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Hearing Loss Prevalence and Risk Factors Among Older Adults in the United States

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Background. Hearing loss has been associated with cognitive and functional decline in older adults and may be amenable to rehabilitative interventions, but national estimates of hearing loss prevalence and hearing aid use in older adults are unavailable.

Methods. We analyzed data from the 2005–2006 cycle of the National Health and Nutritional Examination Survey, which is the first cycle to ever incorporate hearing assessment in adults aged 70 years and older. Audiometry was performed in 717 older adults, and data on hearing aid use, noise exposure, medical history, and demographics were obtained from interviews. Analyses incorporated sampling weights to account for the complex sampling design and yield results that are generalizable to the U.S. population.

Results. The prevalence of hearing loss defined as a speech frequency pure tone average of more than 25 dB in the better ear was 63.1% (95% confidence interval: 57.4–68.8). Age, sex, and race were the factors most strongly associated with hearing loss after multivariate adjustment, with black race being substantially protective against hearing loss (odds ratio 0.32 compared with white participants [95% confidence interval: 0.19–0.53]). Hearing aids were used in 40.0% (95% confidence interval: 35.1–44.8) of adults with moderate hearing loss, but in only 3.4% (95% confidence interval: 0.8–6.0) of those with a mild hearing loss.

Conclusion. Hearing loss is prevalent in nearly two thirds of adults aged 70 years and older in the U.S. population. Additional research is needed to determine the epidemiological and physiological basis for the protective effect of black race against hearing loss and to determine the role of hearing aids in those with a mild hearing loss.

Key Words: Hearing loss—Epidemiology—Older adults—Risk factors—Race—Hearing aids.

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HEARING loss in older adults is highly prevalent, and recent studies have demonstrated independent associations of hearing loss with incident dementia (1), driving ability (2), and walking difficulty (3). Other studies have shown associations between hearing loss and social isolation (4,5), cognition (6–8), functional decline (5,9), and falls (10). Various hypotheses have been proposed to explain the basis of these observed associations. One possibility is that poor hearing requires greater cognitive resources for auditory decoding leading to less cognitive resource capacity for other tasks (8,11). Another possibility is that poor hearing leads to communication impairments and progressive social isolation that may mediate downstream health and functional consequences (12,13). Finally, a common etiology, such as from progressive mitochondrial dysfunction, could underlie both hearing loss and cognitive decline (14,15). Importantly, none of these proposed pathways are mutually exclusive, and coexistent pathways could potentially lead to the same outcome.

Under the hypothesis that hearing loss directly or indirectly leads to cognitive and physical decline, it is reasonable to hypothesize that hearing aids or other aural rehabilitative devices could mitigate these outcomes. Indeed, one moderate-sized randomized controlled trial of hearing aids demonstrated positive effects of hearing aids on cognition and other functional domains (16). A larger trial has never been carried out to confirm these findings definitively.

Surprisingly, despite the potential impact of hearing loss on aging and the possibility of interventional modalities to treat hearing loss, national estimates of hearing loss prevalence and hearing aid use in older adults are unavailable.

Previous studies of hearing loss in older adults have been in nonrepresentative cohorts (17–19), and these studies have resulted in different estimates of hearing loss prevalence even when the same definition of hearing loss was applied across studies (18).

In the current study, we utilize data from the 2005–2006 cycle of the National Health and Nutritional Examination Survey (NHANES) to study the epidemiology of hearing loss and derive prevalence estimates that are generalizable to adults aged 70 years and older in the U.S. population.

Methods

Study Cohort

The NHANES is an ongoing program of studies designed to assess the health, functional, and nutritional status of the civilian noninstitutionalized U.S. population. Each sequential cross-sectional study uses a complex sampling design to survey a sample of the population, with selective oversampling of low-income individuals, racial minorities, and older adults (20). Sampling weights allow for analyses that account for the complex sampling survey and yield results that are generalizable to the U.S. population.

We used data from the 2005–2006 cycle when hearing loss was assessed in adults aged 70 years and older. Overall, 827 older adults participated in both the interview and medical examination, and of these, 110 did not undergo or had incomplete audiometric testing in the speech frequencies (0.5–4 kHz). Individuals with missing audiometric data were more likely to be older, women, and have less education than the 717 individuals who completed audiometric testing.

