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Self-reported hearing loss, hearing aid use, and cognitive function among U.S. older adults

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Abstract

There has been increasing attention to the role of hearing loss as a potentially modifiable risk factor for Alzheimer's disease and related dementias. However, more nationally-representative studies are needed to understand the co-occurring changes in hearing loss and cognitive function in older adults over time, and how hearing aid use might influence this association. The purpose of this report is to examine how age-related changes in hearing loss and hearing aid use are associated with trajectories of cognitive function in a nationally-representative sample of U.S. older adults. We used 11 waves of longitudinal data from the Health and Retirement Study (HRS) from 1998 to 2018 to examine changes in self-reported hearing loss, hearing aid use, and cognitive function in adults 65 and older by race and ethnicity. Results from mixed models showed that greater levels of hearing loss were associated with lower levels of cognitive function at age 65 in non-Hispanic White, non-Hispanic Black, and Hispanic older adults. We also found that the associations diminished across age in White and Black individuals; but remained persistent in Hispanic individuals. The use of hearing aids was not associated with cognitive function in Black older adults but appeared protective for White and Hispanic older adults. Overall, the findings from this report suggest that the timely identification of hearing loss and subsequent acquisition

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Authors' Contributions

Conceived and designed the study and analyzed the data: J.S. West, M.E. Dupre. Wrote the manuscript: J.S. West, M.E. Dupre, S.L. Smith.

Conflicts of Interest

The authors have no conflicts of interest to declare.

Ethical Approval

This study did not involve research on human subjects.

Availability of Supporting Data

The data used in this study are publicly available.

of hearing aids may be important considerations for reducing declines in cognitive function that manifests differently in U.S. population subgroups.

Keywords

Hearing loss; Cognitive decline; Dementia; Racial/ethnic disparities; Longitudinal trajectories

1. Introduction

Alzheimer's disease and related dementias (ADRDs) currently affect more than 55 million people worldwide and are projected to impact nearly 80 million people by 2030 (Gauthier, Rosa-Neto, Morais, et al., 2021). The prevention of ADRD is a global public health priority and identifying modifiable risk factors for cognitive decline will contribute to the development of effective interventions (Gauthier, Rosa-Neto, Morais, et al., 2021). Hearing loss has received increasing attention as a potentially modifiable risk factor for cognitive decline (Livingston, Sommerlad, Orgeta, et al., 2017). In the United States, hearing loss is one of the most common health problems in later life (Whitson, Cronin-Golomb, Cruickshanks, et al., 2018), impacting more than 25% of individuals aged 65–74 and upward of 50% of individuals aged 75 and older (CDC, 2017).

Although there is accumulating evidence that hearing loss is linked to cognitive decline (Whitson, Cronin-Golomb, Cruickshanks, et al., 2018), the findings have been disparate, and the explanations for the associations have varied in the literature (see Wayne and Johnsrude 2015 for a comprehensive review). In particular, most of the research on hearing and cognition has examined cross-sectional measures of hearing loss – either at baseline (Alattar, Bergstrom, Laughlin, et al., 2019; Deal, Betz, Yaffe, et al., 2017; Ge, McConnell, Wu, et al., 2021; Golub, Brickman, Ciarleglio, et al., 2020; Golub, Luchsinger, Manly, et al., 2017; Lin, Yaffe, Xia, et al., 2013) or at the end of the follow-up period (Deal, Sharrett, Albert, et al., 2015). Consequently, these studies do not account for the co-occurring changes in hearing status and cognition that can occur over time. Indeed, research using longitudinal measures of hearing and cognitive function has shown that hearing loss is associated with lower baseline performance on cognitive tests, as well as accelerated declines in cognition compared to those with no hearing loss (Maharani, Dawes, Nazroo, et al., 2018b; 2019). However, more research is needed from a life course perspective to better understand the short- and long-term impact of hearing loss to potentially identify individuals who may be at greater risk of cognitive decline over time.

