Relationship between Hearing Loss and Depression Symptoms among Older Adults in China: The Mediating Role of Social Isolation and Loneliness

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Abstract

Objectives: To evaluate whether social isolation and loneliness mediates the relationship between hearing loss and depression symptoms in older adults in China.

Methods: A cross-sectional analysis was conducted of 3769 participants (aged≥60 years) in Shandong province of China. Hearing loss was assessed using Pure-Tone Audiometry test, depression symptoms using 15-item Geriatric Depression Scale, loneliness through UCLA Loneliness Scale and social isolation using Lubben Social Network Scale. Regression and bootstrap analyses were performed to test both direct associations of hearing loss and depression symptoms, and whether the mediating role of social isolation and loneliness.

Results: Overall, 44% of older adults had hearing loss, which was generally mild (30%) rather than moderate (10%), severe (3%) or profound (0.6%). Increasing levels of hearing loss was associated with increasing levels of social isolation and depressions. Hearing loss was also associated with loneliness, but here a threshold effect was apparent and no trend for increasing loneliness with increasing hearing loss. Models that included social isolation and loneliness showed an amelioration in the association of hearing loss and depression, although it remained significant at all levels of hearing loss. Overall, 8% of the total effect of hearing loss on depression symptoms was explained by the mediated effect through social isolation and 42% by loneliness.

Conclusions: Psychosocial factors such as social isolation and loneliness might explain the association between hearing loss and depression. Interventions that

address older adults' social isolation and loneliness may ameliorate depression in older adults with hearing loss.

Key words: Depression symptoms; Hearing loss; Social isolation; Loneliness

Key points: 1. Older Chinese adults (≥60 years) with hearing loss are more likely to experience depression symptoms; 2. The relationship of depression symptoms and hearing loss in older adults is mediated by loneliness in particular and social isolation to a lesser extent.

Introduction

Depression is a major contributor to healthcare costs and is projected to be the leading contributor to the disease burden in middle- and higher-income countries by the year 2030.[1] Depression in older adults, which is characterized by sadness, feeling of low self-worth or guilt, a loss of interest in daily activities,[2] is associated with disability, increased mortality, and poorer outcomes from physical illness.[1] According to WHO data, approximately 15% of older adults experience mild depression symptoms and 1%-5% live with major depressive disorder.[2,3]

Hearing loss (HL) is also common in older adults.[4] Nearly one-third of the world's population aged over 65 report HL, and there are 15.29 million older adults with HL in China alone.[5] HL in older adults results in increased disability,[6] risk of morbidity,[7] and poorer psychosocial outcomes.[8,9] Hearing loss and depression appear to be linked in older adults, as up to 1 in 5 older adults with HL report a clinically relevant level of depression symptoms that would necessitate treatment,[10] and HL is also associated with the onset of new depression symptoms over time.[11] These associations are confirmed in a recent meta-analysis of 35 studies (N=147,148) that showed that HL increased odds of depression including over time (OR=1.54).[12] While there remain some variations to date, taken together, existing literature suggests that HL is related to the onset and progression of depression,[10,13,14] however, the mechanism underlying this relationship remains unclear.

One candidate mechanism for the association of HL and depression may be through

social isolation and loneliness. Social isolation is a measure of an individual's social network size, number of social contacts, and frequency of engagement with social contacts,[15] whereas loneliness is a subjective measure of an individual's perceived discrepancy between desired and actual social relationships.[16] Social isolation and loneliness are reflections of subjective and objective characteristics of weak social relationships.[17] Difficulties hearing often cause communication barriers, which may pose challenges to social and relationship interaction, resulting in withdrawal from social engagements. Social isolation and loneliness among older adults with HL have been well documented.[18-20] A recently systematic review found that hearing loss was associated with higher risk of social isolation and loneliness in most multivariable-adjusted studies.[21] Social isolation and loneliness have also been individually identified to be associated with depression symptoms in multiple studies.[22-25] However, the literature remains relatively limited, especially for low- and middle-income countries (LMICs), and adjustment for social activities and number of friends does not consistently attenuate the HL–depression relationship.[26] Consequently, additional studies are necessary to elucidate the relationships between social isolation and loneliness and depression in older adults, particularly from LMIC settings.

The aim of this study was to assess the relationship between HL and depression among older adults in China, and explore the mediating role of social isolation and loneliness. We hypothesized that there would be a positive correlation between HL and depression symptoms, which would be mediated by social isolation and loneliness. To our knowledge, this is the first study to clarify the possible mechanism

behind how HL affects depression symptoms in LMICs, which if elucidated, will enable older adults with HL to avoid adverse outcomes, thus supporting successful aging.

