Original Investigation

Association of Using Hearing Aids or Cochlear Implants With Changes in Depressive Symptoms in Older Adults

Janet S. Choi, MPH; Joshua Betz, MS; Lingsheng Li, MHS; Caitlin R. Blake, MSPH; Yoon K. Sung, MHS; Kevin J. Contrera, MPH; Frank R. Lin, MD, PhD

IMPORTANCE Hearing loss is a common health problem in older adults that is strongly associated with the development of depression. Previous cross-sectional studies have reported lower odds of depression among individuals who use hearing aids. However, there have been limited prospective studies investigating the effect of hearing loss treatments on depressive symptoms.

OBJECTIVE To investigate the association between treatment with a hearing aid or cochlear implant with depressive symptoms in older adults.

DESIGN, SETTING, AND PARTICIPANTS A prospective observational study was conducted of 113 participants 50 years or older who received hearing aids (n = 63) or cochlear implants (n = 50). Participants were recruited from August 1, 2011, to January 31, 2014, at a tertiary care academic center.

INTERVENTION Hearing aid or cochlear implantation.

MAIN OUTCOMES AND MEASURES Depressive symptoms were evaluated by the 15-item Geriatric Depression Scale (GDS) at baseline and at 6 and 12 months after intervention. The score ranges from 0 to 15, and various scores between 3 and 10 have been used as being suggestive of depression.

RESULTS The median age of the 113 study participants was 69.6 years (interquartile range, 63.5-77.4 years). At baseline, the mean GDS score for the participants was 41% lower (95% CI, 7%-63%) among those receiving hearing aids (mean score, 1.5; 95% CI, 0.7-3.3) compared with those receiving cochlear implants (mean score, 2.6; 95% CI, 1.3-5.1). Cochlear implant recipients' GDS scores improved from baseline to 6 months after treatment by 31% (95% CI, 10%-47%) and from baseline to 12 months after treatment by 38% (95% CI, 18%-54%). Hearing aid recipients' GDS scores improved by 28% (95% CI, 0%-48%) at 6 months after treatment but were not significantly different from baseline at 12 months after treatment (16%; 95% CI, −24% to 43%).

CONCLUSIONS AND RELEVANCE There was a significant improvement in depressive symptoms at 6 months after treatment for patients receiving cochlear implants and hearing aids; this improvement persisted to 12 months for those who received cochlear implants. Further research is warranted to assess the long-term effect of hearing rehabilitation on mental health in older adults.

JAMA Otolaryngol Head Neck Surg. 2016;142(7):652-657. doi:10.1001/jamaoto.2016.0700
Published online May 12, 2016.

Author Affiliations: Johns Hopkins University School of Medicine, Baltimore, Maryland (Choi, Contrera); Center on Aging and Health, Johns Hopkins Medical Institutions, Baltimore, Maryland (Betz, Blake, Lin); University of Oklahoma College of Medicine, Oklahoma City (Li); Drexel University College of Medicine, Philadelphia, Pennsylvania (Sung); Department of Otolaryngology–Head and Neck Surgery, The Johns Hopkins University, Baltimore, Maryland (Lin); Department of Epidemiology, The Johns Hopkins University, Baltimore, Maryland (Lin).

Corresponding Author: Frank R. Lin, MD, PhD, Center on Aging and Health, Johns Hopkins Medical Institutions, 2024 E Monument St, Ste 2-700, Baltimore, MD 21205 (flin1@jhmi.edu).

Key Points

Question What is the effect of hearing aid and cochlear implant use on depressive symptoms in older adults?

Findings In this prospective observational study of 113 participants 50 years or older, a significant improvement in depressive symptoms was observed in recipients of both cochlear implants and hearing aids at 6 months after treatment, which persisted to 12 months for those who received cochlear implants.

Meaning Treatment of hearing loss with hearing aids and cochlear implants may result in significant improvement in depression and mental health in older adults.

