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Declining Prevalence of Hearing Loss in US Adults Aged 20 to 69 Years

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IMPORTANCE As the US population ages, effective health care planning requires understanding the changes in prevalence of hearing loss.

OBJECTIVE To determine if age- and sex-specific prevalence of adult hearing loss has changed during the past decade.

DESIGN, SETTING, AND PARTICIPANTS We analyzed audiometric data from adults aged 20 to 69 years from the 2011-2012 cycle of the US National Health and Nutrition Examination Survey, a cross-sectional, nationally representative interview and examination survey of the civilian, noninstitutionalized population, and compared them with data from the 1999-2004 cycles. Logistic regression was used to examine unadjusted, age- and sex-adjusted, and multivariable-adjusted associations with demographic, noise exposure, and cardiovascular risk factors. Data analysis was performed from April 28 to June 3, 2016.

INTERVENTIONS Audiometry and questionnaires.

MAIN OUTCOMES AND MEASURES Speech-frequency hearing impairment (HI) defined by pure-tone average of thresholds at 4 frequencies (0.5, 1, 2, and 4 kHz) greater than 25 decibels hearing level (HL), and high-frequency HI defined by pure-tone average of thresholds at 3 frequencies (3, 4, and 6 kHz) greater than 25 decibels HL.

RESULTS Based on 3831 participants with complete threshold measurements (1953 men and 1878 women; mean [SD] age, 43.6 [14.4] years), the 2011-2012 nationally weighted adult prevalence of unilateral and bilateral speech-frequency HI was 14.1% (27.7 million) compared with 15.9% (28.0 million) for the 1999-2004 cycles; after adjustment for age and sex, the difference was significant (odds ratio [OR], 0.70; 95% CI, 0.56-0.86). Men had nearly twice the prevalence of speech-frequency HI (18.6% [17.8 million]) as women (9.6% [9.7 million]). For individuals aged 60 to 69 years, speech-frequency HI prevalence was 39.3% (95% CI, 30.7%-48.7%). In adjusted multivariable analyses for bilateral speech-frequency HI, age was the major risk factor (60-69 years: OR, 39.5; 95% CI, 10.5-149.4); however, male sex (OR, 1.8; 95% CI, 1.1-3.0), non-Hispanic white (OR, 2.3; 95% CI, 1.3-3.9) and non-Hispanic Asian race/ethnicity (OR, 2.1; 95% CI, 1.1-4.2), lower educational level (less than high school: OR, 4.2; 95% CI, 2.1-8.5), and heavy use of firearms (≥1000 rounds fired: OR, 1.8; 95% CI, 1.1-3.0) were also significant risk factors. Additional associations for high-frequency HI were Mexican-American (OR, 2.0; 95% CI, 1.3-3.1) and other Hispanic race/ethnicity (OR, 2.4; 95% CI, 1.4-4.0) and the combination of loud and very loud noise exposure occupationally and outside of work (OR, 2.4; 95% CI, 1.4-4.2).

CONCLUSIONS AND RELEVANCE Adult hearing loss is common and associated with age, other demographic factors (sex, race/ethnicity, and educational level), and noise exposure. Age- and sex-specific prevalence of HI continues to decline. Despite the benefit of delayed onset of HI, hearing health care needs will increase as the US population grows and ages.

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Since 1959, the United States has conducted examination-based health surveys measuring hearing thresholds in nationally representative samples at specified ages (eg, young children aged 6-11 years, adolescents aged 12-17 or 12-19 years, and adults ≥18 or ≥20 years). Hearing testing in adults has been accomplished in 4 surveys. The 1959-1962 National Health Examination Survey performed air-conduction hearing threshold tests in each ear at 6 frequencies (0.5, 1, 2, 3, 4, and 6 kHz) in adults aged 18 to 74 years. The first National Health and Nutrition Examination Survey (NHANES I) in 1971-1975 tested hearing in each ear at 4 frequencies (0.5, 1, 2, and 4 kHz) in adults aged 25 to 74 years. Since 1999, NHANES has operated continuously in 2-year cycles; during 1999-2004 and 2011-2012, NHANES conducted hearing tests in each ear at 7 frequencies (0.5, 1, 2, 3, 4, 6, and 8 kHz) in adults aged 20 to 69 years. The 1999-2004 data encompassed 3 cycles to accumulate a sufficient sample size since audiometric tests were performed on only half the respondents coming to the mobile examination centers. It was previously reported that high-frequency (3-6 kHz) hearing thresholds for people of specified age and sex groups were better in 1999-2004 than in 1959-1962; most of these differences were statistically significant.[1]