Studies have shown that the prevalence of hearing loss in the United States is highest in White adults, followed by Hispanic and Black adults, respectively (Agrawal, Platz, Niparko, et al., 2008). Studies have also shown that Black and Hispanic older adults have higher risks for ADRD compared with White older adults (Babulal, Quiroz, Albensi, et al., 2019). However, most studies that have examined racial/ethnic differences in the impact of hearing loss on cognition have simply controlled for race and/or ethnicity and have not considered possible differences among these groups (Brenowitz, Kaup, Lin, et al., 2019; Curhan, Willett, Grodstein, et al., 2019; Lin, 2011; Lin, Metter, O'Brien, et al., 2011;

Wallhagen, Strawbridge, and Shema, 2008). It is also unclear whether and to what extent the associations change with increasing age among these population groups. Thus, there remains limited evidence of racial/ethnic differences in the longitudinal association between hearing loss and cognitive decline at the national level.

The purpose of this report is to examine how age-related changes in hearing loss and hearing-aid use are associated with trajectories of cognitive function in U.S. older adults. Using nationally-representative longitudinal data of adults aged 65 and older from 1998 to 2018, we characterize how levels of self-reported hearing and hearing aid use are related to changes in cognitive function for 20 years in non-Hispanic White, non-Hispanic Black, and Hispanic older adults. We also account for a wide array of sociodemographic, behavioral, and health-related factors that may contribute to the associations.

2. Data and Methods

2.1. Data

We analyzed 11 waves of publicly-available RAND Health and Retirement Study (HRS) data from 1998 to 2018 (RAND Center for the Study of Aging, 2021). Sponsored by the National Institute on Aging (grant number U01AG009740), the HRS is a nationally-representative prospective study of U.S. adults over the age of 50 that has collected biennial data over the past 30 years. Specific details of the multistage sampling design, data collection techniques, and response rates have been documented extensively elsewhere (Sonnega, Faul, Ofstedal, et al., 2014). The current analysis is limited to 38,231 participants who were eligible to participate in 1998-2018. We limited our analysis to adults aged 65 and older who were administered the measures for cognitive functioning in the HRS (described below) and aged 85 and younger to minimize the potential influence of selective survival at advanced ages. We further limited our analysis to participants who identified themselves as Hispanic, non-Hispanic Black or African American (hereafter referred to as Black), or non-Hispanic White (n = 21,076). Approximately 3% of the sample had missing data on at least one measure of hearing or cognitive function and were omitted. Full details of the inclusion/exclusion criteria for the analytic sample are provided in a flow chart (Figure 1). The final sample included 20,545 individuals who provided a total of 90,990 observations for analysis.

2.2. Measures

Our primary dependent variable was cognitive function. Cognitive function was ascertained in HRS participants using an adapted version of the Telephone Interview for Cognitive Status (TICS) which was modeled after the Mini-Mental State Examination (Ofstedal, Fisher, and Herzog, 2005). Beginning in 1998, all age-eligible participants received the full set of cognitive performance tests – which included six tasks that measured (i) speed of mental processing, (ii) memory, (iii) working memory, (iv) orientation, (v) knowledge, and (vi) language (Ofstedal, Fisher, and Herzog, 2005). Correct responses from each measure were combined to form a total cognitive score that ranges from 0 to 35 (Ofstedal, Fisher, and Herzog, 2005). Self-reported hearing was measured using a five-point scale (excellent, very good, good, fair, or poor) to assess participants' overall level of hearing (while wearing

a hearing aid, if applicable). The use of a hearing aid was also included and dichotomized (0 = no and 1 = yes). Race and ethnicity were assessed using two self-reported measures: 1) do you consider yourself Hispanic or Latino (0=no, 1=yes), and 2) what race do you consider yourself to be: White, Black or African American, American Indian, Alaska Native, Asian, Native Hawaiian, Pacific Islander, or something else? Due to small sample sizes, participants who self-identified as American Indian, Alaska Native, Asian, Native Hawaiian, or Pacific Islander were combined into an "other" category by the HRS to protect participant confidentiality (and were omitted from analysis). We thus use the measures for race and ethnicity to classify individuals as Hispanic, non-Hispanic Black, or non-Hispanic White.