Age-related hearing loss is a highly prevalent condition that affects two-thirds of those older than 70 years in the United States.[1] Prior literature has demonstrated that hearing loss in older adults may lead to accelerated declines in physical and cognitive functioning and poorer mental health.[2-6] Depression among older adults is a major public health problem, associated with increasing morbidity and mortality.[7] Hearing loss is the most common chronic condition associated with depression in older adults.[8] Mechanisms that may underlie these associations include the effect of hearing loss on social isolation, loneliness, and greater dependence on a caregiver, ultimately leading to poorer quality of life and depression.[9-11]

Hearing aids and cochlear implantation are currently available therapies for older adults with hearing loss that are often underused. Previous cross-sectional studies have demonstrated significantly lower odds of depression and depressive symptoms among older adults with hearing loss who used hearing aids compared with those who did not.[6,12-16] However, the actual direction of the association is unclear from these studies—for example, are individuals with fewer depressive symptoms more likely to obtain a hearing aid, or do hearing aids in fact contribute to decreased depressive symptoms after treatment? Several prospective studies[17-23] and a randomized clinical trial[24] have examined the effect of aural rehabilitation using a hearing aid or cochlear implant on depressive symptoms; these studies have demonstrated inconsistent results. Although some studies have shown positive benefit,[17,19-21,24] others have shown little to no benefit of hearing loss treatment on depressive symptoms.[22,23] However, these studies are likely limited in part owing to small sample size and short duration of follow-up in either patients receiving hearing aids or cochlear implants.

The Studying Multiple Outcomes after Aural Rehabilitative Treatment (SMART) study was a prospective observational study evaluating the effect of aural rehabilitation on a range of functional domains for 12 months in a convenience sample of participants 50 years or older receiving a hearing aid or cochlear implant (L. Li, MHS, C. Blake, MSPH, Y. Sung, MHS, B. Shpritz, MA, D. Chen, MD, D. Genther, MD, J. Betz, MS, and F. Lin, MD, PhD, unpublished data, March 2015). Our study aims to explore the association of treatment with a hearing aid or cochlear implant with change in depressive symptoms in older adults using a validated measure of depressive symptoms.

Methods

Study Population

As part of the SMART study, we recruited participants 50 years or older who presented for evaluation to receive a hearing aid or cochlear implant from August 1, 2011, to January 31, 2014, at a tertiary care academic center. The SMART study was a prospective observational study evaluating the change after hearing intervention in overall functioning of older adults with postlingual hearing loss. Participants were English speaking, receiving a hearing aid for the first time or with less than 1 hour per day of prior hearing aid use or receiving a first cochlear implant, and used verbal language as their primary communication modality.

Of 564 patients meeting eligibility criteria, 145 agreed to participate in the study. Of those 145 patients, 32 (22.1%) withdrew from the study for reasons including inability to be reached (n = 10), personal reasons (n = 8), reported device issues (n = 6), illnesses (n = 4), and returned hearing aids (n = 4). The remaining 113 participants completed the baseline questionnaire. There was no significant difference in baseline Geriatric Depression Scale (GDS) scores between participants who completed the baseline questionnaire and those who did not (median score for completers, 2 [interquartile range, 0-3]; median score for noncompleters, 2 [interquartile range, 1-4]; $P = .52$). Of the 113 participants, 78 (69.0%) completed the questionnaire at 12 months after treatment. Baseline characteristics of respondents and nonrespondents at 12 months of follow-up did not differ across age, sex, race/ethnicity, educational level, income, history of comorbidities, or GDS scores. Recipients of hearing aids were more likely to miss their 12-month follow-up, as it was not part of their standard follow-up of care as it is for recipients of a cochlear implant. Study participants provided written informed consent. Our protocol was approved by the Johns Hopkins School of Medicine Institutional Review Board.

Aural Rehabilitation

Study participants received a hearing aid or cochlear implant based on routine clinical care. The fitting procedure for the hearing aid recipients included making a decision on the type of technology, features of the hearing aid, and unilateral vs bilateral fitting, which was determined between the audiologist and the patient and dependent on such factors as the patient's needs and financial resources. Cochlear implantation surgical procedures and associated fitting and programming were performed at the tertiary academic center. The type of cochlear implant technology and fitting procedures were determined between the implant audiologist and the patient. Study participants received an additional 1-year extended warranty on their hearing device from the respective hearing aid (Phonak, Oticon, Starkey, Unitron, and Widex) and cochlear implant (Cochlear America, Med-El Corp, and Advanced Bionics) companies.