In this article, we report the prevalence of hearing impairment (HI) in more recent data from the 2011-2012 NHANES compared with the 1999-2004 cycles to determine whether hearing in US adults has continued to improve. In addition, we report the associations between well-known risk factors (ie, demographic, noise exposure, and cardiovascular) and the prevalence of HI in the 2011-2012 NHANES.

Key Points

Question What changes have occurred in the prevalence of age- and sex-specific hearing loss during the past decade for adults aged 20 to 69 years?

Findings Using data from the National Health and Nutrition Examination Survey, this study found that while the prevalence of hearing loss has continued to decline among adults aged 20 to 69 years, adult hearing loss is associated with increasing age, sex, race/ethnicity, educational level, and noise exposure.

Meaning These results are consistent with a delayed onset of hearing loss to older ages and increased hearing health care needs as the US population grows and ages.

Methods

The NHANES is conducted by the National Center for Health Statistics, Centers for Disease Control and Prevention, to monitor the health and nutritional status of the civilian, noninstitutionalized US population. The survey includes an in-person interview covering sociodemographic characteristics, health status, risk factors, and other health-associated information, as well as a physical examination. Race/ethnicity was self-reported using federal guidelines. The survey uses a complex, multistage, stratified, cluster design with oversampling of targeted subgroups to produce nationally representative estimates. During the 1999-2004 cycles, NHANES oversampled non-Hispanic black and Mexican-American, low-income, adolescents aged 12 to 19 years, and adults 60 years or older to obtain reliable data for these subgroups.[2] In the 2011-2012 cycle, NHANES oversampled Hispanic, non-Hispanic Asian, and non-Hispanic black individuals, as well as all individuals (regardless of race or ethnicity) who were at or below 130% of the poverty index and/or 80 years or older.[3]

The NHANES 1999-2004 cycles conducted audiometric examinations on half the sample of interviewed adults aged 20 to 69 years; audiometric examinations in the NHANES 2011-2012 cycle were conducted on a full sample of interviewed adults in the same age range. Participation rates for audiometry in NHANES 1999-2004 were 67.5% (5291 of 7835) of the eligible sample (ie, those selected for the survey) and 87.8% (5291 of 6026) of participants who actually agreed to participate and completed the household interview. Response rates for NHANES 2011-2012 were 57.4% (3831 of 6671) of the eligible sample and 81.9% (3831 of 4677) of participants who actually agreed to participate and completed the household interview; the lower response rates coincided with the NHANES decision to begin oversampling other (non-Mexican-American) Hispanic and non-Hispanic Asian subgroups. Both surveys were approved by the National Center for Health Statistics Institutional Review Board, and all participants provided written consent. In all survey cycles, the audiometry examination was conducted by trained NHANES health technicians and included otoscopy, tympanometry, and air-conduction, pure-tone audiometry.

Audiometric testing was conducted in sound booths (model Delta 142; Acoustic Systems) in mobile examination centers, which were transported to each survey location. Ambient noise met the American National Standards Institute S3.1 standards for maximum permissible ambient noise levels.[4,5] During testing, background noise was monitored continuously. Thresholds were obtained using an AD226 microprocessor audiometer (Interacoustics), which met the specifications of American National Standards Institute S3.6-1996.[6] The audiometric testing protocols are available on the National Center for Health Statistics website.[7,8]

