# Hearing Loss and Auditory-Visual Episodic Memory among Urban-Dwelling American Indian and Alaska Native Elders in the URBANE Study

Charlotte Bryne

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Committee:

Mandy Fretts

Lonnie Nelson

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## Abstract

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Charlotte Bryne

Chair of the Supervisory Committee:

Mandy Fretts

Department of Epidemiology

Hearing loss is an increasingly recognized risk factor for cognitive decline and Alzheimer's Disease and Related Dementias (ADRD), yet cognitive assessments rarely account for hearing status despite relying heavily on auditory stimuli. Consequently, it remains unclear whether poorer episodic memory performance reflects cognitive decline or suboptimal sensory conditions. Using data from the URBAn Native Elders (URBANE) study (2021-2024), we examined the association between hearing handicap and auditory versus visually presented episodic memory among urban-dwelling American Indian and Alaska Native (AI/AN) Elders. Participants (n = 901) self-identified as AI/AN, were aged 55 years and older, and lived in or commuted to urban areas defined by Rural-Urban Commuting Area codes. Participants completed neurocognitive assessments and structured medical interviews. Self-perceived hearing loss was measured using the Hearing Handicap Inventory for the Elderly-Screening version (HHIE-S). Episodic memory was assessed using the NIH Toolbox Picture Sequence Memory Test (visual episodic memory) and the National Alzheimer's Coordinating Center (NACC) Craft Story immediate recall tests (auditory episodic memory). Multivariable linear regression models estimated associations between

hearing handicap severity and episodic memory performance while adjusting for demographic and cognitive covariates. Higher hearing handicap severity was associated with slightly lower performance across episodic memory measures, though estimates were small and not statistically significant (all p-values > 0.05). Although we did not observe associations of self-perceived hearing loss with markers of auditory and visual episodic memory tasks, our findings highlight the potential burden of hearing loss in this population of AI/AN Elders, and support continued research on hearing health and cognitive function among AI/AN Elders.

## Introduction

Hearing impairment is defined as a Pure Tone Average (a measure of the quietest sounds a person can hear (0.5, 1, 2, 4 kHz)) greater than 25 dB, often in the worse ear. Hearing loss has been shown to negatively impact health, including posing biological, psychological, and sociological consequences for a person's lifestyle.[1] Etiologies include genetics, ear or head trauma, cochlear degeneration, and environmental stressors (e.g. toxicity from compounds found in cigarette smoke).[1,2,3] Hearing loss is also nearly ubiquitous among aging adults, with its neuropsychiatric complications prominently including cognitive decline and dementia.[4,5,6]

National estimates indicate approximately 25% of adults over age 60 and nearly 66% of adults over age 70 experience measurable hearing loss.[7] American Indian and Alaska Native (AI/AN) adults bear a disproportionate burden of hearing loss; AI/AN adults 18 years of age or older nationwide are nearly twice as likely to report moderate to severe hearing problems (6.4% versus 3.5%) than non-Hispanic Whites of similar age.[8] Analyses of 2019-2020 Behavioral Risk Factor Surveillance System (BRFSS) data further indicate that 27% of AI/AN adults aged 65 years or older report hearing loss.[4,8,9] Additionally, the general U.S. population has observed consistent sex differences in hearing loss – men are more likely than women to develop hearing loss.[1,9] Among individuals 45 years or older who participated in the 2019 BRFSS, 36% of men and 27% of women self-reported hearing loss.[9] Comparable differences in hearing loss by sex assigned at birth have been documented in a cohort of adults 18 years or old from a Pacific Northwest Tribe.[8] In that study, 24% of men and 13% of women reported hearing loss.[8] Given its associations with cognitive function in later life[8,10,11], hearing loss provides a relevant context for examining related cognitive outcomes in underrepresented, aging populations.

Dementia is characterized by progressive cognitive decline, most notably in memory and executive functioning.[2] A particularly sensitive facet of memory functioning and a marker of early dementia is episodic memory.[12] Episodic memory refers to the ability to encode, store, and retrieve personally experienced events within a specific temporal framework.[13] This form of memory is uniquely vulnerable to age-related cognitive decline and plays a central role in the characterization of Alzheimer's Disease and Related Dementias (ADRD).[12,14] More notably, episodic memory is frequently examined within the broader

framework of cognitive decline, mild cognitive impairment, and ADRD, given its early vulnerability in neurodegenerative processes. References to these constructs serve to contextualize episodic memory within the continuum of cognitive aging. Mechanisms linking sensory impairment to cognition indicate that effortful listening draws on cognitive resources that would otherwise be available for memory encoding and recall,[15] and prior longitudinal work suggests that hearing loss may precede the onset of cognitive impairment and dementia.[6]