Audiometric Assessment

Audiometry was performed by a trained examiner according to established NHANES protocols (21). Briefly, air conduction hearing thresholds were conducted on both ears in a dedicated sound-isolating room in the mobile examination center. Testing was conducted according to a modified Hughson Westlake procedure using the automated testing mode of the audiometer (Interacoustics AD226, Interacoustics, Eden Prarie, MN) and/or manually per the testing protocol. Quality assurance and quality control were established through daily calibration of equipment and monitoring of ambient noise levels using a sound level meter. The audiometric test room met or exceeded ANSI S3.1-1991 guidelines for maximum permissible ambient noise levels. Air conduction stimuli were presented primarily through supra aural earphones (TDH 39P, Telephonics Corp, Farmingdale, NY). Insert earphones (ER3A, Etymotic Research, Inc., Elk Grove Village, IL) were reserved for cases of collapsing ear canals or for a retesting protocol in cases of asymmetric hearing loss (masking was not performed). As an additional quality measure, thresholds were measured twice at 1 kHz in both ears, and audiometry was repeated if there was more than 10 dB discrepancy between the threshold measurements.

We utilized hearing thresholds from 0.5 to 8 kHz, using the first threshold tested at 1 kHz and incorporating manual retest thresholds as needed. Pure tone averages (PTA) were calculated for standard PTA (0.5, 1, and 2 kHz), speech frequency PTA (0.5, 1, 2, and 4 kHz), and high-frequency PTA (3, 4, 6, and 8 kHz). Categories of hearing loss severity were based on American Speech-Language Hearing Association guidelines (22), but several of the categories were collapsed to simplify analyses (normal hearing ≤ 25 dB, mild loss >25 dB and ≤ 40 dB, moderate loss >40 dB and ≤ 70 dB, severe loss >70 dB). All hearing thresholds in this manuscript are reported as dB HL (American National Standards Institute, 2004).

Other Study Variables

Data on demographic variables, history of noise exposure, and medical history were obtained from interviews. Race/ethnicity was grouped as Mexican-American or other Hispanic, non-Hispanic white, non-Hispanic black, or other race. Education and household income were collapsed into a 3 and 4 level variable, respectively. Noise exposure history incorporated assessment (yes/no) of firearm use (use of firearms for target shooting, hunting, or other purposes), occupational noise (exposure to loud noise for ≥ 5 hours a week), and leisure noise (exposure to steady loud noise or music for ≥ 5 hours a week). Hearing aid use was based on whether an individual had used a hearing aid for ≥ 5 hours a week in the past 12 months. Variables related to medical history included diabetes (based on self-reported diagnosis and/or current use of insulin or other diabetic medications), smoking (current/former/never), hypertension (told by physician on two or more visits about hypertension diagnosis), and stroke (self-reported history).

Statistical Methodology

We accounted for the complex sampling design in all analyses by using sample weights according to National Center for Health Statistics guidelines (23). The population prevalence of hearing loss using different definitions of hearing loss was calculated with 95% confidence intervals (95% CI). Regression analyses were used to determine the association between hearing loss or hearing aid use with studied covariates. When considering hearing loss or hearing aid use as a dichotomous variable, logistic regression models were utilized to calculate odds ratios. When examining hearing loss as a continuous variable, linear regression models were used to obtain β coefficients. The β coefficient is interpreted as the average change in hearing threshold (in dB, positive values indicate greater hearing loss, negative values indicate less hearing loss) per unit change in the studied covariate. Per National Center for Health Statistics guidelines, age standardization was performed utilizing the 2000 Census population, and the Taylor Series Linearization

Table 1. Prevalence of Hearing Loss in Adults Aged 70 Years and Older According to Varying Definitions of Hearing Loss, National Health and Nutritional Examination Survey 2005–2006

