Loneliness and Social Network Characteristics Among Older Adults with Hearing Loss in the ACHIEVE Study

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Abstract

Background: Hearing loss is linked to loneliness and social isolation, but evidence is typically based on self-reported hearing. This study quantifies the associations of objective and subjective hearing loss with loneliness and social network characteristics among older adults with untreated hearing loss.

Methods: This study uses baseline data (N=933) from The Aging and Cognitive Health Evaluation in Elders (ACHIEVE) study. Hearing loss was quantified by the better ear, speech-frequency pure tone average (PTA), Quick Speech-in-Noise test, and hearing related quality of life. Outcomes were validated measures of loneliness and social network characteristics. Associations were assessed by Poisson, negative binomial, and linear regression adjusted for demographic, health, and study design characteristics.

Results: Participants were mean of 76.8 (4.0) years, 54.0% female, and 87.6% White. Prevalence of loneliness was 38%. Worse PTA was associated with 19% greater prevalence of moderate or greater loneliness (PR: 1.19.95% CI: 1.06, 1.33). Better speech-in-noise recognition was associated with greater social network characteristics (e.g., larger social network size [IRR: 1.04, 95% CI: 1.00, 1.07]). Worse hearing related quality of life was associated with 29% greater prevalence of moderate or greater loneliness (PR: 1.29, 95% CI: 1.19, 1.39) and worse social network characteristics (e.g., more constricted social network size [IRR: 0.96, 95% CI: 0.91, 1.00]).

Conclusion: Results suggest the importance of multiple dimensions of hearing to loneliness and social connectedness. Hearing related quality of life may be a potentially useful, easily administered clinical tool for identifying older adults with hearing loss associated with greater loneliness and social isolation.

Key Words: Sensory Loss, Mental Health, Epidemiology

Introduction

Loneliness and social isolation in older adults have gained significant focus over the past decade given its high prevalence and association with greater risk for dementia and other morbidities.[1] A growing body of research suggests that loneliness and social isolation may be more prevalent among older adults with hearing loss.[2] Prior work has, however, typically measured hearing by self-report,[2–4] which tends to underestimate objective hearing, particularly in older adults,[5] and does not discern between the multiple dimensions of hearing. Quantification of the magnitude of association between hearing loss, loneliness, and social isolation at the population level informs public health efforts to identify modifiable risk factors and potential targets for intervention. Further, the link between hearing loss, loneliness and social isolation is particularly important to understand given the hypothesized mediating role of loneliness and social isolation in the relationship between hearing and dementia.[6] The current study investigates the cross-sectional associations of hearing loss (peripheral hearing, speech-in-noise recognition, and hearing related quality of life) with loneliness and social network characteristics (social network size, diversity, and embeddedness) in older adults with untreated hearing loss. This study is uniquely poised to comprehensively assess how multiple dimensions of hearing contribute to loneliness and social isolation.

Methods

Study Population

Data come from the baseline visit (2018-2019) of the Aging and Cognitive Health Evaluation in Elders (ACHIEVE) study. ACHIEVE is a randomized controlled trial designed to test the effect of hearing intervention on cognitive decline in a multi-center sample of older adults with hearing loss

(Clinicaltrials.gov Identifier: NCT03243422). Additional details regarding the ACHIEVE study design have been published elsewhere.[7]

