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REVIEW ARTICLE

Hearing loss and dementia in older adults: A narrative review

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Abstract

The prevalence of hearing loss is high among older adults; globally, 65% of adults over 60 years have hearing loss. Over the past decade, evidence from epidemiologic studies has linked hearing loss to nearly two times greater risk of dementia. The hypothesized mechanistic pathways through which hearing loss could contribute to increased dementia risk include the effects of hearing on greater cognitive load, changes in brain structure and function, and decreased social engagement. These mechanistic pathways may be modified by management of hearing loss using existing intervention (eg, hearing aids). Hearing treatment may be an effective intervention for slowing cognitive decline in some older adults. In this review, we update existing reviews of the current epidemiologic research on the association between hearing loss and dementia risk and discuss hypothesized mechanisms of this association. We also discuss management of hearing loss as a potential intervention for slowing cognitive decline and reducing dementia risk.

Keywords: Cognition; Dementia; Epidemiology; Hearing aids; Hearing loss

1. INTRODUCTION

Dementia is characterized by significant cognitive decline in at least one cognitive domain (eg, memory, executive function, language, problem-solving) that interferes with independence in everyday activities.[1] Incidence of dementia increases exponentially with age.[2,3] By 2050, over 150 million older adults are projected to have dementia,[4] sparking concern for the anticipated elevated burden of dementia on patients, caregivers, and the healthcare system.[5–7] Currently available treatments focus on reducing clinical symptoms rather than eliminating disease and carry significant safety concerns as well as high health care costs.[8,9] Thus, an understanding of the epidemiology of dementia and the potential to reduce dementia risk through intervention in modifiable risk factors is a public health priority.[10]

In 2020, the Lancet Commission on Dementia Prevention, Intervention and Care (Lancet Commission) identified 12 potentially modifiable risk factors for dementia.[7] These multifactorial risk factors occur throughout the life course: early life (less education), mid-life (hearing loss, traumatic brain injury, hypertension, alcohol, obesity), and later life (smoking, depression, social isolation, physical inactivity, air pollution, diabetes). The Lancet Commission estimated that, together, these 12 modifiable risk factors account for 40% of dementia cases globally.[5,7]

The Lancet Commission identified hearing loss as the strongest modifiable risk factor for dementia.[5,7] Hearing loss has the highest population-attributable fraction (8%) of the 12 identified risk factors, meaning that, assuming a causal relationship between hearing loss and dementia, 8% of dementia cases could potentially be prevented if hearing loss was eliminated.[7] In this review, we summarize the current epidemiologic research on the association between hearing loss and dementia and discuss hypothesized mechanisms of this association. We also discuss management of hearing loss as a potential intervention for slowing cognitive decline and reducing dementia risk.

2. EPIDEMIOLOGY AND MEASUREMENT OF HEARING LOSS IN OLDER ADULTS

The Global Burden of Disease Study estimates that, globally, 1.5 billion individuals have hearing loss.[11,12] Both prevalence and severity of hearing loss increase with older age. Sixty-five percent of adults over 60 years have hearing loss with moderate or greater hearing loss more common in older vs younger age groups.[11,12] Age-related hearing loss occurs gradually and is the combined product of physiological changes related to the aging process and other extrinsic risk factors. Physiologically, hearing loss is the result of loss of inner and outer ear hair cells and the degeneration of cochlear nerve synapses and peripheral and central auditory system neurons with age.[13,14] Extrinsic factors, such as noise exposure, chronic conditions (eg, hypertension, diabetes, stroke), and health behaviors (eg, smoking), also contribute to hearing loss.[15]

Epidemiologic studies collecting objective hearing data typically measure peripheral hearing ability, which is the transduction and encoding of sound in the cochlea and the ability to detect an auditory stimulus (ie, sound). Pure-tone audiometry is