	Prevalence (95% CI)*		
	15 dB Threshold	25 dB Threshold	40 dB Threshold
Standard PTA (0.5, 1, 2 kHz)			
Unilateral†	13.2 (10.4–15.9)	16.1(11.9–20.3)	11.7 (9.1–14.4)
Bilateral/better ear	75.6 (73.0–78.2)	44.8 (40.4–49.2)	16.5 (13.2–19.9)
Worse ear	88.6 (85.1–92.2)	60.7 (54.3–67.1)	28.2 (23.9–32.4)
Speech frequency PTA (0.5, 1, 2, 4 kHz)			
Unilateral†	7.0 (4.0–10.0)	12.1 (9.0–15.3)	13.5 (10.4–16.5)
Bilateral/better ear	87.9 (84.2–91.7)	63.1 (57.4–68.8)	26.5 (22.9 -30.2)
Worse ear	94.9 (93.0–96.7)	75.1 (69.7–80.5)	39.9 (36.5–43.3)
High-frequency PTA (3, 4, 6, 8 kHz)			
Unilateral†	2.0 (0.9–3.0)	4.4 (2.4–6.4)	10.2 (5.9–14.5)
Bilateral/better ear	97.8 (96.6–98.9)	90.9 (88.2–93.6)	74.1 (67.2–80.9)
Worse ear	99.7 (99.1–100)	95.2 (92.8–97.6)	84.0 (79.6–88.5)

Notes: CI = confidence interval; PTA = pure tone average.

*Prevalence values represent the weighted percentage of older adults with pure tone averages (standard, speech frequency, or high frequency) above the designated threshold.

†Definitions of hearing loss based on the "better hearing ear" or "bilateral loss" are identical. Hearing loss defined by the better hearing ear/bilateral loss is mutually exclusive from unilateral loss. Using the worse hearing ear to define hearing loss incorporates cases defined by the better hearing ear/bilateral loss and cases defined by unilateral loss.

method was used for variance estimation (23). Missing non-audiometric data comprised less than 2% of the data in any analysis, and these individuals were excluded. All analyses were conducted using STATA 11.0 (StataCorp, College Station, TX), and $p < .05$ were considered statistically significant.

Results

Variability in Hearing Loss Prevalence by Case Definition

The prevalence of hearing loss in older adults varies substantially depending on the tonal frequencies utilized to calculate the PTA, the audiometric threshold defining hearing loss, and whether hearing loss is being considered in the better or worse hearing ear (Table 1). Hearing loss prevalence rates ranged from 16.5% (95% CI: 13.2–19.9) when hearing loss was defined using a standard PTA (0.5, 1, and 2 kHz) with a 40 dB threshold in the better hearing ear to 99.7% (95% CI: 99.1–100) when using a high-frequency PTA (3, 4, 6, and 8 kHz) with a 15 dB threshold in the worse ear. Most prior reports of hearing loss prevalence in adults have used a 25 dB threshold, standard or speech frequency PTA, and either the worse or better ear. However, even with this more limited definition, hearing loss prevalence rates still range from 44.8% (standard PTA in the better ear) to 75.1% (speech frequency PTA in the worse ear).

Herein, we adopt the definition of hearing loss adjudicated by the World Health Organization (speech frequency PTA in the better ear with a 25 dB threshold) (24). Using this definition, the prevalence of hearing loss in adults aged 70 years and older was 63.1% (95% CI: 57.4–68.8).

Prevalence and Correlates of Hearing Loss

In multivariate models adjusting for all confounders (Table 2), the odds of hearing loss were significantly associated with increasing age ($p < .001$ for all age categories) and male sex (odds ratio [OR] 1.67 [95% CI: 1.09–2.55]), whereas black race was strongly protective against hearing loss (OR = 0.32 [95% CI: 0.19–0.53]). Across 5-year age groupings, acceleration in hearing loss prevalence was greatest between 70–74 years and 75–79 years (45.6%–67.6%), with tapering increases in prevalence thereafter (78.2% in 80–84 years and 80.6% in >85 years). The prevalence of hearing loss in black participants (43.3%, [95% CI: 31.1–55.5]) was significantly lower than in white participants (64.4% [95% CI: 58.1–70.8]) ($p = .003$). We found no significant association between history of noise exposure or medical conditions with hearing loss.