Most cognitive and memory assessments used in ADRD studies are administered primarily through auditory or verbal means, and participant hearing status is scarcely screened for.[16] Experimental studies of working memory in non-ADRD participants with hearing loss have shown better performance when tests are administered entirely visually as opposed to entirely verbally[15,17], providing valuable insight into testing conditions and the role that hearing loss plays with memory. However, it is unknown whether memory performance is due entirely to optimal sensory conditions or is a sign of cognitive decline, emphasizing the importance of parsing through the complex variability that is hearing loss and its dynamic with memory.

Currently, one in five AI/AN people over the age of 45 years report memory issues[5], and an estimated 38,000 AI/AN aged 65 and older are living with ADRD.[18] Researchers project these numbers to quadruple by 2050[18]. However, the current literature is largely based on reservation dwelling AI/AN and may not generalize to urban AI/AN Elders. About 70% of AI/ANs now live in urban areas[19] where resources, healthcare access, and social determinants of memory issues differ substantially from rural areas[20]. With hearing loss identified in longitudinal studies as a modifiable, highly prevalent risk factor associated with cognitive decline and ADRD, further culturally grounded research inclusive of urban AI/AN Elders is needed to better understand and contextualize the relationship between hearing loss and episodic memory performance.

**Specific Aims**

The first aim of this project was to characterize the distribution and severity of hearing loss among urban-dwelling AI/AN older adults in the URBAn Native Elders (URBANE): Risk and Protective Factors for Alzheimer's Disease and Related Dementias study (R01AG064493; PI: Nelson). The second aim was to

assess the differential association between hearing loss and episodic memory performance in auditorily versus visually presented memory tests. The third aim was to explore whether the association between hearing status and episodic memory performance differed by assigned sex at birth. Hearing loss was measured by the Hearing Handicap Inventory for the Elderly-Screening version (HHIE-S);[10] crystallized cognitive functioning was measured by the National Institutes of Health (NIH) Toolbox V2 (version 1.27.7219)[21,22] Picture Vocabulary Test (PVT). Episodic memory was measured in two delivery modalities – auditory only and auditory and visual presentation. Auditory only episodic memory performance was measured by the National Alzheimer's Coordinating Center (NACC) Version 3 Uniform Data Set (UDS) Craft Story[23] form. Auditory and visual episodic memory was measured using the NIH Toolbox V2 Picture Sequence Memory Test (PSMT). We hypothesized that auditory only episodic memory would be more strongly associated with hearing loss than visual and auditorily presented episodic memory stimuli. We also hypothesized that the association between hearing loss and episodic memory performance would be stronger among males than females. Findings from this study will contribute to better understanding the relationship between hearing loss and episodic memory performance in older AI/AN adults and contextualize these findings within broader literature on cognitive decline.

## Methods

### *Study Design and Setting*

This project used data from URBANE, a cross-sectional study of ADRD and its protective-risk factors in AI/AN Elders in the USA. Study sites were established in five metropolitan areas in the U.S. with large AI/AN populations: Anchorage, AK; Oklahoma City, OK; Phoenix, AZ; San Bernardino, CA; and Seattle, WA. Data collection spanned from 2021-2024. The study recruited participants through a variety of methods such as fliers, radio station announcements, outreach at Urban Indian Health Organizations, community outreach events (e.g. tabling at powwows), word of mouth referral, and social media marketing through the BuildClinical® platform on Facebook, Instagram, and YouTube. The URBANE study was approved by Advarra and the Washington State University (WSU) institutional review board (IRB) and written informed consent was obtained from study participants at each study site.

### *Study Participants and Eligibility*

To be eligible for URBANE, participants must have self-identified as AI/AN, been 55 years of age or older, and lived in, or regularly commute to, one of the study site urban areas, and not living on reservation lands. Multi-racial participants were eligible to participate. The 2010 Rural-Urban Commuter Area (RUCA)[24] code scoring via zip code defined urbanicity according to Category A guidelines and was used to determine participant eligibility. Individuals who reported participation in the Cerebrovascular Disease and its Consequences in American Indians study (CDCAI)[25] or the Strong Heart Stroke Study (SHSS)[26] were not eligible for URBANE due to partial protocol overlap.