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Table 1

Characteristics of studies that met inclusion criteria

Study	Study population	Hearing measurement	Dementia measurement	Follow-up time	Covariate adjustment	Findings
Lin et al[25]	n = 639 community-dwelling older adults in the Baltimore Longitudinal Study of Aging.	PTA (0.5, 1, 2, and 4 kHz) in the better hearing ear; normal (<25 dB), mild (25-40 dB), moderate (41-70 dB), and severe (>70 dB).	Adjudicated based on neurological and neuropsychological examination.	Median follow-up: 11.9 y.	Sex, age, race, education, diabetes mellitus, smoking, hypertension.	Mild (25-40 dB HL) (HR: 1.89, 95% CI, 1.00-3.58), moderate (41-70 dB HL) (HR: 3.00, 95% CI, 1.43-6.30), and severe (>70 dB HL) (HR: 4.94, 95% CI, 1.09-22.4) hearing loss associated with higher risk of all-cause dementia vs normal hearing (<25 dB HL).
Gallacher et al[27]	N = 1057 men born between 1920 and 1939 living in South Wales in the Caerphilly Prospective Study.	PTA (0.5, 1, 2, and 4 kHz) in both ears.	Assessed according to *DSM-IV* or NINCDS-AIREN criteria.	17 y	Age, social class, anxiety, premorbid intelligence.	Every 10 dB higher PTA (worse hearing) was associated with 2.67 (95% CI, 1.38-5.19) greater odds of all-cause dementia over 17 y.
Choi et al[20]	N = 1889 community-dwelling Black and White adults, aged 70-79 y in Memphis, TN and Pittsburgh, PA in the Health ABC Study.	PTA (0.5, 1, 2, and 4 kHz) in the better hearing ear; normal (≤25 dB HL), mild (26-40 dB HL), moderate/severe (>40 dB HL).	Use of a prescribed dementia medication, dementia diagnosis from adjudicated hospital records, or 3MS decline >1.5 SD from baseline mean.	9 y	Age, sex, race, education, study site, smoking status, hypertension, diabetes, stroke.	Moderate/severe hearing loss (PTA > 40 dB HL) (vs normal hearing) was associated with increased risk of incident dementia (HR: 1.55, 95% CI, 1.10-2.19) over 9 y.
Brenowitz et al[29]	N = 2027 community-dwelling Black and White adults, aged 70-79 y in Memphis, TN and Pittsburgh, PA in the Health ABC Study.	PTA (0.5, 1, 2, and 4 kHz) in the better hearing ear; normal to mild (≤40 dB HL), moderate to severe (>40 dB HL).	Use of a prescribed dementia medication, dementia diagnosis from adjudicated hospital records, or 3MS decline >1.5 SD from baseline mean.	10 y	Age, race, sex, and education, hypertension, diabetes, cardiovascular disease, cerebrovascular disease, smoking status, alcohol use, and physical activity.	Moderate to severe hearing loss (>40 dB HL) (vs normal hearing) was associated with increased risk of incident dementia (HR: 1.25, 95% CI, 1.01-1.55) over 10 y.

3MS = Modified-Mini-Mental State exam; dB HL= decibels hearing level; *DSM-IV= Diagnostic and Statistical Manual of Mental Disorders, 4th edition*; HR = hazard ratio; NINCDS-AIREN = National Institute of Neurological and Communicative Disorders and Stroke–Association Internationale pour la Recherche et l'Enseignement en Neurosciences; PTA = pure-tone average.

a clinical measurement of peripheral hearing.[16,17] In this test, an auditory stimulus (pure tone) is presented at an audible volume at certain frequencies (typically between 250 and 8000 Hertz [Hz]). The pure tone is then presented at progressively lower volumes to identify the lowest, specific volume (in decibels hearing level [dB HL]) at which an individual can still detect the tone. Hearing thresholds at each frequency are averaged to calculate the pure-tone average (PTA).[16,17] The four-frequency PTA, the average of hearing thresholds at four frequencies most important for speech understanding (0.5, 1, 2, 4 kHz), is typically used for analysis in epidemiologic studies. A growing number of epidemiologic studies now include pure-tone audiometry, allowing for greater capacity to investigate questions of hearing loss and health in populations of older adults worldwide.

Some studies that include a broader range of hearing measures may also include measures of central hearing ability. Central hearing ability includes both bottom-up (transmission of auditory signals to the auditory cortex) and top-down processing (cognitive function to recognize and interpret the auditory signals).[16–18] Central hearing ability is typically measured through tests of speech recognition in the presence of increasing volume of background noise (eg, the Quick Speech-in-Noise Understanding test).[19]

Hearing can also be defined by self-report. Self-reported hearing loss can be measured by questions about how an individual rates their hearing (eg, on a scale from "Excellent" to "Poor") as well as questions about perceived hearing in different functional scenarios (eg, talking on the telephone). The construct of self-reported hearing is distinct from objectively measured hearing[20] as it incorporates self-perception, awareness, and compensation mechanisms.[20,21] An understanding of self-reported hearing complements what is known about objective hearing to build a more comprehensive understanding of the relationship between hearing and health.