We performed additional analyses to further explore the association of age, sex, and race with hearing loss by using hearing loss as a continuous (rather than dichotomous) variable and applying different PTA frequency ranges (standard PTA [0.5–2 kHz], speech frequency PTA [0.5–4 kHz], high-frequency PTA [3–8 kHz]). Regardless of the analytic approach, age and race remained significantly associated with hearing loss. There appeared to be a gradient in the degree of hearing protection associated with black race and the studied frequency range. Compared with white participants, black participants on average had hearing thresholds that were better by −3.5 dB (95% CI: −6.6 to −0.4), −5.8 (95% CI: −8.6 to −3.1), and −11.1 (95% CI: −13.9 to −8.2) dB at standard, speech frequency, and high-frequency PTA, respectively. A similar pattern was also seen with male sex. Male sex was not associated with hearing loss at standard PTA but was associated with greater hearing loss at speech frequency (+4.2 dB [95% CI: 0.9–7.6]) and high-frequency PTA (+11.5 dB [95% CI: 7.5–15.5]). Education and noise exposure (firearm use, leisure exposure) were primarily

Table 2. Prevalence and Correlates of Hearing Loss in Adults Aged 70 Years and Older, National Health and Nutritional Examination Survey 2005–2006

	Hearing Loss >25 db in Speech Frequency PTA[†]			Multivariate Analyses With Hearing Loss as a Continuous Variable[†,‡]		
	Prevalence[§](95% CI)	Univariate OR[‖](95% CI)	Multivariate OR[¶] (95% CI)	Standard PTA (0.5–2 kHz), β (95% CI)[#]	Speech Frequency PTA (0.5–4 kHz), β (95% CI)[#]	High-Frequency PTA(3–8 kHz), β (95% CI)[#]
Demographic						
Age (y)						
70–74	45.6 (39.3–51.8)	Reference	Reference	Reference	Reference	Reference
75–79	67.6 (58.8–76.3)	2.49*** (1.79–-3.46)	2.65*** (1.86–3.78)	6.84*** (4.23–9.45)	7.37*** (5.13–9.61)	8.61*** (4.95–12.3)
80–84	78.2 (73.0–83.4)	4.28*** (3.36–5.45)	4.30*** (3.06–6.03)	9.84*** (7.48–12.2)	10.8*** (8.26–13.3)	13.2*** (9.68–16.6)
≥85	80.6 (72.6–88.7)	4.97*** (2.69–9.20)	5.44*** (2.74–10.8)	16.6*** (12.5–20.7)	16.1*** (12.7–19.5)	15.4*** (11.8–19.1)
Sex						
Female	58.2 (50.7–65.6)	Reference	Reference	Reference	Reference	Reference
Male	69.8 (63.6–75.9)	1.66** (1.20–2.30)	1.67* (1.09–2.55)	—	4.23* (0.90–7.56)	11.5*** (7.50–15.5)
Race						
Non-Hispanic white	64.4 (58.1–70.8)	Reference	Reference	Reference	Reference	Reference
Non-Hispanic black	43.3 (31.1–55.5)	0.42** (0.25–0.71)	0.32*** (0.19–0.53)	-3.49* (−6.60 to −0.38)	−5.84*** (−8.58 to −3.10)	−11.1*** (−13.9 to −8.23)
Mexican or other Hispanic	65.1 (50.0–80.2)	1.03 (0.51–2.07)	—	—	—	—
Other	74.6 (46.1–100)	1.62 (0.32–8.14)	—	—	—	—
Education						
< 12th grade	70.1 (62.0–78.2)	Reference	Reference	Reference	Reference	Reference
High school graduate	62.3 (52.5–72.1)	0.70 (0.44–1.13)	—	—	—	−3.07* (−6.00 to −0.14)
Some college or more	58.5 (52.3–64.6)	0.60* (0.38–0.94)	—	—	−2.22* (−4.39 to −0.06)	−5.06** (−8.39 to −1.74)
Household income						
<$20 K/y	69.2 (62.5–76.0)	Reference	Reference	Reference	Reference	Reference
$20K to <$45K	64.8 (57.7–71.9)	0.82 (0.57–1.17)	—	—	—	—
≥$45K	57.1 (48.3–66.0)	0.59* (0.39–0.91)	—	−2.92* (−5.48 to −0.36)	−2.43* (−4.62 to −0.23)	—
Refused/don't know	47.5 (23.6–71.3)	0.40 (0.15–1.11)	0.38* (0.15–0.98)	—	—	—
Noise exposure						
Firearm use						
Yes	68.2 (60.9–75.5)	1.44* (1.01–2.05)	—	—	—	2.65* (0.12–5.19)
No	59.9 (53.1–66.7)	Reference	Reference	Reference	Reference	Reference
Occupational exposure						
Yes	72.2 (65.0–79.4)	1.87* (1.07–3.28)	—	—	—	—
No	58.2 (49.4–66.9)	Reference	Reference	Reference	Reference	Reference
Leisure exposure						
Yes	72.6 (66.6–78.6)	1.65** (1.19–2.29)	—	—	—	3.87* (0.81–6.93)
No	61.6 (55.6–67.7)	Reference	Reference	Reference	Reference	Reference
Medical history						
Diabetes						
Yes	64.9 (56.6–73.1)	1.10 (0.71–1.70)	—	—	—	—
No	62.7 (56.1–69.3)	Reference	Reference	Reference	Reference	Reference
Smoking						
Never	62.6 (54.2–71.1)	Reference	Reference	Reference	Reference	Reference
Former	64.4 (58.0–70.8)	1.08 (0.69–1.68)	—	—	—	—
Current	58.2 (43.0–73.3)	0.83 (0.47–1.45)	—	—	—	—