Participants are 977 community dwelling older adults aged 70-84 years with untreated, audiometric hearing loss (better-hearing ear pure tone average [PTA] ≥30 and <70 decibels hearing level [dB HL]) and without dementia (Mini Mental State Examination [MMSE] ≥23 for those with high school degree or less, and ≥25 for those with some college education or more). Participants with self-reported difficulty in two or more activities of daily living, vision loss, or who were ineligible for the hearing treatment were excluded. ACHIEVE was partially nested within the scientific and physical infrastructure of the Atherosclerosis Risk in Communities (ARIC) study, an ongoing longitudinal study of adults recruited from four communities across the United States (Forsyth County, NC; Jackson, MS; selected suburbs of Minneapolis, MN; and Washington County, MD).[7] ACHIEVE participants were recruited from two populations at each site: (1) existing ARIC study participants and (2) de novo from healthy volunteers in the communities of the four field sites. The analytic sample includes 933 participants from the baseline visit (2018-2019); participants with missing or incomplete hearing (Quick Speech-in-Noise [QuickSIN] test: n=5, Hearing Handicap Inventory for the Elderly [HHIE-S]: n=7), loneliness (n=16), and covariate data (n=16) were excluded.

Measures

Loneliness

Loneliness was measured using the 20-item UCLA Loneliness Scale and analyzed as a continuous score (score range: 20 – 80) and as a binary measure based on the Perry classification of moderate or greater loneliness (no/low loneliness [score 20 - 34] vs. moderate or greater loneliness [score 35 - 80]).[8]

Social Network Characteristics

The Cohen Social Network Index (SNI) measured three social network characteristics: social network size, social network diversity, and embedded social networks. The Cohen SNI asks about engagement with individuals across 12 social roles (e.g. spouse, child, close friend, neighbor). Social network size was defined by the total number of people with whom the participant has regular contact (at least once every two weeks). For each social role, number of network members was capped at seven members to avoid over-inflation of social network size scores through report of large social networks (score range: 0-84). Social network diversity was defined by the number of social roles in which the participant has at least one person with whom they have regular contact with at least once every two weeks (score range: 0-12). Embedded social networks measures the number of social network domains (score range: 0-8) in which the participant remains active. Participants are considered active within each social domain (e.g. family, friends, work) if they have contact with four or more persons within each domain at least once every two weeks.[9]

Peripheral Hearing

Peripheral hearing was measured by air conduction pure tone audiometry. The better ear, speech-frequency PTA was calculated as the average of hearing thresholds at four frequencies (0.5, 1, 2, 4 kilohertz [kHz]). Higher PTA indicates worse peripheral hearing. PTA was analyzed as a continuous score (per 10 worse dB HL]) as well as categorized according to clinical cut points consistent with the World Health Organization: mild (20 – 34.9 dB HL), moderate or greater (≥ 35 dB HL).[10]

Speech-in-noise recognition

The QuickSIN test[11] was used to measure speech-in-noise recognition. The QuickSIN test was conducted in two trials. In each trial, participants were presented with a list of 6 sentences with five key words per sentence. Sentences were presented at 70 dB sound

pressure level in the presence of multi-talker speech babble. With each sentence, the volume of the multi-talker speech babble was progressively increased so that signal-to-noise ratio decreased in 5-unit steps with each sentence (+25 dB HL [first sentence] to no difference [last sentence]). After each sentence, participants were asked to identify the 5 key words. The total number of key words identified in each trial was calculated and then averaged over the two trials (score range: 0 to 30, higher scores indicate better QuickSIN performance). QuickSIN performance was analyzed as a continuous score and as a binary measure (top three quartiles vs. lowest quartile [worse]).[11]

Self-Reported Hearing Related Quality of Life

Participants' perception of the impact of hearing loss was measured by the 10-item screening version of the Hearing Handicap Inventory for the Elderly (HHIE-S).[12] The HHIE-S assesses the social and emotional components of perceived hearing loss such as embarrassment, and limits on personal and social life. HHIE-S was analyzed as a continuous score (score range: 0 [no handicap] – 40 [maximum handicap]) and as a categorical measure of hearing handicap severity: none (0-8), mild to moderate (10-24), severe (26-40).