Additional covariates included sex (0 = female and 1 = male), marital status (married [reference], divorced, widowed, or never married), household size (continuous), and whether the participant lives in the South (reference) versus other geographic regions. Several socioeconomic variables were also included: wealth (logged continuous variable), which was measured using total household assets minus debt (Bugliari, Nancy, Chris, et al., 2016) and years of education (continuous). Health behaviors included smoking status (never [reference], past, or current smoker) and number of alcoholic drinks per day (0 – 4 [reference] or 5 or more) (McKee, Stransky, and Reichard, 2018). Health status included number of limitations in activities of daily living (ADL, continuous) and indicators for ever being diagnosed by a doctor for high blood pressure, diabetes, cancer, lung disease, heart disease, or stroke. We included an indicator for participants who died during the study period (0 = alive and 1 = died) and a continuous variable for the number of waves present to account for attrition as previously shown (Brown, O'Rand, and Adkins, 2012; Yang and Land, 2013). With the exception of sex, race/ethnicity, and the indicators for attrition, all measures were included as time-varying variables in the models described below.

2.3. Analytic strategy

Overall distributions of study variables were calculated separately for each racial/ethnic group. A series of linear mixed models were used to estimate trajectories of cognitive function from age 65 to 85 (Rabe-Hesketh and Skrondal, 2012). The mixed models (i.e., multilevel mixed-effects linear regression models) used a hierarchical framework to incorporate the individuals' repeated observations (level 1) nested within individuals (level 2) to estimate (1) the within-individual change in cognitive function with age and (2) the between-person differences in baseline cognitive function (intercept) and the change in cognitive function (slope) with increasing age. Preliminary tests of model fit indicated that a quadratic function best parameterized the age-related patterns of cognitive decline among older adults – a finding that is consistent with prior research (Cloutier, Chertkow, Kergoat, et al., 2015; Maharani, Dawes, Nazroo, et al., 2019). Preliminary analyses also indicated significant racial/ethnic differences in hearing and/or cognitive function; therefore, the mixed models were estimated separately in each racial/ethnic group. Bayesian Information Criteria (BIC) and Akaike Information Criteria (AIC) statistics indicated that a quadratic function remained the best model fit for all three groups. Differences by sex were also assessed and no significant interactions were found.

All mixed models included adjustments for sex, marital status, household size, geographic region, education, employment, wealth, smoking status, alcohol consumption, ADLs, disease diagnoses, and indicators for mortality/attrition. We also tested for interactions among age, hearing loss, and hearing aid use to account for possible changes in the associations over time. The final models retain the significant associations that provided the best model fit (assessed by BIC and AIC statistics) for each racial/ethnic group. Estimates were then plotted to facilitate interpretation.

3. Results

Overall sample distributions for the study period (1998 – 2018) are shown by race/ethnicity in Table 1. Overall, White older adults exhibited significantly higher cognitive function (22.7, SD = 4.7) compared with Black (18.9, SD = 5.5) and Hispanic (19.1, SD = 5.2) older adults. A larger proportion of Hispanic older adults reported hearing loss (fair/poor hearing, 32.4%) than White (22.3%) and Black (20.1%) older adults. In terms of hearing aid use, a larger proportion of White participants (13.7%) reported wearing hearing aids compared with both Hispanic (8.3%) and Black (5.5%) participants. More White participants died during the study period (39.3%) compared to Black (35.2%) and Hispanic (27.7%) participants.

Table 2 presents the results from the mixed models showing the age-related associations among hearing level, hearing aid use, and cognitive function in White, Black, and Hispanic older adults in the study. To facilitate interpretation of the findings, the results from Table 2 are plotted in Figure 2 for four major categories of hearing and hearing aid use: (i) excellent hearing, unaided; (ii) excellent hearing, aided; (iii) poor hearing, unaided; and (iv) poor hearing, aided. For White older adults, worse self-rated hearing ($P < 0.001$) and wearing a hearing aid ($P < 0.001$) were associated with lower cognitive scores at age 65 compared to those who reported better hearing or wearing a hearing aid, respectively. White participants with excellent (unaided) hearing had an average cognitive score of 24.8 at age 65, compared to 23.9 for excellent (aided), 23.8 for poor (unaided), and 23.0 for poor (aided) among White participants. Results also showed that the differences in cognitive function associated with self-rated hearing and wearing a hearing aid diminished at later ages.