Table 2. (*Continued*)

	Hearing Loss >25 db in Speech Frequency PTA†			Multivariate Analyses With Hearing Loss as a Continuous Variable†‡		
	Prevalence§(95% CI)	Univariate OR‖(95% CI)	Multivariate OR¶ (95% CI)	Standard PTA (0.5–2 kHz), β (95% CI)#	Speech Frequency PTA (0.5–4 kHz), β (95% CI)#	High-Frequency PTA(3–8 kHz), β (95% CI)#
Hypertension						
Yes	60.4 (54.6–66.2)	0.79 (0.57–1.11)	—	—	—	—
No	65.7 (57.9–73.6)	Reference	Reference	Reference	Reference	Reference
Stroke						
Yes	69.2 (53.2–85.2)	1.34 (0.69–2.59)	—	—	—	—
No	62.7 (57.4–67.9)	Reference	Reference	Reference	Reference	Reference

Notes: CI = confidence interval; PTA = pure tone average.

† Asterisks denote level of statistical significance: $*p < .05$; $**p < .01$; $***p < .001$; — not significant.

‡ Multivariate linear regression was used to examine the association of various factors with hearing levels (speech frequency PTA in the better ear treated as a continuous dependent variable) after adjustment for all covariates in Table 2.

§ Prevalence values indicate the weighted percentage of adults with hearing loss (speech frequency PTA >25 dB in the better ear).

‖ Univariate odds ratios indicate the odds of hearing loss relative to the designated reference group.

¶ Multivariate odds ratios indicate the odds of hearing loss relative to the designated reference group after adjusting for all covariates in Table 2.

β coefficients indicate the expected change in hearing levels (in dB) for the factor relative to the designated reference group. Positive β coefficients indicate worse (greater) hearing loss associated with the studied factor, whereas negative βs indicate better hearing.

only significantly associated with high-frequency PTA. Medical covariates including diabetes, smoking history, hypertension, and stroke were not associated with standard, speech frequency, or high-frequency PTA. The variance in hearing loss that could be explained by the covariates (R^2) in each model was 0.20, 0.24, and 0.33 for standard, speech frequency, and high-frequency PTAs.

Hearing Loss and Race

We explored whether the observed protective association between black race and hearing loss could be explained by other factors. The age distributions of the black and white subcohorts were substantially different with the black cohort being younger (data not shown). To account for this potential bias, we calculated age-adjusted prevalence rates using 5-year age groups standardized against the 2000 U.S. census standard population. The age-standardized prevalence of hearing loss >25 db using the speech frequency PTA in the better ear in black participants is 44.7% (95% CI: 32.1–57.4) versus 65.6 % (95% CI: 60.6–70.6) in white participants. These prevalence rates are similar to the unadjusted prevalence rates (Table 2).