The study enrolled 1,007 participants. After accounting for participants who had withdrawn and asked for their data to be excluded from analysis, the final analyzable sample comprised of 1,003 AI/AN Elders. Due to limited data availability, participants from four out of the five study sites who had no missing data were included in this analysis (n = 946). For this project, we excluded participants who did not complete the National Institutes of Health (NIH) Toolbox (n = 9)[21], did not complete or were not offered the Hearing Handicap Inventory for the Elderly-Screening version (HHIE-S; n = 21)[10], or did not complete the following cognitive tasks: NIH Toolbox V2 (version 1.27.7219)[22,] Picture Vocabulary Test (PVT) and Picture Sequence Memory Test (PSMT) (n = 8)[22], or the National Alzheimer's Coordinating Center (NACC) Version 3 Uniform Data Set (UDS) Craft Story form (n = 7)[23]. Participants were also excluded if responses were missing for assigned sex at birth. In total, 901 participants comprised the analytic sample.

*Data Collection*

Participants completed a series of cognitive assessments, physical examination, medication review, neuroimaging, blood and urine specimen collection, and behavioral and lifestyle questionnaires in one or two visits within a set timeframe, as specified below. Standard visits took up to five hours to complete all study components and clinical sample collections were done the same day if a phlebotomist or technician was available on-site. Neuroimaging appointments relied on scheduling availability of sites and their partner imaging center and were typically completed within 1 to 4 weeks (1-31 days) after the initial study visit.

Additional MRI safety criteria excluded participants with aneurysm clips, implantable cardiac devices, internal electrical devices, contraindicated metal prostheses, and/or severe claustrophobia. Eligible

participants underwent a cranial MRI that was reviewed and interpreted by a neuroradiologist. Participants completed the HHIE-S at the beginning of the study visit before any assessments or interviews were conducted. Certified study staff members administered structured interviews to capture information on demographics, medication history, and behavioral and lifestyle factors. Participants also completed neurocognitive testing (e.g., computer-administered NIH Toolbox, UDS Craft Story). Neurocognitive testing was done when participants were most alert (e.g., in the morning or within four hours of waking).

*Data Quality Assurance and Quality Control*

The study implemented multi-layer quality assurance and quality control protocols to ensure that all possible parts of the study protocol were conducted consistently and accurately. The coordinating center team maintained a manual of operations to which all staff had access and was routinely re-distributed. All hired study staff received standardized training for certification by lead study investigators, and all staff members responsible for administering cognitive assessments were certified by the lead clinical neuropsychologist (PI: Nelson). Study staff participated in weekly meetings to discuss study progress and resolve any questions. Five percent of the sample was selected for quality control and had measurements or lab samples taken twice for verification.

The coordinating center team also conducted internal audits, double-entered cognitive assessment data for data accuracy and integrity, managed ongoing data reviews (e.g., reviewing submitted digital forms for completion and accuracy, scanning for missing or inaccurate responses), and re-trained site staff as needed. Cognitive assessment administration and scoring protocols were routinely reviewed over the course of the study for scoring accuracy.

*Primary Exposure*

The primary exposure of interest for this analysis was the presence of self-perceived hearing loss as measured by the HHIE-S. The HHIE-S is a 10-item questionnaire that assesses how an individual perceives the social and emotional effects of hearing loss. The HHIE-S has been widely used since the

early 1980s for early detection of hearing loss in the elderly and has an internal consistency reliability of 0.87 and a test-retest reliability of 0.84 ($p < .0001$).[10,27]

Possible scores of the HHIE-S range from 0 (no handicap) to 40 (maximum handicap). A score of 10 points or higher suggested referral to an audiologist. The HHIE-S includes various emotionally and socially oriented questions, such as: “Does a hearing problem cause you to feel embarrassed when meeting new people?”; “Do you have difficulty hearing when someone speaks in a whisper?”; “Do you feel handicapped by a hearing problem?”; and “Do you feel that any difficulty with your hearing limits or hampers your personal or social life?”. Participants were given the choice to respond “yes (4 points)”, “sometimes (2 points)” or “no (0 points)”. Total raw scores for the HHIE-S were categorized ordinally: no hearing handicap (0-8), mild-moderate hearing handicap (10-24), and significant hearing handicap (26-40).

URBANE used the HHIE-S to guide whether a participant should be offered an assistive listening device (ALD) for the visit. All participants who received a score of 10 points or higher on the HHIE-S were offered an ALD and had the option to accept or deny the device (yes or no). Study staff documented whether participants used the ALD. ALD use (yes/no) was included in sensitivity analysis.