For Black older adults, worse self-rated hearing ($P < 0.001$) was associated with lower cognitive scores at age 65 compared to those who reported better hearing. The use of hearing aids was not significantly associated with cognitive function in Black participants ($P = 0.52$). In Figure 2, Black older adults with excellent (unaided) hearing had an average cognitive score of 20.9, compared to 20.8 for those with excellent (aided) hearing, 19.6 for poor (unaided), and 19.5 for poor (aided). Consistent with the finding for White older adults, the association between self-rated hearing and cognition declined among Black older adults at later ages.

For Hispanic older adults, self-rated hearing ($P = 0.008$) and hearing-aid use ($P < 0.001$) were associated with lower cognitive scores at age 65. Hispanic participants with excellent (unaided) hearing had an average cognitive score of 20.7, while those with excellent (aided) hearing had scores of 18.9, those with unaided (unaided) had scores of 20.2 and those

with poor (aided) had scores of 18.4. Results also showed that the differences in cognitive function associated with wearing a hearing aid (but not self-rated hearing) diminished at later ages.

4. Discussion

In this brief report, we examined 20 years of longitudinal data to characterize how age-related changes in hearing loss and hearing aid use were associated with trajectories of cognitive decline in a large U.S. national sample. Overall, the results suggested that levels of self-reported hearing and hearing aid use had complex associations with cognitive function that varied across age and across major racial/ethnic groups in the U.S.

Three major findings were observed. First, White older adults had overall better cognitive function at all ages compared with Black and Hispanic older adults. This finding is consistent with previous research showing that Black and Hispanic populations are at higher risk for developing ADRD compared to White adults (Babulal, Quiroz, Albensi, et al., 2019). Second, older adults who reported worse hearing had lower levels of cognitive function than those who reported better hearing, regardless of race or ethnicity. Much of the previous research examining longitudinal changes in hearing loss and cognitive status has assessed hearing ability at only one point in time (Alattar, Bergstrom, Laughlin, et al., 2019; Deal, Betz, Yaffe, et al., 2017; Deal, Sharrett, Albert, et al., 2015; Ge, McConnell, Wu, et al., 2021; Lin, Yaffe, Xia, et al., 2013), thus limiting our understanding of age-related changes in hearing status and cognition. In addition, studies that have included multiple measures of both hearing and cognitive function (Maharani, Dawes, Nazroo, et al., 2018b; 2019) did not account for differences related to race and/or ethnicity. Our analysis extends this research by showing that the association between hearing and cognition is patterned differently by race/ethnicity.

Although hearing loss has a negative association with cognitive function at baseline (age 65) for all three groups, the impact of hearing loss on cognitive decline wanes with age for both White and Black adults. This pattern is generally consistent with the age-as-leveler hypothesis (House, Lepkowski, Kinney, et al., 1994), which suggests that stressors (e.g., hearing loss) may be more impactful for health (e.g., cognition) at earlier ages, but dimmish at older ages. For Hispanic older adults, however, we found that the association between level of hearing and cognitive function persisted across age. This pattern is consistent with the notion of persistent inequality, which suggests that the magnitude of the health differential remains stable across age (Haas and Rohlfsen, 2010).