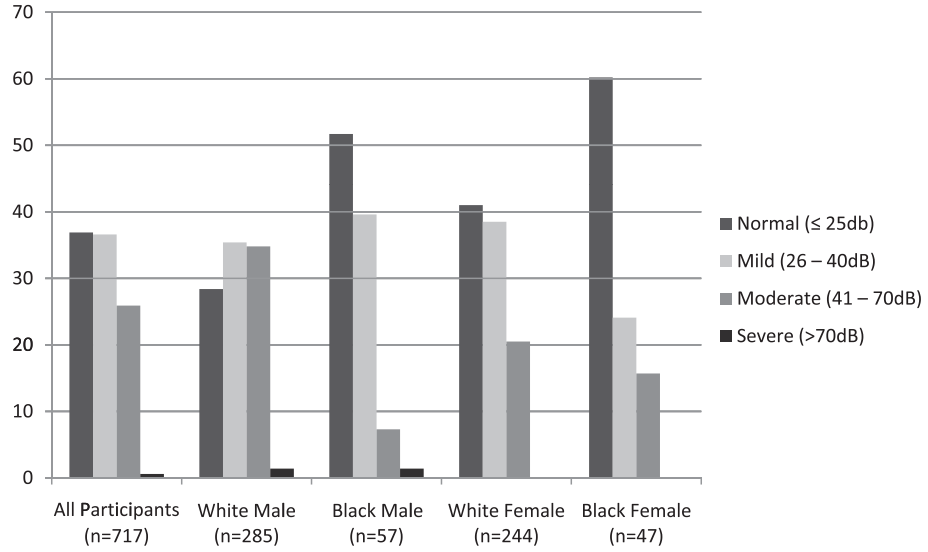
Prevalence estimates according to categories of hearing loss severity and stratified by race and sex demonstrate that black participants are more likely to have normal to mild hearing loss than white participants (Figure 1). Overall, black men had a hearing loss prevalence of 48.3% (95% CI: 36.3–60.3) versus 71.5% (95% CI: 64.8–78.3) in white men ($p = .002$). Similarly, the prevalence of hearing loss in black women is 39.8% (95% CI: 20.6–59.1) versus 59.0% (95% CI: 51.3–66.8) in white women ($p = .03$).

Hearing Aid Use

The overall prevalence of hearing aid use of 5 hours or more per week for individuals with hearing loss was 19.1% (95% CI: 16.2–22.0). There were substantial differences in rates of hearing aid use according to hearing loss severity (Table 3). For individuals with mild hearing loss, hearing aids were used in 3.4% (95% CI: 0.8–6.0) compared with 40.0% (95% CI: 35.1–44.8) and 76.6% (95% CI: 44.9–100) in those with moderate and severe hearing loss, respectively. In multivariate models, increased rates of hearing aid were associated with increasing hearing loss severity, higher education, and leisure noise exposure. There was no association of hearing aid use with age, sex, race, or income, but there was a nonsignificant trend between increased hearing aid use and higher income (data not shown).

Discussion

Using a definition of hearing loss adjudicated by the World Health Organization (24), we estimated that 63.1% (95% CI: 57.4–68.8) of adults aged 70 years and older in



	All Participants (n=717)	White Male (n=285)	Black Male (n=57)	White Female (n=244)	Black Female (n=47)
Normal (≤ 25db)	36.9 (31.1 - 42.6)	28.4 (21.7 – 35.2)	51.7 (39.7 – 63.6)	41.0 (33.2 – 48.7)	60.2 (40.9 – 79.4)
Mild (26 – 40dB)	36.6 (31.1 – 42.1)	35.4 (28.0 – 42.8)	39.6 (25.9 – 53.4)	38.5 (32.0 – 45.0)	24.1 (8.6 – 39.6)
Moderate (41–70 dB)	25.9 (22.4 – 29.5)	34.8 (30.0 – 39.5)	7.3 (0 – 15.5)	20.5 (14.9 – 26.2)	15.7 (4.7 – 26.8)
Severe (>70dB)	0.60 (0.02 -1.2)	1.4 (0 – 2.9)	1.4 (0 – 4.2)	--	--

Figure 1. Prevalence of hearing loss severity by sex and race using speech frequency pure tone averages in the better hearing ear in adults aged 70 years and older, National Health and Nutritional Examination Survey 2005–2006. *There were no cases of severe hearing loss in women.

the U.S. population are affected by hearing loss. Age, sex, and race were the principal factors associated with hearing loss, with black individuals having a hearing loss prevalence two thirds of that of white individuals in both crude and age-standardized estimates. Among individuals with hearing loss, only 19.1% reported using a hearing aid.