Covariates

Covariates include age, sex (male, female), race (White, Black/African American, Other [Asian, American Indian, Native American, Native Hawaiian, Pacific Islander]), education (elementary or some high school, completed high school or some college, Bachelor's degree or greater), marital status (married, not married), hypertension (systolic ≥140 mm HG or diastolic ≥90 mm Hg), high cholesterol (self-reported physician diagnosis or medication use), diabetes (self-reported physician diagnosis or medication use), stroke or transient ischemic attack (self-reported physician diagnosis or medication use), and study design characteristics (recruitment type [recruited from the ARIC Study or de novo], study site [Forsyth County, NC; Jackson, MS; selected suburbs of Minneapolis, MN; and

Washington County, MD]). Inclusion of covariates was guided by factors previously associated with hearing, loneliness, and social isolation or based on previous literature.

Statistical Analysis

The distribution of participant characteristics by category of hearing loss severity was described. Correlation between hearing measures (PTA, QuickSIN, HHIE-S) was examined by Spearman's Rho correlation coefficient. The independent associations between each measure of hearing (PTA, QuickSIN, HHIE-S) and loneliness and social network characteristics were assessed in separate models. Loneliness was modeled both continuously with associations assessed using multivariable-adjusted linear regression and dichotomously (no/low loneliness vs. moderate or greater loneliness) with associations assessed using multivariable-adjusted Poisson regression with robust standard errors. The associations between each measure of hearing (PTA, QuickSIN, HHIE-S) and social network size (analyzed as counts) were independently assessed in separate models using multivariable-adjusted negative binomial regression. The associations between each measure of hearing (PTA, QuickSIN, HHIE-S), social network diversity, and embedded social networks (analyzed as counts) were independently assessed in separate models using multivariable-adjusted Poisson regression with robust standard errors. All models were adjusted for age, sex, race/ethnicity, education, marital status (loneliness models), hypertension, high cholesterol, diabetes, stroke, and study design characteristics. In a sensitivity analysis, associations of QuickSIN and HHIE-S with loneliness and social network characteristics were additionally adjusted for PTA. A p-value < 0.05 was considered statistically significant. Statistical analyses were performed using Stata 16 Statistical Software.

Results

Participants were a mean of 76.8 (4.0) years of age, 54.0% female, 87.6% White, and 53.1% had a Bachelor's degree or higher (Table 1). Participants had mild (29.0%) or moderate or greater (71.0%) peripheral hearing loss (measured by PTA). Strength of the correlation between hearing measures (PTA, QuickSIN, HHIE-S) was moderate to high (PTA and QuickSIN: r = -0.56, PTA and HHIE-S: 0.29, QuickSIN and HHIE-S: -0.24). Median social network size was 22 (Q1, Q3: 15, 30) members, median social network diversity score was 6 (Q1, Q3: 5, 7) social roles, and median embedded social network score was 3 (Q1, Q3: 1, 4) social domains. Prevalence of loneliness was 38.2%.

Compared to participants with mild hearing loss, participants with moderate or greater hearing loss were older (mean age 77.1 (3.9) vs. 75.9 (3.9) years) and a larger proportion were male (48.2% vs. 40.6%), Black/African American (12.4% vs. 10.0%) and had chronic conditions (hypertension: [68.4% vs. 63.8%], high cholesterol [61.0%. vs. 59.8%], diabetes [21.9% vs. 15.9%], stroke or transient ischemic attack [9.2% vs. 5.9%]). Fewer participants with moderate or greater (vs. mild) hearing loss had a Bachelor's degree or higher (50.2% vs. 60.1%) (Table 1).

Peripheral hearing (PTA), was associated with 19% higher prevalence of moderate or greater loneliness (per 10 dB worse PTA: Prevalence Ratio [PR]: 1.19. 95% CI: 1.06, 1.33) and greater loneliness score (per 10 dB worse PTA: β: 0.80, 95% CI: 0.00, 1.61) (Table 2, Supplemental Table 1). No associations between peripheral hearing level and social network characteristics were observed (Figure 1, Supplemental Table 2).