Finally, the findings for hearing aid use differed by racial/ethnic group. The results suggested that wearing hearing aids may be protective for White older adults in slowing cognitive decline among those in the early old age. This general finding is consistent with previous research showing that individuals experience a more gradual decrease in episodic memory decline after beginning to wear hearing aids compared to before (Maharani, Dawes, Nazroo, et al., 2018a). Hearing aid use appears particularly beneficial for Hispanics – those who report either excellent or poor aided hearing experience a small improvement in cognitive functioning from ages 65 to 75. In contrast, our results suggest that self-reported

hearing aid use is not particularly impactful for cognitive functioning among Black adults. We suspect this finding may be due, in part, to the relatively low prevalence of hearing aid use among Black adults (5.5%), which has been well documented. The research has shown that the average delay in adopting hearing aids following hearing aid candidacy is nearly 10 years, ranging from 8.6 years for White adults to 15.2 years for non-White adults (Simpson, Matthews, Cassarly, et al., 2019). Thus, the low/delayed adoption of hearing aids among Black adults may result in these individuals missing the cognitive benefits associated with hearing aids.

Several limitations of this analysis should be noted. First, hearing function and hearing aid use were self-reported measures. Although pure-tone audiometry is the gold standard for clinically assessing hearing sensitivity (West, Smith, and Dupre, 2020), studies also suggest that it may not be able to measure the experience of hearing disability in real world environments (Demeester, Topsakal, Hendrickx, et al., 2012), especially regarding an individual's reported listening comprehension in group conversations (Gatehouse and Noble, 2004) or in noisy environments (Kramer, Kapteyn, Festen, et al., 1996). Furthermore, audiometric data are rarely assessed on repeated occasions, particularly among the general population at a national level. A second limitation of this study is the temporality of the measures. Although the current data are longitudinal, measures of hearing and cognitive function were both assessed at the same time points (i.e., interviews) over the study period. Therefore, the results of this study should be considered associational, and we remain guarded in forming causal interpretations of the findings. Finally, although we extend prior research on hearing and cognitive function by examining major population subgroups (non-Hispanic White, non-Hispanic Black, and Hispanic older adults), we lacked sufficient data on other U.S. racial/ethnic groups. There is some evidence to suggest that Asian Americans with hearing loss are less likely to receive a hearing test compared with White, Black, and Hispanic individuals; and substantially less likely to use hearing aids compared to White adults (Choi, Kari, Friedman, et al., 2018). Additional research is needed to further understand these racial/ethnic differences in hearing, access to hearing healthcare, and their possible implications for changes in cognitive function at older ages.

5. Conclusion

In summary, the current findings extend previous research on the link between hearing loss and cognition by providing national-level evidence of age-related changes in hearing status and cognition, and how these associations vary by major racial/ethnic groups in the United States. Timely identification of hearing loss and subsequent acquisition of hearing aids are important considerations for reducing the burden of ADRD.

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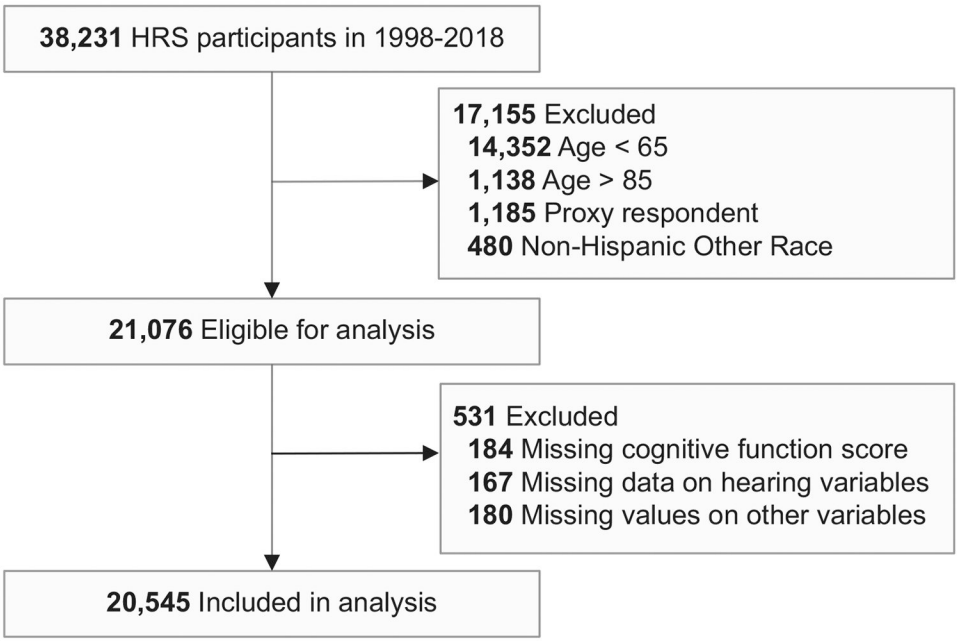

Figure 1. Study participants from the Health and Retirement Study, 1998 – 2018.