Depressive Symptoms

Participants were assessed using self-administered questionnaires before the hearing intervention and at 6 and 12 months after receiving a hearing aid or cochlear implant. Depressive

Table 1. Baseline Demographic Characteristics of Study Participants

Characteristic	All (N = 113)	Cochlear Implant (n = 50)	Hearing Aid (n = 63)	P Value
Age, median (IQR), y	69.6 (63.5-77.4)	69.2 (62.9-78.5)	71.0 (63.4-75.5)	.85
Female sex, No. (%)	46 (40.7)	21 (42.0)	25 (39.7)	.85
White race/ethnicity, No. (%)	102 (90.3)	45 (90.0)	57 (90.5)	>.99
Educational level, No. (%)				
High school or less	16 (14.2)	12 (24.0)	4 (6.3)	
Bachelors or Associates degree	48 (42.5)	22 (44.0)	26 (41.3)	.01
Postgraduate	49 (43.4)	16 (32.0)	33 (52.4)	
Hypertension, No. (%)	62 (54.9)	27 (54.0)	35 (55.6)	>.99
Diabetes mellitus, No. (%)	24 (21.2)	7 (14.0)	17 (27.0)	.16
Current or former smoker, No. (%)	56 (49.6)	30 (60.0)	26 (41.3)	.09
Pure-tone average, median (IQR), dB[a]	46.2 (35.0-65.6)	69.4 (64.4-81.6)	36.2 (27.5-42.5)	<.001

Abbreviation: IQR, interquartile range.

[a] Pure-tone average of hearing thresholds at 1, 2, and 4 kHz in the better-hearing ear.

symptoms were measured using the 15-item GDS, a validated questionnaire widely used to assess depressive symptoms among the geriatric population.[25,26] The scale consists of 15 questions that can be answered as yes or no (eg, "Are you basically satisfied with your life?", "Have you dropped many of your activities and interests?", "Do you often get bored?", "Are you in good spirits most of the time?", "Do you prefer to stay at home rather than going out and doing new things?"). The score ranges from 0 to 15, and various scores between 3 and 10 have been used as being suggestive of depression.[22,27] We chose a score of 5 or greater as suggestive of depression as in prior literature.[28]

Other Covariates

Study participants self-reported demographic variables and medical history at baseline. Sex was included as a binary variable. Race/ethnicity was collapsed to white (non-Hispanic white or Caucasian) or others (non-Hispanic black or African American; Hispanic or Latino; Asian or Pacific Islander; American Indian or Alaskan Native; or Native Hawaiian or other Pacific Islander). Educational level was grouped as high school or less, Bachelor or Associate degree, or postgraduate education. Medical history variables included hypertension, diabetes mellitus, and smoking (former or current vs never). Audiometric data were gathered per clinical routine.

Statistical Analysis

Demographic and clinical characteristics were compared across the treatment groups using the Wilcoxon rank sum and Fisher exact tests where appropriate. Because of the right-skewed distribution of the observed GDS scores, Poisson mixed-effects models were used to model the longitudinal trajectories of GDS scores before and after aural rehabilitation, accounting for the repeated measurements within individuals using random intercepts. Contrasts between the time and treatment interaction were used to assess the difference between groups at each visit, the differences within groups across time, and the changes between consecutive visits by group. All models were adjusted for age, sex, educational level, and history of hypertension, diabetes, and smoking as time-fixed covariates. Residual diagnostic plots were used to assess residual autocorrelation, the linearity of associations, variance specification, and normality of the predicted random effects. Participants were excluded if they were missing any covariates or were missing the outcome at baseline. All covariates associated with the likelihood of a missed study visit were included in outcome models, with the assumption that outcomes were missing at random. Contrasts were adjusted for multiple comparisons using the single-step method. Significance testing was performed using 2-sided tests with a type I error rate of 0.05, and 95% CIs were provided for all estimated differences. All analyses were conducted in R (R Foundation for Statistical Computing).