Thresholds were obtained using a pulsed-tone stimulus and modified Hughson-Westlake procedure.[9] Thresholds were obtained in each ear at 0.5, 1, 2, 3, 4, 6, and 8 kHz. Retest thresholds were obtained at 1 kHz in each ear to confirm consistency; the second 1-kHz threshold was used in this analysis. The first test ear was alternated and tones were initially presented at 40 decibels (dB) hearing level (HL), then followed by adjusting the level up by 5 dB or down by 10 dB until the threshold was found. Threshold was defined as the level at which the participant responded at least 50% of the time to ascending or descending presentations. Thresholds were usually obtained using supra-aural Telephonics Dynamic Headphone-type or TDH headphones (Telephonics); insert transducers (EARtone 3A; Etymotic Research Inc) were used when participants had collapsing ear canals. Masking was not used; however, thresholds were retested in the poorer ear with insert earphones when marked interaural asymmetry was found. When available, thresholds obtained with insert earphones were used in the analysis.

The audiometric test protocol was identical during both survey periods. However, the supra-aural headphones changed from model TDH-39P to TDH-49P in NHANES 2011-2012 to avoid potential calibration errors at 6 kHz when using an NBS-9A style coupler (Quest Technologies).[10] This change might have improved thresholds at 6 kHz; however, we could not find statistically significant evidence of such improvement. A recent study examined threshold measurements using TDH-39P headphones and found negligible evidence of spurious 6 kHz notches.[11]

The NHANES household questionnaire was administered by trained interviewers in the participant's home via computer-assisted personal interview. The 1999-2004 and the 2011-2012 survey questionnaires included similar questions on hearing health and risk factors, including self-assessed hearing ability, use of hearing aids, tinnitus, and both occupational and nonoccupational exposure to noise. Other NHANES questionnaires collected information on important covariates, including cardiovascular disease risk factors.

There were some differences between the questions in the NHANES 1999-2004 and 2011-2012 interviews. First, work-associated noise exposure in the NHANES 1999-2004 was defined as exposure for "at least 3 months" in the "current job" and/or the "job held the longest"; duration of exposure was inferred from length of time each job was held. Noise exposure in other jobs was assessed by asking about noise exposure lasting at least 3 months "in any job" with no further measure of duration. In 2011-2012, respondents were asked if they "ever had a job, or combination of jobs" that included noise exposure "for 4 or more hours a day, several days a week?" and, if so, "for how many months or years?" the exposure occurred.

Second, in 1999-2004, participants were asked about nonoccupational noise, such as "power tools or loud music," that occurred "on average at least once per month for a year." In 2011-2012, participants were asked about nonoccupational "noise or music" exposures such as that from "power tools, lawn mowers, farm machinery, cars, trucks, motorcycles, motorboats, or loud music" that lasted "10 or more hours a week."

Third, the 1999-2004 questionnaire asked about exposure to loud occupational or nonoccupational noise, defined as noise "so loud that you had to speak in a raised voice to be heard." In 2011-2012, participants were asked additionally about very loud noise, defined as "noise so loud you have to shout in order to be understood by someone standing 3 feet away."

Finally, in 1999-2004, only nonoccupational noise from firearms was assessed, via the question, "Outside of work, have you ever been exposed to firearms noise for an average of at least once a month for a year?" Both occupational and nonoccupational noise from firearms was assessed in 2011-2012, and participants were asked to "estimate the total lifetime number of rounds fired."

In both survey periods, participants were classified positive for diabetes if they answered "yes" to "Have you ever been told by a doctor or other health professional that you have diabetes or sugar diabetes?" or "Are you now taking diabetic pills to lower your blood sugar?" or had a 2-hour fasting glucose level of 126 mg/dL or more (to convert to millimoles per liter, multiply by 0.0555). Participants were classified positive for hypertension if they answered "yes" to "Have you ever been told you have high blood pressure?" or "Are you taking a prescription for hypertension?" or, if during the examination in the mobile examination center, the mean of 4 blood pressure measurements was more than 140 mm Hg (systolic) or more than 90 mm Hg (diastolic). Smoking history was defined as *nonsmoker* if the respondent answered "no" to "Have you smoked at least 100 cigarettes in your life?" Current and former smokers were divided into 2 groups: less than 20 pack-years (ie, smoked 1 pack [20 cigarettes] daily for <20 years) and 20 pack-years or more (ie, smoked 1 pack [20 cigarettes] daily for ≥20 years). Additional information is available on the National Center for Health Statistics website.[3]