Methods

Sample

A population-based cross-sectional study was conducted on the prevalence and risk factors of HL in older adults from March to May, 2019 in Guan County of Shandong Province, China.

Stratified multi-stage random sampling was applied: in the first stage, 23 townships were selected randomly from Guan county as the primary sampling units (PSUs). For each township, 3 villages were selected as the secondary sampling units (SSUs). Then, from each village, an average of 60 households were randomly selected to make up the total sample. Eligible participants were those aged 60 years or older from selected households, who had local household registrations. A total of 3769 older adults completed the survey, with response rate of 92%.

Data collection protocol

A paper-based household roster was completed in selected households with individuals aged 60+, recording basic information about eligible members of the household. Next, a general questionnaire was used to collect data on depression, social isolation, loneliness, demographics and other variables. Then, all participants had their hearing screened in a quiet room available in local community hospitals by pure-tone audiometry (PTA). Auditory tests were performed by the audiologists and audiometric data for each participant was recorded by the investigators.

All participants provided written informed consent. For those with profound hearing loss, or those with communication difficulties, a family member was asked to assist in explaining the study to participants, and the information sheet given to the participant to read. Consent was obtained from the study participant when possible, or a proxy family member on behalf of the research participant. This study was approved by the Ethics Committee of Shandong ENT hospital.

Measures

Functional Hearing: This study used the WHO definitions of HL to estimate prevalence, which are based on the better hearing ear, and average of PTA thresholds at 500, 1000, 2000, 4000Hz. For the degree of HL, the following PTA cut off values were used: mild 26-40dBHL; moderate 41-60dB HL, severe 61-80dB HL, and profound ≥81dB HL.

Depression: The 15-item Geriatric Depression Scale (GDS-15) was used to measure depression symptoms, as it is appropriate for use with community-dwelling adults[27] and the Chinese version has been validated.[28-30] The participants were asked about 15 depression symptoms that they might have experienced in the two weeks preceding the interview. The scores of the whole scale was the unweighted sum of the 15 component items, with a potential range of 0 to 15. A dummy variable was formed using the cut-off points of ≥5 to indicate depression.[27]

Social isolation: Social isolation was assessed using the Lubben Social Network

Scale-6 (LSNS-6).[31] The 6 items in the LSNS-6 were derived from the full 10-items Lubben Social Network Scale (LSNS-10).[32] LSNS- 6 scale is a brief instrument designed to gauge social isolation in older adults by measuring perceived social support received by family and friends with 6-point Likert-type response choices: 0 = *none*, 1 = *one*, 2 = *two*, 3 = *three or four*, 4 = *five through eight*, and 5 = *nine or more*. The sum of six item scores (ranging from 0 to 30) is used to measure the extent of overall social connectedness, and the sum of each three family-related item scores and three friend-related item scores (each ranging from 0 to 15) is used to evaluate kinship ties and nonkinship ties, respectively.[33] Lower scores indicate increased isolation. Psychometric properties of the LSNS-6 have been evaluated through classic test theory, factor analysis techniques, and internal consistency measures such as Cronbach's alpha.[34]

Loneliness: Loneliness was assessed using UCLA Loneliness Scale (UCLA).[35] This scale contains 20 items that assess how frequently a participant has felt certain emotions with values ranging from 1=*never*, 2=*rarely*, 3=*sometimes*, to 4=*often*. The scale consists of 10 positively and 10 negatively scored items with a total score of 20-80 points. Higher scores indicate greater degrees of loneliness and no identified cut-off score that defines loneliness.[36] This tool is the most widely used assessment of loneliness in human subject's research.[37]

Covariates

Other variables of interest collected included demographic measures such as age and gender, and measures related to other physical health problems, factors that

potentially could confound any effects of functional hearing on the depression factors. Age was reported as years of age at the time of recruitment, while gender was dichotomies. All participants provided a “yes/no” response to a question on hearing aid (HA) usage: “Do you use a hearing aid most of the time?” Three measures provided information about physical diseases and overall health. The chronic variables derived form the question sequence, “Do you have any diseases?” and if “yes” please tick any of 5 listed disease (Hypertension, Diabetes, Coronary heart disease, Chronic obstructive pulmonary disease, Cancer), but there was no information about severity. Disability in basic activities of daily living (BADL) was categorized into “yes” or “no” based on six items: ambulating, feeding, dressing, personal hygiene, continence, and toileting. Disability was defined as self-reported difficulty with or unable to perform one or more of these activities.