Results

Our baseline cohort comprised 113 participants who completed the questionnaire as part of the SMART study. Of these participants, 50 (44.2%) received cochlear implants and 63 (55.8%) received a hearing aid. Demographic characteristics of the baseline cohort are summarized in **Table 1**. The median age of the participants was 69.6 years (interquartile range, 63.5-77.4 years). The characteristics of those who received cochlear implants and hearing aids did not differ across demographic characteristics except for level of hearing loss and education. Those who received a cochlear implant were more likely to have a greater degree of hearing loss and a higher educational level.

Geriatric Depression Scale scores at baseline were significantly different between those who received a cochlear implant (mean score, 2.6; 95% CI, 1.3-5.1) and those who received a hearing aid (mean score, 1.5; 95% CI, 0.7-3.3), with hearing aid recipients having 41% lower mean GDS scores than cochlear implant recipients (95% CI, 7%-63%) (**Table 2**). There were no statistically significant differences in mean GDS scores between those who received a cochlear implant and those who received a hearing aid at 6 months (cochlear impant: 1.8; 95% CI, 0.9-3.6; hearing aid: 1.1; 95% CI, 0.5-2.4) and at 12 months (cochlear implant: 1.6; 95% CI, 0.8-3.2; hearing aid: 1.3; 95% CI, 0.6-2.9).

Geriatric Depression Scale scores among cochlear implant recipients decreased by 31% from baseline at 6 months after treatment and decreased by 38% at 12 months after treat-

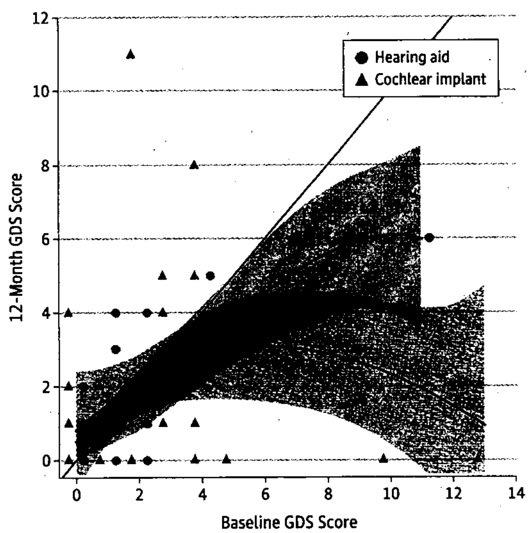
Table 2. Poisson Mixed-Effects Model of the Effect of Hearing Aids and Cochlear Implantation on Mean GDS Scores[a]

GDS Score	Cochlear Implant (n = 50)	Hearing Aids (n = 63)	Difference Between Cochlear Implant and Hearing Aid, % (95% CI)
Mean GDS score (95% CI)			
Baseline	2.6 (1.3 to 5.1)	1.5 (0.7 to 3.3)	41 (7 to 63)
6 mo	1.8 (0.9 to 3.6)	1.1 (0.5 to 2.4)	49 (−1 to 63)
Decrease from baseline to 6 mo, % (95% CI)	31 (10 to 47)	28 (0 to 48)	−4 (−58 to 31)
12-mo mean GDS score (95% CI)	1.6 (0.8 to 3.2)	1.3 (0.6 to 2.9)	21 (−39 to 55)
Decrease from baseline to 12 mo, % (95% CI)	38 (18 to 54)	16 (−24 to 43)	−36 (−120 to 16)

Abbreviation: GDS, Geriatric Depression Scale.

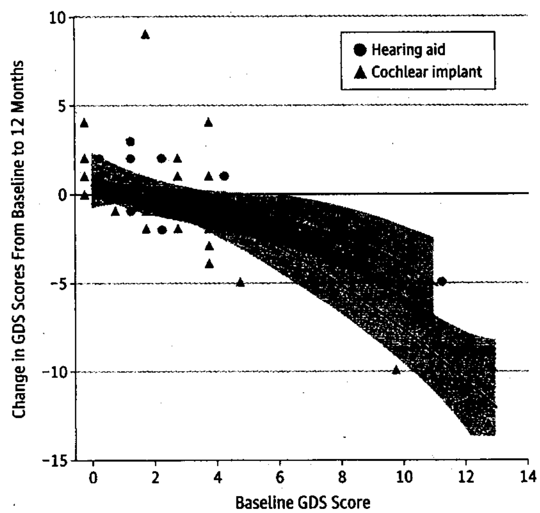
[a] Adjusted for age, sex, educational level, and history of hypertension, diabetes, and smoking.