*Primary Outcome*

The primary outcomes of interest were continuous measures of performance on auditory and visual episodic memory tasks. Auditory memory was assessed using the UDS Craft Story, which involved immediate and delayed (20 minutes) free recall of a standardized, 44-unit short story read aloud by the examiner. No visual assistance was provided for this task. Scoring followed standardized UDS protocols, where points were rewarded for verbatim (44 possible points) and paraphrased (25 possible points) recall. The Craft story inter-rater reliability is 0.90.[23] Visual memory was assessed with NIH Toolbox PSMT, an approximately ten-minute assessment where participants viewed a sequence of pictures and must later reproduce the order. Difficulty levels increased with sequence length, and scoring was based on correctly recalled sequential placements (uncorrected standard scores in this sample ranged from 76-133). The test has been shown to have strong reliability of 0.79-0.83.[22] Both assessments have strong convergent, construct, and criterion validity across the lifespan.[21,22,23] Because each memory task was

scored using different scales, relative differences were evaluated by comparing the magnitude of the regression coefficients across different models.

For contextualization and clarity within this project, any terminological use of auditory episodic memory refers to the UDS Craft Story, and the use of visual episodic memory refers to the NIH Toolbox PSMT.

*Key Covariates*

Key covariates of interest included study site (Oklahoma City, Phoenix, San Bernardino, Seattle), age (5-year groups), sex assigned at birth (male or female), education (No HS Diploma, HS Diploma or GED, Attended College, Bachelor's Degree, Advanced Degree), first spoken language (Indigenous language, English, Other), crystallized intelligence, self-reported history of traumatic brain injury (TBI), and self-reported transient ischemic attack (TIA). History of TBI was assessed through questions about injuries to the head or neck in their lifetime from crashes, falls, sports injuries, violence, gunshots, and military service.[28] Crystallized intelligence was measured using the NIH Toolbox PVT, an approximately seven-minute computer-administered task in which participants hear a spoken word accompanied by four pictures and are asked to select the picture that best matches the word's meaning.[21] The PVT assessed receptive vocabulary, serving as baseline crystallized cognition. The test has strong reliability of 0.85-0.92.[21]

*Data Analysis*

All statistical analyses were performed in the R statistical software environment. Participants with "don't know", "refused", or missing responses to variables of interest were excluded. Descriptive statistics summarized the sample overall and by HHIE-S category (0-8 none, 10-24 mild-moderate, 26-40 significant) using measures of central tendency. Primary outcomes were performance on visual and auditory episodic memory tasks, modeled as separate continuous outcomes on their respective scoring scales. Linear regression was used to estimate associations between hearing loss (continuous raw score) and each memory outcome. For each outcome, we fit a sequence of models: Model 0: crude; Model 1 (primary analytic model): adjusted for study site, age, sex assigned at birth, first spoken language, and crystallized intelligence; Model 2: further adjusted for history of TBI and self-reported TIA.

For secondary analyses, we evaluated whether sex assigned at birth impacted the association of hearing loss with episodic memory performance by constructing a multiplicative interaction term of sex with hearing loss on episodic memory outcomes. We examined its significance using the Wald test. In further exploratory analyses, we assessed whether the association of hearing loss and episodic memory performance differed based on use of the offered ALD during the exam.

**Results**

Participant characteristics are described in Table 1. Among the 901 participants who comprised the analytic cohort, 72% (n = 652) were female. Most participants were between the age of 55 and 69 years, with 33% (n = 300) 55 to 59 years old, 26% (n = 233) 60 to 64 years old, and 22% (n = 198) 65-69 years old. Education attainment varied, with 42% (n = 375) reporting having attended college and 17% (n = 154) with no high school diploma. Most participants reported English as their first spoken language (83%, n = 749), while 13% (n = 113) reported an Indigenous language. A history of TBI was reported by 34% of participants (n=307). A prior TIA was reported by 7.5% (n = 68) of participants. For crystallized intelligence, participants had a mean score of 103.89 (SD 10.36), with observed scores ranging from 64 to 133.

In total, 29.5% (n=265) of study participants had self-perceived mild-moderate (score of 10-24) or significant hearing handicap (score of 26-40). Compared with participants with no hearing handicap, those with mild-moderate or significant hearing handicap were more often male (34% and 31% vs. 25%, respectively) and were more frequently represented in older age groups, particularly ages 75 years and older (13% and 9% vs. 6.6%, respectively).

Participants with self-perceived hearing handicap more frequently reported a history of TBI, with TBI reported by 29% of participants with no hearing handicap, 42% of participants with mild-moderate hearing handicap, and 58% of participants with significant hearing handicap. Participants with hearing handicap also more commonly reported an Indigenous language as their first spoken language (15% mild-moderate; 21% significant) compared with participants with no hearing handicap (11%). Mean crystallized intelligence scores were lower among participants with hearing handicap, decreasing from 104.28 (SD

10.44) among participants with no hearing handicap to 103.55 (SD 9.97) among those with mild-moderate hearing handicap and 101.51 (SD 10.50) among those with significant hearing handicap.

