

The Longitudinal Relationship Between Hearing Loss and Cognitive Decline

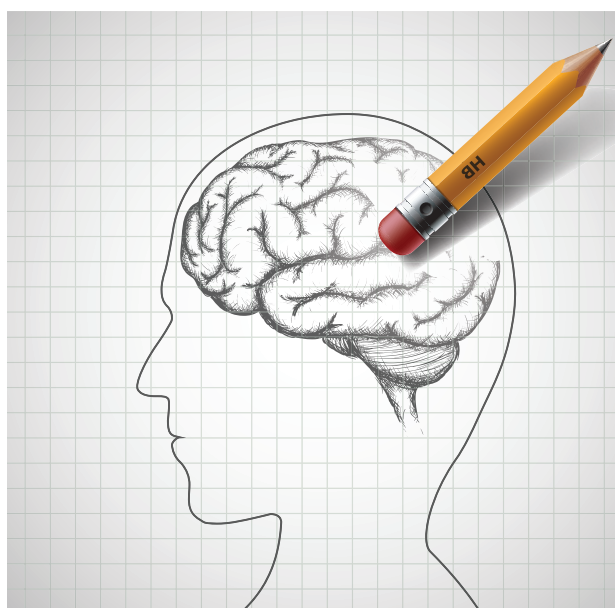
By Nicholas A. Waring, BS; Alexander Chern, MD; and Justin S. Golub, MD, MS

Age-related hearing loss (ARHL) is both highly prevalent and undertreated. About two-thirds of adults over the age of 70 have hearing loss,^{1,2} but fewer than 20% of adults with hearing loss wear hearing aids.³ This is concerning in the face of accumulating data showing an association between hearing loss and cognition. Recent prospective cohort studies have shown that ARHL is independently associated with the development of cognitive impairment and dementia in individuals with normal cognition at baseline.⁴⁻¹⁶ In fact, ARHL is the largest modifiable risk factor for cognitive decline and dementia; complete elimination of hearing loss would be expected to reduce the incidence of dementia by about 8%.¹⁷

Although not definitively proven, evidence suggests a causal relationship between ARHL and cognitive decline. The relationship between hearing loss and cognitive decline also appears to be dose-dependent, meaning that the risk of cognitive decline increases as the severity of hearing loss increases.^{4,5,8,9} Additionally, recent studies from our group suggest that this relationship persists within the range of “normal” hearing (i.e., pure tone average ≤ 25 dB hearing level), which we refer to as subclinical hearing loss (SCHL). This relationship between SCHL and cognitive impairment has been demonstrated in a cross-sectional study¹⁸, in which data were collected at a single point in time. Our group previously analyzed a longitudinal study conducted over multiple years demonstrating an association between SCHL and cognitive impairment.¹⁵ This accounting for change over time further supports a causal relationship. However, that study was limited by a predominantly highly educated, white population from a single geographic location. A recent study by our group addressed these limitations by examining the longitudinal association between SCHL and cognitive impairment using a large multi-ethnic and multi-center cohort study in the United States.¹⁹

STUDY METHODS

The Health, Aging and Body Composition (Health ABC) Study is a longitudinal multi-center cohort study of 3,075 com-



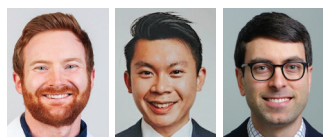
www.shutterstock.com

munity-dwelling individuals (42% black and 58% white) 70-79 years old when they were recruited in 1997-1998. Subjects were included in our analysis if they underwent both a hearing evaluation and cognitive testing. Subjects with dementia at baseline were excluded, leaving 2,110 subjects for analysis.

Hearing was assessed at Year 5 in the Health ABC study using pure-tone audiometry in sound booths meeting ANSI standards. The primary exposure variable in our analysis was hearing, as measured by the 4-frequency (0.5, 1, 2, 4 kHz) pure-tone average (PTA) of the better-hearing ear. As the commonly used cutoff for outright HL in adults is PTA > 25 decibels (dB) hearing level, we define SCHL as PTA ≤ 25 dB hearing level.

Cognitive impairment was assessed every 1-2 years using neurocognitive tests, including the Digit Symbol Substitution Test (DSST), Modified Mini Mental State Examination (3MS), and CLOX1.⁸ The DSST involves filling correctly coded symbols within 90 seconds, assessing working memory, motor speed, attention, and visuo-perceptual functions.²⁰ The 3MS assesses a variety of cognitive functions and is used as a screening test for cognitive decline.²¹ The CLOX1 assesses executive impairment by having participants draw a clock at 1:45.²²

Our analysis accounted for additional variables that may confound the association between hearing loss and cognition: age, race, sex, education level, smoking status, hearing aid use, diabetes, stroke, and hypertension. A confounder is a variable



Nicholas A. Waring is a fourth-year medical student at Columbia University's Vagelos College of Physicians & Surgeons. **Dr. Alexander Chern** is a resident physician in the Department of Otolaryngology-

Head & Neck Surgery at NewYork-Presbyterian Hospital (Columbia and Weill Cornell). **Dr. Justin S. Golub** is an associate professor in the Department of Otolaryngology-Head & Neck Surgery at Columbia University and NewYork-Presbyterian Hospital.