Figure 1. Geriatric Depression Scale (GDS) Scores at 12 Months vs Baseline With Loess Fit



The black line is a reference line representing no change in depressive symptoms at 12 months of follow-up vs baseline. The shaded areas represent 95% CI bands.

Figure 2. Change in Geriatric Depression Scale (GDS) Scores From Baseline to 12 Months by Baseline GDS Score With Loess Fit



The black line is a reference line representing no change in depressive symptoms at 12 months of follow-up vs baseline. The shaded areas represent 95% CI bands.

ment. Among hearing aid recipients, GDS scores decreased by 28% from baseline to 6 months after treatment to a mean of 1.1 and decreased by 16% from baseline at 12 months after treatment to a mean of 1.3.

Figure 1 and **Figure 2** demonstrate the distribution of GDS scores at baseline vs 12-month scores and baseline vs change in scores at 12 months, respectively. The most extensive improvements in GDS scores were observed in individuals with higher baseline GDS scores.

Eight cochlear implant recipients (16.0%) and 5 hearing aid recipients (7.9%) had GDS scores suggestive of depression (score, ≥5) at baseline. At 12 months after treatment, the number of individuals with GDS scores suggestive of depression decreased to 6 cochlear implant recipients (12.0%) and 3 hearing aid recipients (4.8%).

Discussion

Our results demonstrate that use of a cochlear implant in older adults was associated with a significant decrease in depressive symptoms at 6 months after treatment, which persisted to 12 months. Use of a hearing aid was associated with a significant decrease in depressive symptoms at 6 months but not 12 months. In general, we observed that the most substantial improvements in depressive scores were seen in individuals who had the highest depressive symptoms at baseline.

Our results are generally consistent with the few studies that have explored the effect of hearing loss treatment on depression. Several studies previously examining the effect of cochlear implants on depression demonstrated a significant decrease in scores using various depression scales (GDS-4,[17] GDS-15,[18] General Depression Scale,[19] Minnesota Multiphasic Personality Inventory, and Beck Depression Inventory[23]) at 6 to 54 months after cochlear implantation. The mitigating effects of a cochlear implant on depression may be mediated by improved social engagement along with preservation of independence. However, our study, along with the prior studies, used self-report screening instruments. The statistically significant decrease in depressive symptoms measured on a screening instrument, such as the GDS-15, may not indicate a clinically meaningful decrease in depression. Screening instruments tend to overestimate the prevalence of depression.[27]

Results from previous studies examining the effect of hearing aids on depression have been inconsistent, with some studies showing fewer depressive symptoms after use of a hearing aid[20,21,29] and others showing no effect.[22] This inconsistency may have been owing to the heterogeneity in depression questionnaires used (eg, GDS-15, the Center for Epidemiological Studies Depression Scale), sample size (15-254), and duration of follow-up (3-12 months). One study in the Netherlands that used the GDS-15, whose participants had mean baseline GDS scores similar to those in our study, demonstrated no significant change in GDS score after 1 year of use with a hearing aid.[22] These findings may be explained by the relatively low mean GDS scores with a floor effect at baseline in these populations, requiring substantially larger sample sizes to have enough power to detect a small change in GDS scores. In our study, we found significant decreases in depressive symptoms after 6 months of hearing aid use. The observed decrease at 12 months had a wider 95% CI, which was nonsignificant (P = .37). This finding may be secondary to the reduced sample size among hearing aid participants at 12 months of follow-up in addition to the floor effect at baseline in this sample of high-functioning patients. Similar to the cochlear implant recipients, hearing aid recipients with the greatest depressive symptoms at baseline had the greatest improvement after treatment (Figures 1 and 2).