HRS: Health and Retirement Study. Note: In the HRS, the non-Hispanic Other race category includes participants who self-identified as American Indian, Alaska Native, Asian, Native Hawaiian, or Pacific Islander. The HRS combines these individuals into an "other" category to protect participant confidentiality due to their small sample sizes.

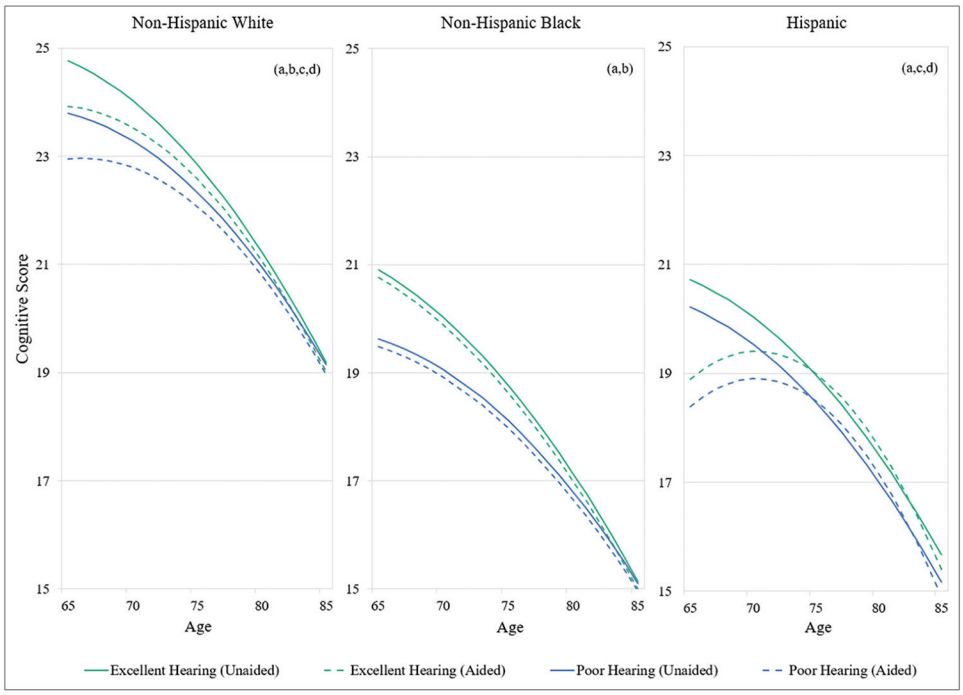

Figure 2. Plots of age-related changes in cognitive function associated with self-reported hearing loss and hearing aid use in U.S. older adults, HRS 1998 – 2018.

HRS: Health and Retirement Study. Results were calculated from estimates reported, as shown in Table 2. (a) Statistically significant intercept difference ($P < 0.05$) related to hearing loss. (b) Statistically significant slope difference ($P < 0.05$) related to hearing loss. (c) Statistically significant intercept difference ($P < 0.05$) related to hearing aid use. (d) Statistically significant slope difference ($P < 0.05$) related to hearing aid use.

Table 1.

Characteristics of study participants in the Health and Retirement Study, 1998 – 2018 (n=20,545).