Mean PSMT scores were similar across hearing handicap categories. Overall, the mean PSMT score was 95.33 (SD 12.31). Participants with no hearing handicap had a mean score of 95.44 (SD 12.17), those with mild-moderate hearing handicap had a mean of 95.59 (12.76), and those with significant hearing handicap had a mean of 93.81 (SD 12.38).

For Craft Story verbatim, the overall mean score was 33.24 (SD 13.26). Mean scores had a slight decrease per level of increased hearing handicap. Participants with no hearing handicap had a mean score of 33.59 (SD 13.21), those with mild-moderate hearing handicap had a mean of 32.71 (SD 12.99), and those with significant hearing handicap had a mean of 31.67 (SD 14.30). Similarly for Craft Story Paraphrase, the overall mean score was 25.09 (SD 9.07). Participants with no hearing handicap had a mean score of 25.36 (SD 8.96), those with mild-moderate hearing handicap had a mean of 24.62 (SD 8.98), and those with significant hearing handicap had a mean of 24.01 (SD 10.08).

Table 2 shows the association of HHIE-S with UDS Craft Story Verbatim Performance, UDS Craft Story Paraphrase performance, and PSMT performance. In unadjusted analyses (Model 0), higher HHIE-S scores were associated with lower UDS Craft Story Verbatim (Beta = -0.09, 95% CI [-0.18, 0.00], p = 0.047) and Paraphrase performance (Beta = -0.07, 95% CI [-0.13, -0.01], p = 0.025). Associations between HHIE-S score and PSMT performance (Beta = -0.05, 95% CI [-0.13, 0.03], p = 0.204) were not statistically significant. After adjustment for demographic and cognitive covariates (Model 1), HHIE-S score was not significantly associated with PSMT performance (Beta = 0.03, 95% CI [-0.04, 0.11], p = 0.386), Craft Story Verbatim (Beta = -0.01, 95% CI [-0.09, 0.08], p = 0.877), or Craft Story Paraphrase (Beta = -0.01, 95% CI [-0.07, 0.04], p = 0.667).

Further adjustment for TBI and TIA (Model 2) did not materially alter effect estimates, and HHIE-S score remained unassociated with PSMT performance (Beta = 0.03, 95% CI [-0.05, 0.11], p = 0.435), Craft Story Verbatim (Beta = -0.00, 95% CI [-0.09, 0.08], p = 0.917), or Craft Story Paraphrase (Beta = -0.01, 95% CI [-0.07, 0.05], p = 0.740).

No statistically significant interaction was observed between HHIE-S score and sex assigned at birth for PSMT, Craft Story Verbatim, or Craft Story Paraphrase (all p values > 0.05). Similarly, no statistically significant interaction was observed between HHIE-S score and ALD use across PSMT, Craft Story Verbatim, or Craft Story Paraphrase (all p values > 0.05).

**Discussion**

In this large cross-sectional study of AI/AN Elders 55 years of age or older who live in urban areas, HHIE-S scores were elevated in approximately 30% of participants, indicating a substantial burden of self-perceived hearing handicap. However, we did not observe associations between HHIE-S scores and markers of auditory or visual episodic memory performance in models that adjusted for other risk factors. Contrary to our hypothesis, we also did not observe differences in these associations by sex assigned at birth.

The findings herein support previous work on hearing loss and related cognitive decline. One prospective cohort study in non-AI/AN populations examined the temporal sequence between hearing loss and cognitive performance using repeated measures over time.[6] They observed no association between poorer hearing and cognitive performance among cognitively intact older adults.[6] Our findings similarly suggest that HHIE-S scores were not independently associated with episodic memory performance in adjusted models. A cross-sectional study has also evaluated older adults with and without hearing loss using a comprehensive neuropsychological battery.[16] They found that participants with hearing loss performed similarly to those with normal hearing on most cognitive measures.[16] However, the study only showed intact results when testing non-auditory cognitive domains as opposed to auditory tests, which does contrast our findings in that we found no associations across both visual and auditory assessments. The prospective cohort study made the distinction between unaided and aided hearing loss in participants, and primarily tested with numeric-based assessments, which could require less auditory effort in comparison to our study's use of extended, verbal-based tests that require recalling a full story and its details.