Our estimates of hearing loss prevalence in older adults differ somewhat from results observed in other studies. Prevalence rates reported have been 29% (>26 dB in the standard PTA in the better ear, participants >60 years), 73% (>25 dB in the speech frequency PTA in the worse ear, participants >70 years), and 60% (>25 dB in the standard PTA in the worse ear, participants 73–84 years) in the Framingham (19), Beaver Dam (17), and HealthABC (18) studies, respectively. Using similar definitions of hearing loss, prevalence from the current NHANES study would be 45%, 75%, and 61%, respectively. However, comparing prevalence estimates across different studies is difficult even when applying the same definition of hearing loss given the different demographic characteristics across cohorts particularly with regard to age and race. For example, both the Framingham cohort and Beaver Dam cohorts included few black individuals, but the HealthABC cohort included 36.3% black individuals. Age distributions and ranges also varied across these study cohorts. A strength of our study is that by applying the NHANES sample weights, our reported prevalence rates are generalizable to the entire civilian non-institutionalized U.S. population.

Consistent with other studies, we found that age, sex, and black race were associated with hearing loss (17,18,25–27). Increasing age was associated with hearing loss across all frequency definitions of PTA but with greater hearing loss changes seen at the higher frequencies. Sex differences were also most apparent at higher frequencies consistent with other prior studies (18,26). Similarly, we found that black race was strongly associated with lower odds of hearing loss across all frequency definitions of PTA but with greater protective associations seen at higher frequency ranges.

The association of black race with lower odds of hearing loss has been well described in both epidemiological (18,28–31) and in clinical research studies (32). Current hypotheses focus on the possible protective effect of melanin in the stria vascularis (33), but experimental animal studies studying skin pigmentation and hearing loss have been inconclusive (34,35). There have not been any studies examining whether residual confounding associated with racial disparities or a potential genetic etiology could explain the protective association of black race with hearing loss. However, the role of residual confounding associated with racial disparities (e.g. higher risk of poverty, hypertensive disease in blacks) would likely bias our results toward an underestimate of the protective effect of hearing loss observed in blacks rather than toward the null hypothesis.

We did not observe significant associations of hearing loss with other cardiovascular risk factors (hypertension,

Table 3. Prevalence and Correlates of Current Hearing Aid Use for 5 hours or more per week in Individuals With Speech Frequency Pure Tone Average Greater Than 25 dB in the Better Hearing Ear, National Health and Nutritional Examination Survey 2005–2006