Speech-in-noise recognition (QuickSIN test, per 5 unit better QuickSIN performance) was associated with greater social network size (IRR: 1.04, 95% CI: 1.00, 1.07), social network diversity (IRR: 1.02, 95% CI: 1.00, 1.04), and embedded social network score (IRR: 1.05, 95% CI: 1.01, 1.10) (Figure 1,

Supplemental Table 2). Associations were consistent when QuickSIN was modeled dichotomously. No associations between QuickSIN and loneliness were observed (Table 2, Supplemental Table 1).

Worse hearing-related quality of life (per 10-unit worse HHIE-S score) was associated with 29% greater prevalence of loneliness (PR: 1.29, 95% CI: 1.19, 1.39) and higher loneliness score (β: 2.31, 95% CI: 1.76, 2.86) (Table 2, Supplemental Table 1). Findings were consistent when HHIE-S score was modeled categorically. Worse hearing-related quality of life (per 10-unit worse HHIE-S score) was also associated with more constricted social network size (IRR: 0.96, 95% CI: 0.93, 1.00) and lower embedded social network score (IRR: 0.95, 95% CI: 0.91, 1.00) (Figure 1, Supplemental Table 2).

In a sensitivity analysis, associations of QuickSIN and HHIE-S with social network characteristics and loneliness were additionally adjusted for PTA. Estimates were the same or similar in magnitude as estimates produced in the primary analysis (Supplemental Tables 3 and 4).

Discussion

In 933 older adults with untreated hearing loss, 38% reported loneliness. Worse peripheral hearing and worse hearing related quality of life were associated with greater loneliness. Better speech-in-noise recognition was associated with larger social network size, higher network diversity, and higher embedded social network score. Worse hearing related quality of life was also associated with more constricted social network size and social network embeddedness. Collectively, these results suggest the importance of hearing to social connectedness.

Prevalence of loneliness in this study (38%) is higher than prevalence (29%) in the general population of older adults (with and without hearing loss).[1] Associations between hearing loss, loneliness, and social isolation have been investigated in samples that include older adults across the full range of hearing, but findings are difficult to compare to the current study as analytic approaches and interpretations differ. Associations between poorer peripheral hearing and loneliness have been demonstrated in a limited number of studies.[3,13,14] Studies of speech-in-noise recognition, hearing-related quality of life, and loneliness and social isolation are limited and mixed.[3,4,15] Mixed findings across studies may be due to differences in study samples and method of measuring loneliness and social network characteristics. Findings from the current study help to fill a research gap in the existing literature by highlighting associations of lesser studied dimensions of hearing with social health outcomes.

It is important to note that statistical associations between hearing loss and social network characteristics were observed, but magnitude of associations were small and clinical significance is unknown. Interestingly, though, patterns of associations suggest speech-in-noise recognition was more strongly associated with social network characteristics than loneliness. Speech-in-noise measures more closely capture hearing ability in real world settings by capturing both bottom-up processing (peripheral hearing to transmit auditory signals to the auditory cortex) and top-down processing (central auditory and cognitive function) needed to perceive and understand speech in the presence of competing noise. Social interactions commonly take place in settings where background noise is present (e.g. restaurants, social gatherings) and the ability to communicate in these settings may be important to developing and maintaining social relationships.

This study also suggests the functional impacts of hearing loss are strongly associated with greater loneliness and smaller social network size. Worse hearing related quality of life (HHIE-S) may reflect reductions in social participation, increases in social strain, and/or hearing-related anxiety that can

lead to lower social connectedness.[16] Worse hearing related quality of life may also reflect lower perceived self-efficacy and affect an individuals' desire to socialize and participate in activities that promote socialization.[16] The strong associations observed between worse hearing related quality of life and both loneliness and social network size supports the perspective that older adults' self-perception of their hearing loss, in addition to objectively measured hearing, is important to health and mental health.