Our findings are discordant with previous longitudinal studies that have demonstrated robust associations between hearing loss and cognitive decline over time. For instance, in one community-based cohort of

older adults, hearing loss was measured using pure-tone audiometry, and participants were followed longitudinally for incident dementia and change in neuropsychological performance.[2] Dementia outcomes were determined through standardized clinical evaluation procedures. Another population-based study similarly defined hearing loss using objective audiometric thresholds and examined longitudinal change in global cognitive function and dementia incidence.[29] Both cohorts primarily included community-dwelling older adults from non-AI/AN populations, used audiometric measures to define hearing loss, and incorporated longitudinal follow-up to assess cognitive change over time. In contrast, our study examined self-perceived hearing loss using HHIE-S scores and assessed episodic memory performance at a single cross-sectional time-point without the ability to evaluate incident dementia or cognitive decline.

Additionally, a large meta-analysis reported a significant inverse association between hearing loss and cognitive performance across domains.[30] The meta-analysis synthesized data from multiple cross-sectional and longitudinal studies where hearing loss was primarily defined using objective audiometric thresholds or standardized hearing assessments. Cognitive outcomes included global cognition, memory, executive function, and incident dementia. Pooled analyses observed that hearing loss was associated with lower cognitive test performance and increased risk of cognitive impairment and dementia. Two cross-sectional studies[31,32] that assessed the association of HHIE-S with cognitive impairment also found that higher HHIE-S is significantly associated with worse global cognition[31] and mild behavioral impairment – both considered to be markers of early warning signs of incident cognitive decline.[32] Sex-stratified analyses also demonstrated significant differences where males with higher HHIE-S was associated with poorer cognition and auditory memory.[31] Further, sex-by-hearing interactions in memory performance showed strong variation by sex.[33]

Although we did not observe associations, point estimates are in the right direction. Several factors may explain why our findings differ from previous work. Some studies used more detailed metrics to define hearing[1,2,3,6,29], which may provide a more accurate measure of hearing loss in their sample. Unlike the cross-sectional results reported herein, many prior studies have been longitudinal[2,6,29] and focused on incident dementia or general cognitive decline rather than episodic memory performance, emphasizing how crucial temporal sequencing can be. Hearing loss may exert cumulative effects over time, rather than

becoming immediately detectable in a cross-sectional setting.[29,34] Additionally, episodic memory represents a complex hippocampal-dependent system.[6] Modest perceived hearing handicap may not disrupt hippocampal binding processes sufficiently to produce measurable differences in episodic recall in a cross-sectional design. Differences in sample size may have influenced statistical power, and most importantly, the absence of AI/AN representation in prior research may overlook important sociocultural and structural contexts that warrant focused examination within our sample.[5,8]

Hearing loss was measured using the HHIE-S, a self-report instrument assessing perceived social and emotional impact of hearing difficulty. Self-reported hearing loss has demonstrated reasonable validity compared to audiometric measures.[35] However, the subjective nature of the HHIE-S captures psychosocial impact rather than the physiological threshold loss. This may reflect hesitancy around views towards hearing loss and self, and the challenges of social participation. Tangentially, stigma surrounding hearing loss may influence reporting patterns, particularly in historically marginalized communities.[36] Internalized stigma could lead to social withdrawal and reduced help-seeking behaviors. Importantly, stigma has been associated with social isolation and emotional distress, which may be linked to cognitive decline[36,37,38] and bear further consideration.

The lived experiences of AI/ANs differ greatly from non-AI/AN populations due to multigenerational trauma, structural racism, underfunded healthcare systems, and financial barriers.[5,8,39] Hearing health disparities are well documented among historically marginalized communities[35], where reduced access to hearing care may compound long-term risk.[38] Interestingly, recent randomized controlled trials suggest that hearing intervention may slow cognitive decline in high-risk populations.[40] Hearing loss has been considered a modifiable risk factor for cognitive decline[9], associated with loneliness, depression, and social isolation.[41] Hearing loss may have meaningful psychosocial implications among AI/ANs not fully captured in standardized cognitive testing. There is limited research including AI/AN populations in studies of hearing loss and cognitive decline. Many studies that do focus on hearing loss have been conducted in predominantly White or non-AI/AN samples. Evidence suggests that the magnitude of association between hearing loss and cognitive may differ by race and ethnicity.[1,30] The absence of strong associations in our study may reflect unique contextual factors within urban AI/AN Elders.