Statistical analyses

All analyses were performed using SPSS 23.0 and M-plus 7.0. Statistical significance was set as $P<0.05$. Descriptive statistics were performed to describe the sample including means and standard deviations for continuous variables, and frequencies and percentages for categorical variables. A model was developed to test for mediation with a binary dependent variable, as defined by MacKinnon and Dwyer.[38] (1) using a linear regression analysis, we assessed the association between the independent variable (HL) and the mediator (social and emotional loneliness); (2) using another linear regression analysis, we estimated the association between the

independent variable (HL) and the dependent variable (depression symptoms); (3) we further tested whether the effect of HL on depression symptoms wreaked (partial mediator) or became statistically insignificant (full mediator) with the addition of the mediator to the model. Demographic characteristics and variables about hearing aids usage, physical diseases and overall health were controlled in all regression analyses to achieve a more unbiased assessment of our model. Lastly, we used a nonparametric bootstrapping method to examine the total, direct and indirect effects of the model, as suggested by Hayes.[39] Specially, 95% confidence interval (CI) of the indirect effects was obtained based on 5000 bootstrap samples. An indirect effect was considered significant if its CI excluded zero.

Results

Participants characteristics

A total of 3769 older adults participated in this study, with a mean age of 70.2 (SD=6.2) years. Over half of the sample was female (63%). 1684 (44%) older adults were found to have HL. The degree of HL for the better hearing ear was mild in 1119 (30%) older adults, moderate in 390 (10%) older adults, severe in 116 (3%) older adults and profound in 23 (0.6%) older adults. The mean standard deviation (SD) for depression symptoms, as measured by the GDS-15 scale, was 1.87±2.00. Overall, 412 (11%) subjects had a positive screening value of ≥5 on the GDS-15 scale indicating depression. The mean score for social isolation was 14.8 (SD=5.7) while for loneliness it was 24.9 (SD=9.9).

Differences in variables between depressed and non-depressed older adults

There was a significant difference between people with and without depression in terms of average of PTA thresholds, social isolation and loneliness (Table 1). The prevalence of depression symptoms was higher in older adults with moderate, severe and profound HL (χ^2=182.71, P<0.01). Compared with the non-depressed group, the depressed group had more disability (i.e. limitations of BADLs, χ^2=43.31, P<0.01). There were no significant differences between the older adults with and without depression with regard to age, gender, hearing aids usage and chronic diseases.

The effect of social isolation and loneliness on the relationship between hearing loss and depression

The linear regression indicated that HL was positively related to social isolation, with increasing levels of HL associated with higher levels of social isolation (Table 2). HL was also associated with loneliness, but here a threshold effect was apparent and no trend for increasing loneliness with increasing HL. Table 3 showed that HL was positively with depression symptoms, that older adults with poorer hearing loss are more likely to report depression symptoms, and a trend was apparent by severity of HL. Models that included social isolation and loneliness showed an amelioration in the association of HL and depression, although it remained significant at all levels of HL. Depression symptoms were positively associated with social isolation (β=-0.03, P<0.001) and loneliness (β=0.17, P<0.001).

In the bootstrap test for mediation, after adjusting for control variables (age, gender, hearing aids usage and chronic diseases), the direct effect of HL on depression symptoms was still rather strong as 0.20 (95%CI=0.16, 0.24, P<0.001). The indirect mediation effect of HL on depression symptoms through loneliness and social isolation were 0.03 (95%CI=0.03,0.04, P<0.001) and 0.16 (95%CI=0.12, 0.21, P<0.001) respectively (Figure 1). Overall, 8% of the total effect of HL on depression symptoms was explained by the mediated effect through social isolation and 42% by loneliness.

Discussion

This study showed that older Chinese adults with HL reported significantly more feeling of loneliness as well as a smaller social network than peers with normal hearing, and this was also associated with being more likely to report depression symptoms. Loneliness was a particularly important mediator. This study makes an important contribution to the literature, as although several studies have found a relationship between HL and depression symptoms,[40] few have explored the possible mechanism for this association in older adults such as through a mediation model[26], particularly in a LMIC setting.

Our findings are consistent with the previous literature about the association of HL and depression symptoms.[41] A systematic review investigating the relationship of HL and mental health conditions in LMICs included 12 studies and provided evidence that hearing loss was associated with statistically greater odds of depression.[42] Compared with previous studies, our analyses offered compelling and robust evidence of an association between HL and depression symptoms according to the objective measures of functional hearing.