Our study has some limitations. First, our study cohort was based on a convenience sample of patients presenting for routine clinical care; this cohort may not be generalizable to other populations. Our analysis was also based on the assumption that data were missing at random for the 31% of participants who had missing 12-month data. Another limitation is that our study design without randomization or a control group limits any causal inference with respect to the actual effect of hearing loss treatment on depressive symptoms. Finally, the observed outcomes reported at 12 months after treatment may not be reflected with longer durations of follow-up.

Conclusions

Our results suggest that older adults with hearing loss undergoing treatment with hearing aids and cochlear implantation exhibit improved depressive symptoms in the first 6 to 12 months after treatment. Further research is needed to assess the long-term effect on depression and other domains of mental health of treating hearing loss in older adults.

ARTICLE INFORMATION

Accepted for Publication: March 13, 2016.

Published Online: May 12, 2016. doi:10.1001/jamaoto.2016.0700.

Author Contributions: Ms Choi and Dr Lin had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Choi, Sung, Lin.
Acquisition, analysis, or interpretation of data: Choi, Betz, Li, Blake, Contrera, Lin.
Drafting of the manuscript: Choi, Betz, Contrera.
Critical revision of the manuscript for important intellectual content: Betz, Li, Blake, Sung, Contrera, Lin.
Statistical analysis: Choi, Betz, Contrera, Lin.
Obtained funding: Lin.
Administrative, technical, or material support: Choi, Li, Blake, Sung, Contrera, Lin.
Study supervision: Lin.

Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Dr Lin reported serving as a consultant to Cochlear, serving on the scientific advisory board for Autifony and Pfizer, and serving as a speaker for Med El Corp and Amplifon. No other conflicts were reported.

REFERENCES

1. Lin FR, Thorpe R, Gordon-Salant S, Ferrucci L. Hearing loss prevalence and risk factors among older adults in the United States. *J Gerontol A Biol Sci Med Sci*. 2011;66(5):582-590.

2. Lin FR, Ferrucci L, Metter EJ, An Y, Zonderman AB, Resnick SM. Hearing loss and cognition in the Baltimore Longitudinal Study of Aging. *Neuropsychology*. 2011;25(6):763-770.

3. Genther DJ, Frick KD, Chen D, Betz J, Lin FR. Association of hearing loss with hospitalization and burden of disease in older adults. *JAMA*. 2013;309(22):2322-2324.

4. Strawbridge WJ, Wallhagen MI, Shema SJ, Kaplan GA. Negative consequences of hearing impairment in old age: a longitudinal analysis. *Gerontologist*. 2000;40(3):320-326.

5. Chen DS, Betz J, Yaffe K, et al; Health ABC study. Association of hearing impairment with declines in physical functioning and the risk of disability in older adults. *J Gerontol A Biol Sci Med Sci*. 2015;70(5):654-661.

6. Mener DJ, Betz J, Genther DJ, Chen D, Lin FR. Hearing loss and depression in older adults. *J Am Geriatr Soc*. 2013;61(9):1627-1629.

7. Blazer DG, Hybels CF, Fillenbaum GG, Pieper CF. Predictors of antidepressant use among older adults: have they changed over time? *Am J Psychiatry*. 2005;162(4):705-710.

8. Huang CQ, Dong BR, Lu ZC, Yue JR, Liu QX. Chronic diseases and risk for depression in old age: a meta-analysis of published literature. *Ageing Res Rev*. 2010;9(2):131-141.

9. Heine C, Browning CJ. Communication and psychosocial consequences of sensory loss in older adults: overview and rehabilitation directions. *Disabil Rehabil*. 2002;24(15):763-773.

10. Weinstein BE, Ventry IM. Hearing impairment and social isolation in the elderly. *J Speech Hear Res*. 1982;25(4):593-599.

11. Arlinger S. Negative consequences of uncorrected hearing loss—a review. *Int J Audiol*. 2003;42(suppl 2):2S17-2S20.

12. Gopinath B, Wang JJ, Schneider J, et al. Depressive symptoms in older adults with hearing impairments: the Blue Mountains Study. *J Am Geriatr Soc*. 2009;57(7):1306-1308.