Statistical Analysis

Data analysis was performed from April 28 to June 3, 2016. The statistical programs SAS, version 9.2 (SAS Institute Inc), and SUDAAN (Research Triangle Institute International) were used to incorporate the NHANES examination sample weights, which accounted for differential probabilities of selection and adjustments for oversampling of selected populations, nonresponse, and noncoverage (for groups in the population that do not appear in the sample).

Based on 3831 adults with complete threshold measurements, the speech-frequency pure-tone average (PTA) was calculated across 4 test frequencies (0.5, 1, 2, and 4 kHz) and the high-frequency PTA was calculated across 3 test frequencies (3, 4, and 6 kHz) in each ear. The ear with the lower PTA was considered the better ear for that set of frequencies. Hearing impairment was defined by PTAs greater than 25 dB HL. This criterion for mild or worse HI has been used in other surveys[12]; it is strongly associated with self-reported hearing difficulty.[13] Bilateral HI is defined as PTA in the better ear at greater than 25 dB HL. Unilateral HI is defined as PTA in the worse ear at greater than 25 dB HL and PTA in the better ear at 25 dB HL or less. Overall HI includes both unilateral and bilateral HI and is equivalent to HI in the worse ear.

We calculated the prevalence of HI across several demographic, noise exposure, and cardiovascular risk factors. We also compared the prevalence of HI for individual frequencies and PTAs between the 1999-2004 and 2011-2012 cycles. The hearing threshold data from the 2 time periods were combined, maintaining appropriate survey weights, and then odds ratios (ORs) and 95% CIs for HI were calculated using SUDAAN logistic regression adjusting for age and sex. The SUDAAN logistic regression procedure was also used to calculate ORs and 95% CIs for bilateral (better ear) speech-frequency HI and high-frequency HI in the following 3 different analyses: unadjusted (each variable separately in the predictive model), age- and sex-adjusted (each variable plus age and sex in the predictive model), and multivariable-adjusted (all variables included in the predictive model).

Results

In the 2011-2012 cycle, the prevalence of unilateral speech-frequency HI was 6.6% (13.0 million) and the prevalence of bilateral speech-frequency HI was 7.5% (14.7 million) (**Table 1**). The prevalence of overall (unilateral plus bilateral) speech-frequency HI in the 2011-2012 cycle among adults aged 20 to 69 years was 14.1% (27.7 million), which is reduced from the prevalence of 15.9% (28.0 million) published for NHANES 1999-2004.[14] After adjustment for age and sex, the comparison of speech-frequency HI in the worse ear (2011-2012 vs 1999-2004) shows a significant reduction (OR, 0.70; 95% CI, 0.56-0.86) (**Table 2**).

High-frequency HI was more prevalent than speech-frequency HI, affecting 31.1% (61.1 million) in the 2011-2012 cycle compared with 31.9% in the 1999-2004 cycle.[14] Although the apparent reduction between the 2011-2012 and 1999-2004 cycles appears slight, after adjustment for age and sex (Table 2), the decline in high-frequency HI in the worse ear is also statistically significant (OR, 0.75; 95% CI, 0.65-0.88).

The effect of age is shown in the **Figure**. For almost all age groups and both sexes, prevalence of HI is lower in the 2011-2012 cycle, although most 95% CIs overlap. A more informative comparison of the data from the 2011-2012 and 1999-2004 cycles is shown in Table 2, which adjusts for age and sex, since there were relatively more adults aged 50 to 59 years and 60 to 69 years in the 2011-2012 cycle. For most audiometric frequencies except 1 kHz (in the better ear) and 8 kHz (in both ears), the age- and sex-adjusted ORs in Table 2 were less than 1.00, suggesting better hearing in the 2011-2012 cycle. Statistical significance was found for high-frequency HI in the better ear (OR, 0.78; 95% CI, 0.64-0.94; *P* = .01) and worse ear (OR, 0.75; 95% CI, 0.65-0.88; *P* = .001) and for speech-frequency HI in the worse ear (OR, 0.70; 95% CI, 0.56-0.86; *P* = .001), while the better ear failed to achieve significance (OR, 0.75; 95% CI, 0.56-1.00; *P* = .053).