Limitations of the study include the cross-sectional study design. Further, while we could not make comparisons to older adults with normal hearing (study inclusion restricted to older adults with hearing loss), the moderately large sample size of older adults with hearing loss provided the opportunity to fill a gap in the literature by further assessing differences in social isolation and loneliness within levels of hearing loss severity. Finally, like most randomized controlled trials, the ACHIEVE study has high internal validity; however, external validity may be limited. Study participants differ from the general population of older adults as participants met strict hearing, health, and cognitive criteria for study inclusion and were recruited from four communities in the U.S. Additionally, given the requirements and benefits of study participation (receipt of hearing aids), the ACHIEVE study may have attracted a healthier and/or more health-conscious group of participants who may differ from the general population.

The need for prevention and mitigation of loneliness and social isolation in older adults and identification of older adults at higher risk is important, particularly since the onset of the COVID-19 pandemic. In addition to objective measures of hearing, the HHIE-S is an easy to administer tool that has strong value for inclusion in clinical settings (audiometric examinations as well as primary care)[17] to aid in identifying older adults with hearing loss who may benefit from intervention or connection to community-based resources for preventing and reducing loneliness and social isolation.[1,18]

Further, existing public health interventions for reducing loneliness and social isolation are limited in effect size and capacity for large-scale implementation. Hearing treatment is efficacious for most hearing loss cases (with benefits for speech-in-noise recognition[19] and hearing related quality of life[20] as well) and can be implemented at the population level; but, it is currently unknown whether hearing treatment can effectively mitigate loneliness and social isolation. Upcoming work in the ACHIEVE study will provide evidence from a randomized controlled trial of the effect of hearing intervention versus health education control on loneliness and social isolation among older adults with hearing loss. Future research should continue to investigate the social consequences of hearing loss and potential opportunities for intervention.

Conflict of Interest

Dr. Reed reported serving on the scientific advisory boards of Neosensory.

Dr. Lin reported being a consultant to Frequency Therapeutics and Apple and being the director of a research center funded in part by a philanthropic gift from Cochlear Ltd to the Johns Hopkins Bloomberg School of Public Health. Dr. Lin is also a board member of the nonprofit Access HEARS.

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Table 1: Participant characteristics by hearing level (N=933), Aging and Cognitive Health Evaluation in Elders (ACHIEVE) Study, Baseline (2018-2019)

	Total	**Mild Hearing Impairment**	**≥ Moderate Hearing Impairment**
	N=933	N=271	N=662
Age, mean ± SD	76.8 ± 4.0	75.9 ± 3.9	77.1 ± 3.9
Sex, n (%)			
Female	504 (54.0)	161 (59.4)	343 (51.8)
Race, n (%)			
White	817 (87.6)	243 (89.7)	574 (86.7)
Black/African American	109 (11.7)	27 (10.0)	82 (12.4)
Other	7 (1.0)	1 (0.4)	6 (1.0)
Education, n (%)			
Some High School or Elementary	35 (3.8)	8 (3.0)	27 (4.1)
High School Diploma or Some College	403 (43.2)	100 (36.9)	303 (45.8)
Bachelor Degree or Higher	495 (53.1)	163 (60.1)	332 (50.2)
Marital status, n(%)			
Married	577 (61.8)	179 (66.1)	398 (60.1)
Hypertension, n (%)	626 (67.1)	173 (63.8)	453 (68.4)