13. Li CM, Zhang X, Hoffman HJ, Cotch MF, Themann CL, Wilson MR. Hearing impairment associated with depression in US adults, National Health and Nutrition Examination Survey 2005-2010. *JAMA Otolaryngol Head Neck Surg*. 2014;140(4):293-302.

14. Cacciatore F, Napoli C, Abete P, Marciano E, Triassi M, Rengo F. Quality of life determinants and hearing function in an elderly population: Osservatorio Geriatrico Campano Study Group. *Gerontology*. 1999;45(6):323-328.

15. Dawes P, Emsley R, Cruickshanks KJ, et al. Hearing loss and cognition: the role of hearing aids, social isolation and depression. *PLoS One*. 2015;10(3):e0119616.

16. Lee AT, Tong MC, Yuen KC, Tang PS, Vanhasselt CA. Hearing impairment and depressive symptoms in an older Chinese population. *J Otolaryngol Head Neck Surg*. 2010;39(5):498-503.

17. Mosnier I, Bebear JP, Marx M, et al. Improvement of cognitive function after cochlear implantation in elderly patients. *JAMA Otolaryngol Head Neck Surg*. 2015;141(5):442-450.

18. Poissant SF, Beaudoin F, Huang J, Brodsky J, Lee DJ. Impact of cochlear implantation on speech understanding, depression, and loneliness in the elderly. *J Otolaryngol Head Neck Surg*. 2008;37(4):488-494.

19. Olze H, Szczepek AJ, Haupt H, et al. Cochlear implantation has a positive influence on quality of life, tinnitus, and psychological comorbidity. *Laryngoscope*. 2011;121(10):2220-2227.

20. Acar B, Yurekli MF, Babademez MA, Karabulut H, Karasen RM. Effects of hearing aids on cognitive functions and depressive signs in elderly people. *Arch Gerontol Geriatr*. 2011;52(3):250-252.

21. Boi R, Racca L, Cavallero A, et al. Hearing loss and depressive symptoms in elderly patients. *Geriatr Gerontol Int*. 2012;12(3):440-445.

22. Metselaar M, Maat B, Krijnen P, Verschuure H, Dreschler WA, Feenstra L. Self-reported disability and handicap after hearing-aid fitting and benefit of

hearing aids: comparison of fitting procedures, degree of hearing loss, experience with hearing aids and uni- and bilateral fittings. *Eur Arch Otorhinolaryngol*. 2009;266(6):907-917.

23. Knutson JF, Murray KT, Husarek S, et al. Psychological change over 54 months of cochlear implant use. *Ear Hear*. 1998;19(3):191-201.

24. Mulrow CD, Aguilar C, Endicott JE, et al. Quality-of-life changes and hearing impairment: a randomized trial. *Ann Intern Med*. 1990;113(3): 188-194.

25. Yesavage JA, Brink TL, Rose TL, et al. Development and validation of a geriatric depression screening scale: a preliminary report. *J Psychiatr Res*. 1982-1983;17(1):37-49.

26. D'Ath P, Katona P, Mullan E, Evans S, Katona C. Screening, detection and management of depression in elderly primary care attenders: I: the acceptability and performance of the 15 item Geriatric Depression Scale (GDS15) and the development of short versions. *Fam Pract*. 1994;11 (3):260-266.

27. Wancata J, Alexandrowicz R, Marquart B, Weiss M, Friedrich F. The criterion validity of the Geriatric Depression Scale: a systematic review. *Acta Psychiatr Scand*. 2006;114(6):398-410.

28. Lyness JM, Noel TK, Cox C, King DA, Conwell Y, Caine ED. Screening for depression in elderly primary care patients: a comparison of the Center for Epidemiologic Studies-Depression Scale and the Geriatric Depression Scale. *Arch Intern Med*. 1997; 157(4):449-454.

29. Murlow CD, Aguilar C, Endicott JE, et al. Quality-of-life changes and hearing impairment: a randomized trial. *Ann Intern Med*. 1990;113(3): 188-194.