	Non-Hispanic White	Non-Hispanic Black	Hispanic
Number of participants	15,319	3,235	1,991
Number of observations	70,202	12,883	7,905
Age, mean (SD), y	73.7 (5.7)	72.6 (5.6)	72.5 (5.5)
Sex (male)	42.3	37.1	40.7
Self-rated hearing, mean (SD)	1.7 (1.1)	1.7 (1.0)	2.0 (1.1)
Self-rated hearing			
Excellent	14.5	12.9	12.0
Very good	27.2	26.1	17.3
Good	36.0	40.9	38.4
Fair	16.9	15.8	26.7
Poor	5.4	4.3	5.7
Hearing aid use (yes)	13.7	5.5	8.3
Cognitive score, mean (SD)	22.7 (4.7)	18.9 (5.5)	19.1 (5.2)
Marital status			
Married/partnered	64.0	43.2	59.8
Divorced	8.4	18.6	13.5
Widowed	24.3	32.7	23.4
Never married	2.3	5.5	3.3
Household size, mean (SD)	1.9 (0.8)	2.2 (1.3)	2.6 (1.5)
Live in South	37.6	57.7	45.6
Wealth, median, US$	248,000	50,000	50,000
Education, mean (SD), y	12.9 (2.6)	11.4 (3.3)	8.6 (4.6)
Employment status			
Employed	13.9	13.2	11.6
Unemployed	13.4	16.7	26.9
Retired	72.7	70.1	61.5
Smoking status			
Never smoker	41.7	41.7	47.6
Past smoker	48.8	46.1	42.9
Current smoker	9.6	12.2	9.5
Heavy drinking	0.9	0.9	2.5
ADL, mean (SD)	0.3 (0.8)	0.5 (1.0)	0.5 (1.1)
Ever diagnosed with:			
High blood pressure	58.5	77.6	64.5
Diabetes	19.6	34.0	36.4
Cancer	19.1	14.8	11.1
Lung disease	11.6	8.9	6.1
Heart disease	30.4	25.8	20.0
Stroke	9.6	11.2	7.4

	Non-Hispanic White	Non-Hispanic Black	Hispanic
Study follow-up			
Years of follow-up, mean (SD)	12.2 (5.2)	11.3 (5.4)	11.2 (5.3)
Died during study period	39.3	35.2	27.7

Values reported as percentages or means (standard deviation [SD]); and are reported for the pooled data.

Table 2.

Mixed model estimates of age-related changes in cognitive function associated with self-reported hearing loss and hearing aid use in U.S. older adults, HRS 1998 – 2018.

	Non-Hispanic White (*n*=15,319)	Non-Hispanic Black (*n*=3,235)	Hispanic (*n*=1,991)
Age	−0.11 (0.01)***	−0.14 (0.02)***	−0.10 (0.03)***
Age^2	−0.01 (0.00)***	−0.01 (0.00)***	−0.01 (0.00)***
Hearing loss	−0.24 (0.03)***	−0.32 (0.06)***	−0.13 (0.05)**
Age*Hearing loss	0.01 (0.00)***	0.02 (0.01)*	
Hearing aid	−0.84 (0.14)***	−0.14 (0.22)	−1.82 (0.50)***
Age*Hearing aid	0.08 (0.03)**		0.29 (0.10)**
Age^2*Hearing aid	−0.00 (0.00)*		−0.01 (0.00)*
Constant	17.46 (0.18)***	13.93 (0.40)***	16.82 (0.36)***
Random-effects parameters			
Variance (age)	0.05 (0.00)	0.04 (0.00)	0.05 (0.01)
Variance (intercept)	7.22 (0.18)	11.34 (0.52)	10.84 (0.62)
Covariance (age, intercept)	−0.16 (0.02)	−0.20 (0.04)	−0.24 (0.05)
Residual variance	7.57 (0.05)	9.03 (0.14)	8.18 (0.16)
BIC	371,899.30	71,148.27	43,088.90
AIC	371,569.60	70,894.50	42,844.77

HRS, Health and Retirement Study; BIC, Bayesian information criterion; AIC, Akaike information criterion. All models included sex, marital status, household size, geographic region, education, employment, wealth, smoking status, alcohol consumption, ADLs, disease diagnoses, and indicators for attrition (mortality during the study and number of waves present).

*P<0.05

**P<0.01

***P<0.001.