Nearly twice as many men (18.6% [17.8 million]) as women (9.6% [9.7 million]) had speech-frequency HI. The prevalence of bilateral high-frequency HI was even greater in men (27.6% [26.9 million]) than in women (10.6% [11.1 million]). The prevalence of speech-frequency HI reaches 39.3% (10.8 million) for those aged 60 to 69 years and, for all categories of HI, the prevalence rises sharply above ages 30 to 39 years. The prevalence of bilateral speech-frequency HI rises about 27-fold over 3 decades of age, approximately 3-fold per decade.

Other factors significantly associated with HI were non-Hispanic white race/ethnicity, lower educational level, occupational noise exposure, use of firearms (≥1000 rounds fired in a lifetime), smoking (≥20 pack-years), hypertension, and diabetes. Many of these risk factors are correlated with one another; for example, diabetes is more prevalent in older people.

A clearer understanding of HI risks requires multivariable analysis (**Table 3**) of the demographic, noise exposure, and cardiovascular risk factors. Unadjusted odds ratios confirm that non-Hispanic white race/ethnicity (OR, 2.3; 95% CI, 1.4-3.8), educational level less than high school (OR, 3.1; 95% CI, 1.8-5.3), 5 years or more of exposure to very loud occupational noise (OR, 3.7; 95% CI, 2.1-6.7), 1000 or more firearm rounds fired in a lifetime (OR, 3.1; 95% CI, 1.7-5.7), a 20 pack-year or longer history of smoking (OR, 2.8; 95% CI, 2.1-3.7), hypertension (OR, 2.2; 95% CI, 1.6-3.0), and diabetes (OR, 2.4; 95% CI, 1.7-3.3) are associated with increased prevalence of bilateral speech-frequency HI. After adjustment for age and sex, however, hypertension (OR, 1.0; 95% CI, 0.7-1.4) and diabetes (OR, 1.1; 95% CI, 0.8-1.6) were no longer associated with increased prevalence of bilateral speech-frequency HI.

After adjustment for all risk factors, age had the strongest association with HI: compared with participants aged 20 to 29 years, those aged 60 to 69 years had a 39.5 higher odds of bilateral speech-frequency HI (95% CI, 10.5-149.4). Other than age, the risk factor most associated with risk of bilateral speech-frequency HI was educational level less than high school (OR, 4.2; 95% CI, 2.1-8.5). Male sex (OR, 1.8; 95% CI, 1.1-3.0), non-Hispanic white race/ethnicity (OR, 2.3; 95% CI, 1.3-3.9), and lower educational level (high school diploma: OR, 2.8; 95% CI, 1.2-6.9; some college or associate degree: OR, 2.4; 95% CI, 1.2-4.9) remained significantly associated with bilateral speech-frequency HI, but no cardiovascular variables retained statistically significant associations. Of the noise exposure variables, only 1000 or more firearm rounds fired in a lifetime retained a statistically significant association (OR, 1.8; 95% CI, 1.1-3.0).

Since the hearing threshold average of the speech frequencies is not as sensitive to the effects of noise (and some other exposures) as the hearing loss in the higher frequencies, we also evaluated the association of all demographic, noise exposure, and cardiovascular variables with hearing loss as determined by bilateral high-frequency HI (**Table 4**). Several variables have stronger associations in the multivariable model with high-frequency HI than with speech-frequency HI, including male sex (OR, 3.8; 95% CI, 2.7-5.4), 5 years or more of exposure to very loud occupational noise (OR, 2.0; 95% CI, 1.3-2.9), and possibly diabetes (OR, 1.5; 95% CI, 0.9-2.6).