3. HEARING LOSS AND DEMENTIA: EPIDEMIOLOGIC EVIDENCE

A strong body of evidence from epidemiologic studies links hearing loss to accelerated declines in multiple cognitive domains,[22] such as memory,[23] executive function,[24] and global cognitive function,[23,24] as well as higher risk of dementia.[25–28] In 2017, the Lancet Commission conducted a literature review and meta-analysis of longitudinal studies of hearing loss and dementia risk that met strict inclusion criteria for scientific rigor.[5] Criteria for inclusion were a cohort of cognitively healthy people followed for at least 5 years, hearing measured using pure-tone audiometry, incident dementia as the outcome, covariate adjustment for age and cardiovascular risk factors.[5]

The three epidemiological studies of audiometric hearing and dementia that met these criteria were conducted in the Baltimore Longitudinal Study of Aging,[25] the Health, Aging, and Body Composition Study,[26] and the Caerphilly Prospective Study (Table 1).[27] In the Baltimore Longitudinal Study of Aging, 639 community-dwelling adults were followed for over 10 years. Mild (25-40 dB HL) (hazard ratio [HR]: 1.89, 95% CI, 1.00-3.58), moderate (41-70 dB HL) (HR: 3.00, 95% CI, 1.43-6.30), and severe (>70 dB HL) (HR: 4.94, 95% CI, 1.09-22.4) hearing loss were associated with higher risk of all-cause dementia vs normal hearing (<25 dB HL).[25] In a cohort of men (mean age: 56 years) in South Wales from the Caerphilly Prospective Study, every 10 dB higher

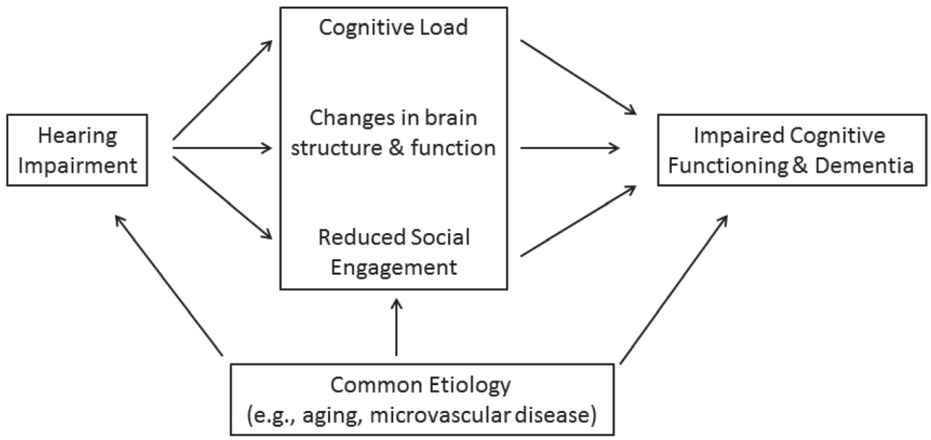

Fig. 1 Hypothesized mechanistic pathways linking hearing loss, cognitive decline, and dementia.[30]

PTA (worse hearing) was associated with 2.67 (95% CI, 1.38-5.19) greater odds of all-cause dementia over 17 years.[27] In 387 healthy older adults aged 70 to 79 years in Memphis, TN and Pittsburgh, PA in the Health, Aging, and Body Composition Study,[26] moderate/severe hearing loss (PTA > 40 dB HL) was also associated with increased risk of incident dementia (HR: 1.55, 95% CI, 1.10-2.19) over 9 years compared to normal hearing (≤25 dB HL). Meta-analysis of these three studies estimates that hearing loss is associated with nearly two times higher risk of dementia (pooled relative risk: 1.94, 95% CI, 1.38-2.73).[5]

For the present article, we conducted a focused review that updates the Lancet Commission's review to include any subsequent studies published since 2017 that meet the same prespecified inclusion criteria. Search terms used to identify studies include the following categories: hearing (hearing), dementia (dementia or Alzheimer disease), aging (older adults or aging), longitudinal (longitudinal or cohort or change). The search was limited to studies published between 2018 and September 2023.