Our finding is in line with the sparse evidence from LMICs that older adults with HL have an increased probability of loneliness. A cross-sectional analysis conducting of 7070 older adults in China found that after controlling variables, older adults with hearing loss reported significantly higher levels of loneliness than those with normal hearing.[43] This association may partly be due to difficulty following a conversation

further leading to withdrawal from social interactions.[44] Data from high-income setting also confirms the adverse links between HL and social isolation,[45-47] although there is a lack of comparable evidence from LMICs. Our findings also support previous evidence on the association of loneliness and social isolation with depression,[48] including from LMICs. Another study from China also indicated that high level of social isolation was significantly associated with a higher incidence of self-reported depression among middle-aged and older adults (OR=1.24). However, interpretation of this result was limited by the highly proportion of missing data about depression, which may lead to underestimate the true associations between social isolation and depression.[49] Therefore, studies such as ours with large sample size and critically sampled data that make an important contribution to the literature.

In line with our hypotheses, our results suggest that loneliness, and to a lesser extent social isolation, mediated the relationship between HL and depression symptoms among older adults. Our finding has potential implication for the management and prevention of the influence of HL on depression symptoms, that adjustment to communication limitation and social engagement might mitigate isolation as a pathway to depression. However, this study has some limitations that should be taken into account when interpreting the results. First, the generalizability of the finding should be treated cautiously because participants were from one county in China. Second, our study was cross-sectional, and thus the direction of causality between depression and HL could not be ascertained. Data from this study warrant further investigations into the pathway from hearing to depression symptoms among older

adults, including potentially through qualitative research. Particularly, findings from this study suggested that future studies should consider the value of social interaction which may have a positive effect on depression symptoms via reduction of social isolation and loneliness.

Conclusions and Implications

Our findings suggest that people with HL are more likely to experience depression symptoms, and that this is mediated by loneliness in particular and social isolation to a lesser extent. These findings may increase our understanding of the effective interventions to depression in older adults with HL, thus facilitating successful aging.

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Table 1. Participant's Characteristics and Differences in Variables by Depression (N=3769)

Variables	Total (N=3769)	Depression		$\chi^2/t/f$	*P*
		GDS-15 Negative (<5) (n=3357)	GDS-15 Positive (≥5) (n=412)		
Age, years ($\bar{X}$±SD)	70.2±6.2	70.2±6.2	70.1±6.6	0.30[a]	0.77
Gender, n (%)				0.004[b]	0.95
Male	1394 (37%)	1241 (37%)	153 (37%)		
Female	2375 (63%)	2116 (63%)	259 (63%)		
Hearing					
PTA ($\bar{X}$±SD)	25.5±17.5	24.2±16.9	36.4±18.7	-13.70[a]	<0.001
Category, n (%)				182.71[c]	<0.001
Normal hearing	2121 (56%)	2010 (59.9%)	111 (27%)		
Mild hearing loss	1119 (30%)	930 (28%)	189 (46%)		
Moderate hearing loss	390 (10%)	39 (1%)	71 (17%)		
Severe hearing loss	116 (3%)	83 (2%)	33 (8%)		
Profound hearing loss	23 (0.6%)	15 (0.5%)	8 (2%)		
Hearing Aids Usage, n (%)				2.13[b]	0.15
Yes	25 (0.7%)	20 (0.6%)	5 (1%)		
No	3744 (99%)	3337 (99.4%)	407 (99%)		
Chronic Diseases, n (%)				0.65[b]	0.42
Yes	3475 (92%)	3091 (92%)	384 (93%)		
No	294 (8%)	266 (8%)	28 (7%)		
Disability (BADL), n (%)				43.31[b]	<0.001
Yes	899 (24%)	747 (22%)	152 (37%)		
No	2870 (76%)	2610 (78%)	260 (63%)		
Depressive Symptoms ($\bar{X}$±SD)	1.9±2.0	1.3±0.9	6.8±1.7	-106.74[a]	<0.001
Social Isolation ($\bar{X}$±SD)	14.8±5.7	15.1±5.7	12.4±5.6	9.27[a]	<0.001
Loneliness ($\bar{X}$±SD)	41.9±9.9	34.2±9.9	53±8.0	-13.50[a]	<0.001

Note: BADL, Basic activities of daily living; PTA, pure-tone average; GDS, Geriatric Depression Scale; [a] *t*-test; [b] chi-square test; [c] ANOVA