Discussion

Age-adjusted prevalence of HI in adults aged 20 to 69 years declined from the 1999-2004 cycles to the 2011-2012 cycle of the NHANES. However, the US population grew during that decade and the age distribution also changed, with disproportionate growth (augmented by Baby Boomers born approximately between 1946 and 1964) of older adults who are more likely to have HI. Based on NHANES tabulation of Census Bureau estimates in 2011-2012, there were 196.6 million civilian, noninstitionalized US adults aged 20 to 69 years, which is 20 million more than the mean annual number of 176.2 million in 1999-2004. The relative shift in the percentage of adults aged 60 to 69 years was 34.8% (increasing from 11.5% [20.6 million] to 15.5% [27.6 million]) and, similarly, the percentage of adults aged 50 to 59 years grew by 18.9% (increasing from 18.1% [32.2 million] to 21.5% [38.3 million]). Despite these unfavorable demographic shifts, the estimated number of adults aged 20 to 69 years with hearing loss declined absolutely, from an estimate of 28.0 million in the 1999-2004 cycles to 27.7 million in the 2011-2012 cycle. The reason for this decrease is the decline in overall prevalence from 15.9% to 14.1%. The percentage decrease of adults with hearing loss is small, at less than 1%; however, one could have expected the opposite result based on the changing demographic figures. Hence, the decrease in overall prevalence of hearing loss between the

Table 1. Prevalence of Speech-Frequency and High-Frequency HI, US Adults Aged 20 to 69 Years, NHANES, 2011-2012