A total of 181 articles were retrieved by this search. During the review of article titles and abstracts, 162 articles were excluded for failing to meet eligibility requirements. Of the 19 articles included in the full-text review, only one study met the inclusion criteria and was included in this review (Table 1). This study[29] uses data from the Health, Aging, and Body Composition Study, the same cohort assessed in Deal et al,[26] and extends participant follow-up to up to 10 years (vs 9 years in Deal et al). In a sample of 2027 healthy Black and White older adults aged 70 to 79 years at enrollment, moderate to severe (>40 dB HL) hearing loss (vs normal to mild [≤40 dB HL] hearing loss) was associated with higher hazard (HR: 1.25, 95% CI, 1.01-1.55) of dementia over 10 years after adjustment for demographic, cardiovascular, and health behavior covariates.[29]

4. MECHANISMS LINKING HEARING LOSS AND DEMENTIA

The hypothesized mechanistic pathways through which hearing loss could contribute to poorer cognitive functioning and dementia include effects on cognitive load, brain structure/function, and decreased social engagement (Fig. 1). Common factors that could underlie both hearing loss and dementia age, shared pathologic etiologies (eg, diabetes, hypertension, neurodegenerative processes), and demographic factors (eg, education).[30,31]

4.1. Cognitive load

Hearing loss results in poor fidelity and distorted encoding of complex sounds (eg, speech) in the cochlea.[32] The effect of poor peripheral encoding of sound is demonstrated by studies in which under conditions where the auditory signal is degraded (ie, from hearing loss), greater cognitive resources are required for auditory perceptual processing to the detriment of other cognitive processes such as working memory.[33–39] These observations are both consistent with existing resource capacity models[40] and supported by functional neuroimaging studies demonstrating compensatory recruitment of prefrontal regions to maintain auditory processing in older adults with hearing loss.[41–44]

4.2. Brain structure

Neuroimaging studies have demonstrated that hearing loss is associated with reduced volumes in the primary auditory cortex[42,45,46] and loss of integrity of central auditory white matter tracks.[45,47–49] The basis of these associations remains unknown but may be related to alterations in the degree of neural activation provided by an impoverished auditory signal with subsequent changes in cortical reorganization and brain morphometry.[42] In animal models, cochlear impairments are known to be causally associated with both tonotopic reorganization of the auditory cortex[50–52] as well as morphologic changes in central neuronal structures.[53] In older adults, hearing loss is prospectively associated with accelerated volume declines in the right superior, middle, and inferior temporal gyri over a mean of 6.4 years of longitudinal follow-up.[54] These regions are important for spoken language processing[55–57] (potentially affected by impoverished/reduced auditory stimuli) and also important for semantic memory and sensory integration. These regions are involved in the early stages of mild cognitive impairment and dementia.[58–61]

4.3. Social isolation

Communication impairments caused by hearing loss can disrupt the quantity and quality of one's social interactions, potentially leading to reduced social engagement, activity participation, and social isolation and loneliness.[62–66] In its 2017 report, the Lancet Commission identified social isolation as a later life risk factor associated with 1.6 times higher risk of dementia.[5] Poor social engagement could likely contribute to impaired cognitive functioning through both behavioral/psychological effects[67–69] and direct neurobiological effects from stress and inflammation.[70–72]

Risk factors for cognitive decline and dementia are multifactorial in etiology. Hearing loss may act in parallel to other established dementia risk factors (eg, Alzheimer disease pathology, microvascular disease) to adversely affect cognitive performance.[73]