	Prevalence of Hearing Aid Use* (95% CI)	Univariate OR†,‡ (95% CI)	Multivariate OR†,§ (95% CI)
Hearing level¶			
Mild	3.4 (0.8–6.0)	Reference	Reference
Moderate	40.0 (35.1–44.8)	18.9*** (8.6–41.7)	23.0*** (9.43–56.1)
Severe	76.6 (44.9–100)	93.3*** (11.8–735)	95.1*** (16.3–555)
Demographic			
Age (y)			
70–74	11.2 (4.2–18.2)	Reference	Reference
75–79	22.1 (11.9–32.2)	2.24 (0.72–6.96)	—
80–84	19.5 (15.1–24.0)	1.92 (0.86–4.30)	—
≥85	26.5 (16.9–36.1)	2.86* (1.27–6.40)	—
Sex			
Female	15.1 (12.2–18.1)	Reference	Reference
Male	23.6 (18.2–29.1)	1.74* (1.14–2.64)	—
Race			
Non-Hispanic white	19.9 (17.1–22.7)	Reference	Reference
Non-Hispanic black	8.3 (0.6–15.9)	0.36 (0.13–1.01)	—
Mexican or other Hispanic	12.9 (0.5–25.2)	0.59 (0.19–1.85)	—
Other	24.4 (0–59.2)	1.30 (0.21–8.11)	—
Education			
<12th grade	16.2 (11.6–20.9)	Reference	Reference
High school graduate	11.9 (3.7–20.0)	0.69 (0.30–1.61)	—
Some college or more	28.2 (19.6–36.7)	2.02* (1.17–3.49)	1.90* (1.01–3.60)
Household Income			
< $20K/y	12.5 (6.7–18.3)	Reference	Reference
$20K to <$45K	19.6 (12.3–27.0)	1.70 (0.72–4.02)	—
≥ $45K	22.9 (13.8–32.1)	2.08 (0.96–4.49)	—
Refused/don't know	49.9 (1.2–98.5)	6.95 (0.91–53.0)	—
Noise exposure			
Firearm use			
Yes	23.6 (16.9–30.2)	1.62* (1.01–2.60)	—
No	16.0 (13.0–19.0)	Reference	Reference
Occupational exposure			
Yes	21.5 (14.5–28.4)	1.28 (0.77–2.15)	—
No	17.6 (14.5–20.6)	Reference	Reference
Leisure exposure			
Yes	29.7 (20.2–39.3)	2.03* (1.15–3.55)	2.35* (1.29–4.29)
No	17.3 (13.8–20.8)	Reference	Reference

Notes: CI = confidence interval; OR = odds ratio.

*Prevalence values indicate the weighted percentage of adults reporting hearing aid use > 5 hours/week.

†Asterisks denote level of statistical significance level: *$p < .05$; **$p < .01$; ***$p < .001$; — Not significant.

‡Univariate odds ratios indicate the odds of hearing aid use relative to the designated reference group.

§Multivariate odds ratios indicate the odds of hearing aid use relative to the designated reference group after adjusting for all covariates in Table 3.

¶Hearing level determined by speech frequency pure tone average in the better hearing ear (mild loss > 25 dB and ≤ 40 dB, moderate loss > 40 dB and ≤ 70 dB, severe loss > 70 dB).

smoking, diabetes, stroke) even when multiple different frequency ranges of hearing loss were considered, and hearing loss was used as a continuous variable (providing for more statistical power). Results from other large representative cohorts of older adults have also demonstrated equivocal results with regard to these risk factors (18,27,36–38). For example, diabetes mellitus was found to be positively associated with hearing loss in the HealthABC study (18) but not in the Framingham (36) and Beaver Dam studies (37). One likely explanation for these inconsistent results is that cardiovascular risk factors are only weakly associated with hearing loss, and their effects may be masked by stronger risk factors (eg, age) particularly in cohorts comprising older adults.

Among older adults with hearing loss, we estimate that approximately one fifth use a hearing aid, and this estimate is consistent with other national estimates of hearing aid use (19,39). Rates of hearing aid use differed substantially by hearing loss severity with only 3% of individuals with mild hearing loss reporting hearing aid use versus 41% in those with moderate or worse hearing loss. Interestingly, rates of hearing aid use in the United Kingdom where bilateral hearing aids are covered by the National Health Service are not higher (40), which suggests that access and affordability are not the only issues that limit hearing health care. These observations are likely indicative of general perceptions that undervalue the potential impact of hearing loss on health and functioning in aging.

There are limitations to our study. Approximately 13% of older adults who underwent the medical examination did not complete audiometric testing, and these individuals were generally older. Our prevalence estimates may, therefore, underestimate the true population prevalence of hearing loss. Our relatively modest cohort size also limited our statistical power to detect weaker associations or to explore potential interactions between race, sex, and other covariates.

Our results demonstrate that hearing loss is highly prevalent in older adults and that the nonmodifiable risk factors of age, sex, and race are the strongest determinants of hearing loss status. Although preventative strategies focused on noise exposure and other medical risk factors remain important, increasing emphasis needs to be placed on determining the genetic, epidemiological, and pathophysiological basis for the strong protective association conferred by black race. Other research focusing on clinical trials should further examine whether aural rehabilitative strategies, particularly among individuals with mild hearing loss where hearing aids are seldom used, can potentially mitigate the adverse health and functional effects associated with hearing loss in older adults.

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