karate sportsmen after significant physical activity. J Phys Educ Sport. 2018;18(1):28-32. https://doi.org/10.7752/jpes.2018.01004
16. Volgger V, Schießler IT, Müller J, Schrötzlmair F, Pollotzek M, Hempel JM. Audiological results and subjective benefit of an active transcutaneous bone-conduction device in patients with congenital aural atresia. Eur Arch Otorhinolaryngol. 2022;279(5):2345-52. https://doi.org/10.1007/s00405-021-06938-8 PMid:34173875 PMCid: PMC8986742
17. Maier H, Lenarz T, Agha-Mir-Salim P, et al. Consensus statement on bone conduction devices and active middle ear implants in conductive and mixed hearing loss. Otol Neurotol. 2022;43(5):513-29. https://doi.org/10.1097/MAO.0000000000003491 PMid:35383700
18. Skarzynski PH, Ratuszniak A, Osinska K, et al. A comparative study of a novel adhesive bone conduction device and conventional treatment options for conductive hearing loss. Oto Neurotol. 2019;40(7):858-64. https://doi.org/10.1097/MAO.0000000000002323 PMid: 31295197 PMCid:PMC6641089
19. Gao Q, Wong LLN, Chen F. A review of speech perception of mandarin-speaking children with cochlear implantation. Front Neurosci. 2021;15:773694. https://doi.org/10.3389/fnins.2021.773694 PMid:34970113 PMCid:PMC8712552
20. Moher D. Preferred reporting items for systematic reviews and meta-analyses: PRISMA statement (Chinese edition). J Chin Integr Med. 2009;7:889-96. https://doi.org/10.3736/jcim20090918
21. Higgins JPT, Altman DG, Gøtzsche PC, et al. The Cochrane collaboration's tool for assessing risk of bias in randomised trials. BMJ. 2011;343:d5928. https://doi.org/10.1136/bmj.d5928 PMid:22008217 PMCid:PMC3196245
22. Pearson GD, Mensah GA, Rosenberg Y, Stoney CM, Kavounis K, Goff DC. National Heart, Lung, and Blood Institute cardiovascular clinical trial perspective. Am Heart J. 2020;224:25-34. https://doi.org/10.1016/j.ahj.2020.02.014 PMid:32298849
23. Katz A. Microsoft Excel 2010. DeKalb (IL), USA: Style; 2010.
24. Lebowitz F. Endnote. In: Short G, Reed CA, editors. Issues in holocaust education. New York (NY), USA: Routledge; 2004. https://doi.org/10.4324/9781315251714-10
25. Higgins JPT, Thomas J, Chandler J, et al. Cochrane handbook for systematic reviews of interventions. Cochrane; 2023. https://doi.org/10.1002/9781119536604
26. Zernotti ME, Alvarado E, Zernotti M, Claveria N, Di Gregorio MF. One-year follow-up in children with conductive hearing loss using ADHEAR. Audiol Neurotol. 2021;26(6):435-44. https://doi.org/10.1159/000514087 PMid:33831862
27. Almuhawas F, Alzhrani F, Saleh S, Alsanosi A, Yousef M. Auditory performance and subjective satisfaction with the ADHEAR system. Audiol Neurotol. 2021;26(1):1-10. https://doi.org/10.1159/000507775 PMid:32544908
28. Favoreel A, Heuninck E, Mansbach A. Audiological benefit and subjective satisfaction of children with the ADHEAR audio processor and adhesive adapter. Int J Pediatr Otorhinolaryngol. 2020;129:109729. https://doi.org/10.1016/j.ijporl.2019.109729 PMid:31689608
29. Kong TH, Lee J, Kwak C, Han W, Gwon O-H, Seo YJ. Audiological benefits and performance improvements of Baha® attract implantation in patients with unilateral hearing loss. Cochlear Implants Int. 2021;22(5):270-82. https://doi.org/10.1080/14670100.2021.1903713 PMid: 33752582
30. Šikolová S, Urík M, Hošnová D, et al. Two bonebridge bone conduction hearing implant generations: Audiological benefit and quality of hearing in children. Eur Arch Otorhinolaryngol. 2022;279(7):3387-98. https://doi.org/10.1007/s00405-021-07068-x PMid:34495351 PMCid: PMC9130159
31. Yakunina N, Nam E. A double-blind, randomized controlled trial exploring the efficacy of frequency lowering hearing aids in patients with high-frequency hearing loss. Auris Nasus Larynx. 2021;48(2):221-6. https://doi.org/10.1016/j.anl.2020.08.021 PMid:32891496
32. Hoppe U, Hesse G. Hearing aids: Indications, technology, adaptation, and quality control. GMS Curr Top Otorhinolaryngol Head Neck Surg. 2017;16:Doc08. https://doi.org/10.3205/cto000147

33. Canfarotta MW, O'Connell BP, Giardina CK, et al. Relationship between electrocochleography, angular insertion depth, and cochlear implant speech perception outcomes. Ear Hear. 2021;42(4):941-8. https://doi.org/10.1097/AUD.0000000000000985 PMid:33369942 PMCid: PMC8217403
34. Cheng HM, Koutsidis G, Lodge JK, Ashor A, Siervo M, Lara J. Tomato and lycopene supplementation and cardiovascular risk factors: A systematic review and meta-analysis. Atherosclerosis. 2017;257:100-8. https://doi.org/10.1016/J.ATHEROSCLEROSIS.2017.01.009 PMid:28129549
35. Derinsu U, Yuksel M, Gecici CR, Ciprut A, Akdeniz E. Effects of residual speech and auditory deprivation on speech perception of adult cochlear implant recipients. Auris Nasus Larynx. 2019;46(1):58-63. https://doi.org/10.1016/j.anl.2018.06.006 PMid:29945747