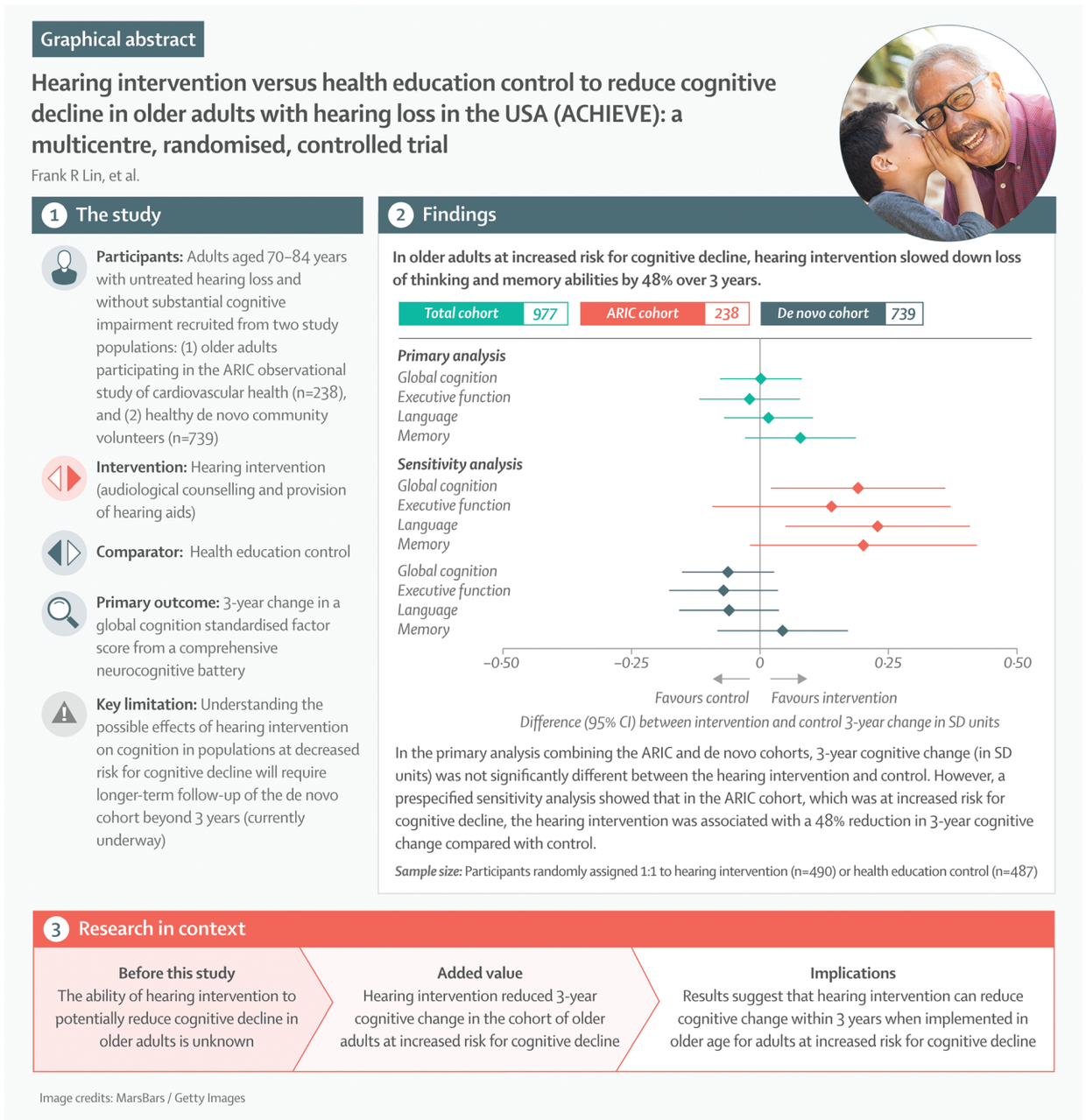

Fig. 2 Graphical abstract depicting results from the ACHIEVE study. Imaged reproduced with permission by *The Lancet*.[75] ACHIEVE = Aging and Cognitive Health Evaluation in Elders; ARIC = Atherosclerosis Risk in Communities.

5. MANAGEMENT OF HEARING LOSS AS A POTENTIAL INTERVENTION FOR REDUCING DEMENTIA RISK

The mechanistic pathways potentially linking hearing loss and dementia may be modifiable with existing hearing interventions. Evidence from observational studies suggests hearing aid use may be associated with greater cognitive function and lower risk of cognitive decline. A meta-analysis of eight longitudinal studies (2-25 years of follow-up) reported self-reported hearing aid use was associated with 19% lower hazard of cognitive decline compared to those with untreated hearing loss.[74] Observational studies of the hearing aid—cognition association, however, typically exclude data on other key variables (eg, years of hearing aid use, adequacy of hearing aid fitting and rehabilitation, etc.) that would affect the success of hearing loss treatment. Results obtained from observational studies must also be interpreted with caution because individuals choosing to use a hearing aid likely differ significantly from those individuals not using a hearing aid in both measured and unmeasured factors. Hearing aid users are typically healthier and have

higher socioeconomic status than nonusers. Consequently, determining whether hearing intervention could affect cognitive decline and dementia risk cannot be answered from observational studies; randomized trials are needed.