*Strengths and Limitations*

The URBANE study captured the diverse lived experience within AI/AN Elders across the United States by sampling from five metropolitan locations. Participants underwent extensive interviews, assessments, and clinical appointments to provide a wide range of context into protective and risk factors for probable ADRD, including hearing status, an underexplored risk factor. We were able to evaluate auditory and visual episodic memory performance outcomes and explore effect modification by sex assigned at birth. However, the cross-sectional nature of this study precludes establishing temporal order and examining causality. It is important to emphasize that this study assessed episodic memory performance of a single cross-sectional time point and did not evaluate cognitive decline, cognitive impairment, or ADRD. Therefore, these findings would not be interpreted as evidence regarding the presence or absence of cognitive decline in this population. Hearing loss was assessed with the HHIE-S, a self-report screening tool that only captured perceived social and emotional impact rather than audiometric thresholds, did not distinguish the type of hearing loss, its duration and onset, nor prior use of hearing aids outside the visit. Crystallized intelligence was measured using the NIH Toolbox PVT, which relied on auditory presentation and may be influenced by differences in hearing ability. The neurocognitive assessments were either fully computer-based or administered by a certified staff member. Finally, sample size for some subgroups may have been underpowered to detect small effect sizes.

**Conclusion**

Although we did not observe associations of HHIE-S with markers of auditory and visual episodic memory tasks, our findings highlight the potential burden of hearing loss in this population of AI/AN Elders. Screening and early management of hearing loss remain important to optimize health and well-being. Older adults should be routinely screened for hearing loss as part of comprehensive cognitive risk assessment, particularly in communities with known healthcare access disparities. Continued collaborative research with AI/AN populations is essential to ensure culturally grounded, equitable approaches to hearing health and cognitive function.

**Table 1.** Characteristics of Study Participants According to Hearing Handicap Inventory-Screening Categories

| | | Hearing Handicap Severity Scores[2] | | |
|---|---|---|---|---|
| | **Overall** N = 901[1] | **No Hearing Handicap** N = 636[1] (70.6%) | **Mild-Moderate Hearing Handicap** N = 187[1] (20.8%) | **Significant Hearing Handicap** N = 78[1] (8.7%) |
| **Site** | | | | |
| Oklahoma City | 237 (26%) | 184 (29%) | 43 (23%) | 10 (13%) |
| Phoenix | 277 (31%) | 194 (31%) | 53 (28%) | 30 (38%) |
| San Bernardino | 187 (21%) | 135 (21%) | 38 (20%) | 14 (18%) |
| Seattle | 200 (22%) | 123 (19%) | 53 (28%) | 24 (31%) |
| **Age (5-year groups)** | | | | |
| 55 to 59 | 300 (33%) | 214 (34%) | 56 (30%) | 30 (38%) |
| 60 to 64 | 233 (26%) | 176 (28%) | 41 (22%) | 16 (21%) |
| 65 to 69 | 198 (22%) | 136 (21%) | 41 (22%) | 21 (27%) |
| 70 to 74 | 95 (11%) | 68 (11%) | 25 (13%) | 2 (2.6%) |
| 75+ | 75 (8.3%) | 42 (6.6%) | 24 (13%) | 9 (12%) |
| **Sex Assigned at Birth** | | | | |
| Female | 652 (72%) | 475 (75%) | 123 (66%) | 54 (69%) |
| Male | 249 (28%) | 161 (25%) | 64 (34%) | 24 (31%) |
| **Education** | | | | |
| No HS Diploma | 154 (17%) | 101 (16%) | 37 (20%) | 16 (21%) |
| HS Diploma or GED | 146 (16%) | 109 (17%) | 26 (14%) | 11 (14%) |
| Attended College | 375 (42%) | 253 (40%) | 81 (43%) | 41 (53%) |
| Bachelor's Degree | 131 (15%) | 103 (16%) | 22 (12%) | 6 (7.7%) |
| Advanced Degree | 95 (11%) | 70 (11%) | 21 (11%) | 4 (5.1%) |
| **First spoken language** | | | | |
| Indigenous language | 113 (13%) | 69 (11%) | 28 (15%) | 16 (21%) |
| English | 749 (83%) | 540 (85%) | 152 (81%) | 57 (73%) |
| Other | 34 (3.8%) | 26 (4.1%) | 5 (2.7%) | 3 (3.8%) |
| Missing | 5 (0.6%) | 1 (0.2%) | 2 (1.1%) | 2 (2.6%) |