Table 2. Correlates of Social Isolation and Loneliness (N=3769)

Variables	Social Isolation			Loneliness		
	***β* (95%CI)**	***S.E.***	***P***	***β* (95%CI)**	***S.E.***	***P***
Age	-0.02 (-0.05, 0.01)	0.01	0.13	-0.02 (-0.05, 0.06)	0.02	0.11
Gender						
Female	Reference	Reference	Reference	Reference	Reference	Reference
Male	0.26 (-0.07, 0.60)	0.60	0.13	-0.13 (-0.51, 0.25)	0.19	0.52
Hearing						
Normal hearing	Reference	Reference	Reference	Reference	Reference	Reference
Mild hearing loss	-4.60 (-4.97, -4.2)	0.19	<0.001	16.32 (15.90,16.74)	0.21	<0.001
Moderate hearing loss	-6.29 (-6.84, -5.73)	0.28	<0.001	16.56 (15.94, 17.19)	0.32	<0.001
Severe hearing loss	-6.59 (-7.55, -5.64)	0.49	<0.001	16.56 (15.48, 17.63)	0.55	<0.001
Profound hearing loss	-8.53 (-10.63, -6.43)	1.07	<0.001	15.79 (13.61, 18.33)	1.20	<0.001
Hearing Aids Usage						
Yes	Reference	Reference	Reference	Reference	Reference	Reference
No	0.47 (-1.55, 2.48)	1.03	0.65	2.84 (0.59, 5.11)	1.15	0.01
Chronic Diseases						
No	Reference	Reference	Reference	Reference	Reference	Reference
Yes	0.28 (-0.33, 0.90)	0.31	0.36	0.34 (-0.35, 1.02)	0.35	0.34
Disability (BDAL)						
No	Reference	Reference	Reference	Reference	Reference	Reference
Yes	0.16 (-0.24, 0.56)	0.20	0.43	0.24 (-0.21, 0.68)	0.23	0.30

Note: CI, confidence interval; *S.E.*, standard error, BADL, Basic activities of daily living

Table 3. The Mediating Effect of Social and Loneliness on the Relationship Between Hearing Loss and Depression (N=3769)

Variables	Model without Mediators			Model with Mediators		
	***β* (95%CI)**	***S.E.***	***P***	***β* (95%CI)**	***S.E.***	***P***
Age	-0.11 (-0.02, -.001)	0.01	0.03	-0.01 (-0.20, -0.001)	0.01	0.03
Gender						
Female	Reference	Reference	Reference	Reference	Reference	Reference
Male	0.002 (-0.12, 0.13)	0.06	0.97	0.02 (-0.10,0.15)	0.06	0.73
Hearing						
Normal hearing	Reference	Reference	Reference	Reference	Reference	Reference
Mild hearing loss	0.16 (0.01, 0.39)	0.12	0.04	0.11 (0.01, 0.26)	0.11	0.02
Moderate hearing loss	0.33 (0.05, 0.61)	0.14	0.02	0.13 (0.02, 0.33)	0.14	0.002
Severe hearing loss	1.23 (0.83, 1.63)	0.20	<0.001	0.69 (0.14, 0.98)	0.18	<0.001
Profound hearing loss	1.74 (0.95, 2.54)	0.40	<0.001	1.12 (0.72, 1.99)	0.32	<0.001
Hearing Aids Usage						
Yes	Reference	Reference	Reference	Reference	Reference	Reference
No	-0.18 (-0.92, 0.55)	0.37	0.63	-0.29 (-1.03, 0.45)	0.38	0.44
Chronic Diseases						
No	Reference	Reference	Reference	Reference	Reference	Reference
Yes	-0.23 (-0.45, -0.06)	0.11	0.04	-0.22 (-0.44, 0.003)	0.11	0.05
Disability (BDAL)						
Yes	Reference	Reference	Reference	Reference	Reference	Reference
No	0.49 (0.35, 0.64)	0.07	<0.001	0.50 (0.35, 0.65)	0.08	<0.001
Social Isolation	-	-	-	-0.03 (-0.04, -0.01)	0.01	<0.001
Loneliness	-	-	-	0.17 (0.14, 0.25)	0.004	<0.001

Note: CI, confidence interval; *S.E.*, standard error, BADL, Basic activities of daily living

Figure legends

Figure 1. Bootstrap mediation analysis of social isolation and loneliness between hearing loss and depression symptoms in older adults