Table 1. Predicted Change in Each Cognitive Test Score (And 95% Confidence Interval) Per Year for Every 10 dB Worse Hearing

Cognitive Test	All Subjects	Subjects With Subclinical Hearing Loss**
DSST	–0.054 (–0.082 to –0.026)*	–0.120 (–0.227 to –0.012)*
3MS	–0.044 (–0.062 to –0.026)*	–0.064 (–0.131 to 0.003)
CLOX1	0.001 (–0.010 to 0.012)	0.000 (–0.041 to 0.041)

Model accounts for the following potential confounders: age, race, sex, education level, smoking status, diabetes, history of stroke, hypertension, and hearing aid use. *Indicates statistical significance ($P < 0.05$). **Indicates PTA ≤ 25 dB in better ear.

cross-sectional data show that this relationship persists even within the range of “normal” hearing (i.e., SCHL). We found that among subjects of all hearing levels, worse hearing was associated with steeper declines in cognitive performance over time as measured by the DSST and 3MS. Among subjects specifically with SCHL, worse hearing was still associated with steeper declines in cognitive performance

over time as measured by the DSST. This is the first study that demonstrates a longitudinal relationship between SCHL and cognition over time in a multi-center and multi-ethnic cohort. These findings may better generalize to the diverse U.S. population compared with the earlier single-center study conducted by our group.¹⁵

That an association between SCHL and cognitive decline was found in only one test (the DSST) can be explained by previous research suggesting that this particular test—which measures motor speed, attention, visuo-perceptual processing, and working memory—is sensitive to even mild cognitive changes.^{20,23} Additionally, the sample size of individuals with SCHL may have been too small to detect a significant change in the 3MS score (which did approach significance). The lack of an apparent association between hearing and a change in the CLOX1 score can be explained by the fact that individuals may be able to draw a clock from long-term memory, and thus the test may be less sensitive to mild cognitive impairment, which preferentially affects short-term memory. Another limitation is that participants underwent a hearing evaluation at Year 5; some participants with SCHL may have later progressed to outright hearing loss, which may have conferred the risk for cognitive decline. Although we used statistical techniques to adjust for confounders, it is not possible to completely control for confounding, since not all confounders are known.

STUDY RESULTS

There were 2,110 participants who did not have dementia at baseline and underwent both a hearing evaluation and cognitive testing. Of these participants, 881 had SCHL. The mean age of participants was 73.5 years, 52.3% were women, and 37.4% were black. The mean PTA of the better-hearing ear in all subjects was 30.1 dB.

Among participants of all hearing levels, adjusting for confounders, worse hearing was associated with a significantly steeper decline in cognitive performance over time as measured by the DSST (0.054 points per year for every 10 dB worse hearing) and as measured by the 3MS (0.044 points per year per 10 dB) (see Table 1). There was no significant association between hearing level and CLOX1 score.

Among the 881 subjects who had SCHL, adjusting for confounders, worse hearing was associated with a significantly steeper decline in cognitive performance over time as measured by the DSST (–0.120 points per year for every 10 dB worse hearing). Worse hearing was not associated with a score decline in the CLOX1 or 3MS, although the latter narrowly missed statistical significance.

WHAT THIS MEANS

Prior studies have shown an independent association between hearing loss and cognitive decline over time, and recent

cross-sectional data show that this relationship persists even within the range of “normal” hearing (i.e., SCHL). We found that among subjects of all hearing levels, worse hearing was associated with steeper declines in cognitive performance over time as measured by the DSST and 3MS. Among subjects specifically with SCHL, worse hearing was still associated with steeper declines in cognitive performance

over time as measured by the DSST. This is the first study that demonstrates a longitudinal relationship between SCHL and cognition over time in a multi-center and multi-ethnic cohort. These findings may better generalize to the diverse U.S. population compared with the earlier single-center study conducted by our group.¹⁵

WHY THIS IS IMPORTANT

This study provides further evidence for a causal relationship between hearing loss and cognitive decline that begins early on, even at the stage of “normal” hearing, which we term SCHL. Although we cannot be certain that a causal relationship truly exists without randomized controlled trials, there are several plausible pathways that could explain causality. ARHL confers a risk of social isolation, which can in turn increase the risk of cognitive decline. ARHL could also cause changes in brain structure, such as temporal lobe shrinking, that increase the risk of cognitive decline. A third possibility is that the increased cognitive load of deciphering sounds and speech experienced by individuals with ARHL may exhaust cognitive resources. However, it is also possible that a common mechanism (i.e., confounder) causes both hearing loss and cognitive decline, such as microvascular disease (which we attempted to control for) or another unknown process (which we cannot control for).^{11,14}

These findings also have important implications for the threshold that should define hearing loss. For example, the World Health Organization now recommends 20 dB, yet in the United States, 25 dB is still commonly used for adults. Perhaps a lower threshold is warranted if patients experience clinical sequelae of hearing loss (e.g., cognitive decline/dementia) at lower hearing thresholds. Further, testing for and treating hearing loss confers essentially no risk but offers a large potential payoff. Although hearing aids are the most common solution for hearing loss, they may not be the ideal solution for SCHL. Efforts should emphasize optimizing the acoustic environment with strategies including improving visual cues like lip reading (made more difficult with COVID-19 preventive measures such as wearing masks), minimizing

background noise, optimizing seating arrangements for verbal communication, and reducing reverberation. Nevertheless, further research is needed to elucidate the utility of targeting hearing loss as a modifiable risk factor for cognitive decline. Randomized controlled trials such as the ACHIEVE trial and a spinoff planned by our team for lesser levels of hearing loss (EARHLI) will be necessary for establishing causality between ARHL and cognition.²⁴ 

Disclosure: Justin S. Golub, MD, MS, is the recipient of consulting fees or honoraria from Decibel Therapeutics and Alcon.

References for this article can be found at <http://bit.ly/HJcurrent>.