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| **Traumatic Brain Injury (TBI)**[a] | | | | |
| No | 573 (64%) | 445 (70%) | 99 (53%) | 29 (37%) |
| Yes | 307 (34%) | 183 (29%) | 79 (42%) | 45 (58%) |
| Don't Know | 3 (0.3%) | 1 (0.2%) | 2 (1.1%) | 0 (0%) |
| Missing | 15 (1.7%) | 6 (0.9%) | 6 (3.2%) | 3 (3.8%) |
| Not Applicable | 3 (0.3%) | 1 (0.2%) | 1 (0.5%) | 1 (1.3%) |
| **Transient Ischemic Attack (TIA)**[b] | | | | |
| No | 828 (92%) | 591 (93%) | 170 (91%) | 67 (86%) |
| Yes | 68 (7.5%) | 44 (6.9%) | 15 (8.0%) | 9 (12%) |
| Missing | 5 (0.6%) | 1 (0.2%) | 2 (1.1%) | 2 (2.6%) |
| **Picture Vocabulary Test**[c] | 103.89 (10.37) | 104.28 (10.44) | 103.55 (9.97) | 101.51 (10.50) |
| **Picture Sequence Memory Test**[d] | 95.33 (12.31) | 95.44 (12.17) | 95.59 (12.76) | 93.81 (12.38) |
| **Craft Story Verbatim**[e] | 33.24 (13.26) | 33.59 (13.21) | 32.71 (12.99) | 31.67 (14.30) |
| **Craft Story Paraphrase**[f] | 25.09 (9.07) | 25.36 (8.96) | 24.62 (8.98) | 24.01 (10.08) |

[1]Values are n (%) for categorical variables and mean (SD) for continuous variables.
Percentages may not sum to 100 due to rounding or missing data.
[2]HHIE-S categories: no hearing handicap (0–8), mild–moderate hearing handicap (10–24), and significant hearing handicap (26–40).
[a]Resulting in loss of consciousness or post-traumatic; [b]Ever told by doctor or medical professional they had condition.
[c]NIH Toolbox Picture Vocabulary Test Uncorrected, mean (SD). Range is 64-133.
[d]NIH Toolbox Picture Sequence Memory Test Uncorrected, mean (SD).
[e]Craft Story Verbatim Raw Total, mean (SD)
[f]Craft Story Paraphrase Raw Total, mean (SD)

**Table 2**. Linear regression of episodic memory outcomes on HHIE-S score

| Memory Test | Model 0[1] | | | Model 1[2] | | | Model 2[3] | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Beta[4]** | **95% CI** | **p-value** | **Beta** | **95% CI** | **p-value** | **Beta** | **95% CI** | **p-value** |
| **PSMT** | -0.05 | -0.13, 0.03 | 0.204 | 0.03 | -0.04, 0.11 | 0.386 | 0.03 | -0.05, 0.11 | 0.435 |
| **CSV** | -0.09 | -0.18, -0.00 | 0.047 | -0.01 | -0.09, 0.08 | 0.877 | -0.00 | -0.09, 0.08 | 0.917 |
| **CSP** | -0.07 | -0.13, -0.01 | 0.025 | -0.01 | -0.07, 0.04 | 0.667 | -0.01 | -0.07, 0.05 | 0.740 |

Abbreviation: CI = Confidence Interval
PSMT = Picture Sequence Memory Test
CSV = Craft Story Verbatim
CSP = Craft Story Paraphrase
[1]Model 0: Crude, unadjusted.
[2]Model 1: Primary analytic model and adjusted for study site, age, sex assigned at birth, first spoken language, and crystallized intelligence.
[3]Model 2: Uses model 1 base, further adjusted for history of TBI and self-reported TIA.
[4]Beta: Beta coefficient represents estimated change in episodic memory test score associated with a one-unit increase in HHIE-S score. Beta reflects the average difference in episodic memory test outcomes per one-point increase in HHIE-S score.

**Table 3.** Interaction and Sensitivity Analyses of HHIE-S and Episodic Memory Performance

| Analysis | | F statistic | p-value |
|---|---|---|---|
| Craft Story Paraphrase | Interaction: HHIE-S * Sex | 0.794 | 0.373 |
| Craft Story Verbatim | Interaction: HHIE-S * Sex | 0.327 | 0.567 |
| Picture Sequence Memory Test | Interaction: HHIE-S * Sex | 0.139 | 0.709 |
| Craft Story Paraphrase | Sensitivity: HHIE-S * ALD | 0.127 | 0.722 |
| Craft Story Verbatim | Sensitivity: HHIE-S * ALD | 1.096 | 0.296 |
| Picture Sequence Memory Test | Sensitivity: HHIE-S * ALD | 0.423 | 0.516 |

Sex = Sex assigned at birth
ALD = Assistive listening device

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