High cholesterol, n (%)	566 (60.7)	162 (59.8)	404 (61.0)
Diabetes, n (%)	188 (20.2)	43 (15.9)	145 (21.9)
Stroke, n (%)	77 (8.3)	16 (5.9)	61 (9.2)
Recruitment Type, n (%)			
De novo	705 (75.6)	204 (75.3)	501 (75.7)
Study Site, n (%)			
Forsyth County	233 (25.0)	69 (25.5)	164 (24.8)
Jackson, MS	234 (25.1)	58 (21.4)	176 (26.6)
Minneapolis, MN	216 (23.2)	67 (24.7)	149 (22.5)
Washington County, MD	250 (26.8)	77 (28.4)	173 (26.1)
Pure tone average, mean (SD)	39.4 (6.8)	32.2 (1.5)	42.3 (5.9)
Quick Speech-in-Noise (QuickSIN) Score, mean ± SD	18.4 ± 5.2	21.3 ± 3.0	17.2 ± 5.4
Hearing Handicap Inventory for the Elderly (HHIE-S)			
No Hearing Handicap	293 (31.4%)	116 (42.8%)	177 (26.7%)
Mild/Moderate	467 (50.1%)	123 (45.4%)	344 (52.0%)
Severe	173 (18.5%)	32 (11.8%)	141 (21.3%)

Loneliness, n (%)	356 (38.2%)	86 (31.7%)	270 (40.8%)
Social Network Size, median (Q1, Q3)	22.0 (15.0-30.0)	22.0 (15.0-30.0)	22.0 (14.0-29.0)
Social Network Diversity, median (Q1, Q3)	6.0 (5.0-7.0)	6.0 (5.0-7.0)	6.0 (5.0-7.0)
Embedded Social Networks, median (Q1, Q3)	3.0 (1.0-4.0)	3.0 (2.0-4.0)	3.0 (1.0-4.0)

Notes:

Abbreviations: (Q1, Q3): Quartile 1, Quartile 3

Other race includes Asian (n=6), American Indian, Native American, Native Hawaiian, Pacific Islander (n=3).

Mild hearing impariment: 20 – 34.9 dB HL, Moderate or greater hearing impairment: ≥35 dB HL

Table 2: Association between pure tone average, QuickSIN speech-in-noise understanding, and hearing health handicap and loneliness, Aging and Cognitive Health Evaluation in Elders (ACHIEVE) Study, Baseline (2018-2019)

		Loneliness			
	$N_{Loneliness}$ (%)	***β***	**95% CI**	**PR**	**95% CI**
Peripheral Hearing					
Pure Tone Average					
Mild Hearing Impairment	172 (63.5)	Ref.	Ref.	Ref.	Ref.
≥ Moderate Hearing Impairment	458 (69.2)	0.87	-0.31, 2.05	1.20	0.98, 1.47
Per 10 dB worse PTA		0.80	0.00, 1.61	1.19	1.06, 1.33
Central Auditory Function					
Quick Speech-in-Noise (QuickSIN)					
Lowest quartile (worse function)	161 (68.8)	Ref.	Ref.	Ref.	Ref.
Top 3 quartiles	469 (67.1)	-0.91	-2.15, 0.33	0.90	0.75, 1.08

Per 5 unit better QuickSIN performance		-0.45	-0.98, 0.08	0.93	0.86, 1.01
Hearing Handicap					
Hearing Handicap Inventory for the Elderly (HHIE-S)					
No Hearing Handicap	166 (56.7)	Ref.	Ref.	Ref.	Ref.
Mild/Moderate	322 (69.0)	2.23	1.04, 3.43	1.41	1.14, 1.75
Severe	142 (82.1)	6.19	4.65, 7.73	1.84	1.47, 2.31
Per 10 unit worse Hearing Handicap		2.31	1.76, 2.86	1.29	1.19, 1.39

Notes:

Abbreviations: CI: Confidence Interval, PR: Prevalence Ratio

Models adjusted for age, sex, race/ethnicity, education, marital status, hypertension, high cholesterol, diabetes, stroke, and study design characteristics.

Figure 1: Association between pure tone average, QuickSIN speech-in-noise understanding, and hearing health handicap and social network characteristics, Aging and Cognitive Health Evaluation in Elders (ACHIEVE) Study, Baseline (2018-2019)

Notes:

PTA: pure tone average

QuickSIN: Quick Speech-in-Noise Test

HHIE-S: Hearing Handicap Inventory for the Elderly Screening Version

HI: hearing impairment

Ref: reference category

Figure 1