Only one randomized controlled trial, to our knowledge, has tested the long-term effect of hearing aid use on cognitive decline. The Aging and Cognitive Health Evaluation in Elders (ACHIEVE) study randomized participants to either hearing intervention (audiological counseling and provision of hearing aids) or health education control (individual sessions with a health educator covering topics on chronic disease prevention) to test the effect of hearing intervention on 3-year change in global cognition.[23,75] The ACHIEVE study enrolled 977 community-dwelling participants aged 70 to 84 years with untreated hearing loss (better-ear 4-frequency [0·5-4·0 kHz] PTA ≥30 dB HL and <70 dB HL) and without substantial cognitive impairment from two cohorts across four field sites in the United States (Forsyth County, NC; Jackson, MS; Minneapolis suburbs, MN; and Washington County, MD). Participants were (1) older adults participating in the Atherosclerosis Risk in Communities (ARIC) study, a long-standing observational study of cardiovascular health (n = 238), or (2) healthy community volunteers recruited de novo (n = 739). Participants from the ARIC cohort had more risk factors for cognitive decline (eg, older, lower baseline cognitive scores) compared to participants from the de novo cohort.[23,75]

When the ARIC and de novo cohorts were analyzed together, no significant effect of hearing intervention on 3-year change in global cognition was observed (Fig. 2). When ARIC and de novo cohorts were analyzed separately in pre-specified sensitivity analyses, hearing intervention slowed the rate of 3-year cognitive decline (3-year rate of cognitive decline: –0.211, 95% CI, –0.349 to –0.073) by 48% compared to the health education control (3-year rate of cognitive decline: –0.402, 95% CI, –0.536 to –0.267) in the ARIC cohort. No significant effect of hearing intervention was observed in the de novo cohort potentially due to the slow rate of cognitive decline observed in the de novo cohort, which can limit the ability to observe any effect of hearing intervention on cognitive change within 3 years. Findings from the ACHIEVE study suggest that hearing intervention may slow cognitive decline within 3 years in older adults at increased risk for cognitive decline.[75]

6. IMPLICATIONS AND FUTURE DIRECTIONS

Treatment of hearing loss, an established intervention with almost no associated medical risks, may be a valuable intervention for inclusion in existing global efforts to slow cognitive decline and reduce dementia risk. Future investigations include continued research of the long-term effects (6 years of follow-up) of hearing intervention on cognitive decline and dementia, further understanding of specific populations who may benefit the most from hearing intervention, and investigation of the effect of hearing intervention on other cognitive and health outcomes, such as brain structure and function, social isolation and loneliness, and physical activity.[75]

Although prevalence of hearing loss is high, hearing treatment is greatly underutilized; only 17% of individuals with hearing loss use hearing aids.[12] Barriers to hearing aid use include limited access to hearing care particularly in low- and middle-income countries, cost and/or lack of health insurance coverage for hearing aids in some countries, and societal stigma.[11] Continued multidisciplinary efforts across clinical, public policy, and public health practices are critical for advancing hearing health. Efforts include increasing awareness of hearing loss and associated health impacts, efforts to reduce severity of hearing loss (eg, limit excessive noise exposure), and advocating for affordable access to hearing aids and hearing care.

In conclusion, longitudinal studies have linked hearing loss to higher risk of cognitive decline and dementia. Potential mechanistic pathways include the impact of hearing loss on increased cognitive load, changes in brain structure and function, and increased social isolation and loneliness. Recent findings from both observational and experimental studies suggest management of hearing loss through provision of hearing aids may be effective for slowing cognitive decline, particularly among older adults with more risk factors for cognitive decline. Hearing loss may be a critical risk factor for focus in dementia prevention efforts; additional investigation and continued follow-up will further our understanding of hearing intervention as a potential intervention for reducing dementia risk.

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