Characteristic	Sample No. (Population-Weighted %)[a]	Speech-Frequency HI, % (95% CI)[b]			High-Frequency HI, % (95% CI)[c]		
		Overall[d]	Unilateral[e]	Bilateral[f]	Overall[d]	Unilateral[e]	Bilateral[f]
Total (2011-2012)	3831 (100)	14.1 (11.6-17.1)	6.6 (5.4-8.1)	7.5 (5.8-9.6)	31.1 (28.0-34.3)	11.9 (10.5-13.5)	19.1 (16.6-21.9)
Sex							
Male	1953 (50.0)	18.6 (14.8-23.1)	8.7 (6.6-11.4)	9.9 (7.2-13.3)	42.2 (36.6-48.1)	14.6 (12.2-17.5)	27.6 (23.0-32.8)
Female	1878 (50.0)	9.6 (7.2-12.7)	4.5 (3.3-6.1)	5.1 (3.6-7.3)	19.9 (17.5-22.6)	9.3 (7.6-11.3)	10.6 (8.6-13.0)
Age, y							
20-29	840 (21.6)	2.2 (1.3-3.7)	1.4 (0.7-2.6)	0.8 (0.3-2.3)	7.1 (4.8-10.2)	5.0 (3.2-7.6)	2.1 (1.0-4.2)
30-39	758 (19.0)	3.3 (2.1-5.2)	2.4 (1.3-4.2)	0.9 (0.4-2.1)	10.8 (8.7-13.5)	7.8 (6.2-9.9)	3.0 (1.7-5.3)
40-49	739 (21.5)	7.8 (5.5-11.0)	4.4 (3.2-5.9)	3.4 (2.1-5.6)	26.0 (20.8-32.1)	11.3 (8.7-14.6)	14.7 (11.0-19.4)
50-59	772 (22.1)	23.1 (18.7-28.1)	11.8 (8.7-15.9)	11.2 (7.5-16.6)	50.2 (44.5-55.8)	19.3 (15.5-23.8)	30.8 (25.2-37.1)
60-69	722 (15.9)	39.3 (30.7-48.7)	14.6 (9.6-21.6)	24.7 (20.2-29.9)	68.0 (59.0-75.8)	16.9 (13.5-20.9)	51.1 (43.7-58.5)
Race/ethnicity							
Non-Hispanic white	1334 (66.5)	15.9 (12.8-19.6)	6.9 (5.2-9.1)	9.0 (7.1-11.5)	33.8 (30.6-37.1)	12.4 (10.6-14.4)	21.4 (18.7-24.5)
Non-Hispanic black	1063 (11.6)	9.0 (7.5-10.9)	5.0 (4.1-5.9)	4.1 (2.7-6.2)	22.4 (19.0-26.3)	10.8 (8.8-13.1)	11.7 (9.3-14.6)
Mexican American	397 (7.9)	9.2 (6.5-13.0)	4.9 (2.7-8.7)	4.3 (3.3-5.7)	27.9 (24.1-32.0)	12.8 (10.5-15.5)	15.1 (12.5-18.0)
Non-Hispanic Asian	538 (4.9)	10.8 (7.2-15.8)	6.1 (3.9-9.2)	4.7 (2.8-7.8)	24.7 (19.3-31.1)	11.1 (8.8-13.8)	13.7 (10.0-18.4)
Other Hispanic	378 (6.3)	9.1 (6.3-13.0)	5.2 (2.8-9.5)	3.9 (1.9-7.7)	25.8 (21.1-31.2)	9.1 (6.7-12.2)	16.8 (11.9-23.2)
Other race/ethnicity	121 (2.8)	22.6 (10.3-42.6)	15.2 (6.9-30.1)	7.4 (2.3-21.2)	34.2 (18.5-54.4)	12.6 (5.5-26.3)	21.6 (13.1-33.5)
Educational level							
Less than high school	737 (13.8)	19.2 (15.6-23.3)	7.9 (6.1-10.1)	11.3 (8.5-14.8)	42.2 (39.0-45.5)	14.0 (11.1-17.5)	28.2 (24.2-32.6)
High school	805 (19.7)	19.1 (13.9-25.8)	9.7 (6.8-13.6)	9.5 (6.5-13.5)	39.7 (33.9-45.7)	14.5 (11.2-18.6)	25.1 (21.8-28.7)
Some college or associate degree	1246 (33.7)	14.8 (11.3-19.3)	6.6 (4.8-8.9)	8.3 (5.5-12.4)	27.1 (21.1-34.1)	10.8 (8.4-13.8)	16.3 (12.1-21.6)
College graduate or higher	1043 (32.9)	8.3 (6.0-11.3)	4.3 (2.4-7.6)	4.0 (2.6-6.0)	25.3 (21.1-30.0)	10.7 (8.3-13.8)	14.6 (11.4-18.4)
Smoking status							
Nonsmoker	2206 (55.8)	11.1 (8.9-13.7)	5.3 (4.3-6.4)	5.8 (4.2-7.9)	26.0 (22.4-29.8)	11.2 (9.3-13.4)	14.8 (11.9-18.3)
<20 pack-years	623 (17.2)	7.6 (5.1-11.0)	4.8 (3.1-7.5)	2.7 (1.6-4.6)	23.3 (18.8-28.4)	10.2 (6.8-15.0)	13.1 (8.7-19.1)
≥20 pack-years	874 (23.5)	26.4 (22.0-31.3)	11.8 (9.2-15.0)	14.6 (12.0-17.7)	49.8 (45.1-54.5)	15.1 (12.3-18.3)	34.8 (31.2-38.5)
Unknown	128 (3.4)	12.5 (5.6-25.7)	1.8 (0.7-4.4)	10.7 (4.2-24.9)	24.3 (16.9-33.5)	11.7 (5.6-22.7)	12.6 (7.1-21.4)
Hypertension							
No	2481 (68.3)	10.9 (8.5-13.7)	5.3 (4.1-6.7)	5.6 (4.1-7.6)	24.2 (21.1-27.6)	10.0 (8.5-11.7)	14.2 (11.9-12.0)
Yes	1350 (31.7)	21.1 (17.7-25.0)	9.6 (7.4-12.3)	11.6 (9.1-14.6)	45.8 (41.9-49.6)	16.2 (13.0-19.9)	29.6 (26.2-33.3)
Diabetes[g]							
No	3331 (90.5)	12.5 (10.1-15.3)	5.7 (4.6-7.1)	6.8 (5.1-8.9)	28.0 (25.2-31.0)	11.0 (9.6-12.6)	17.0 (15.0-19.2)
Yes	499 (9.5)	29.8 (22.6-38.2)	15.2 (9.0-24.5)	14.6 (12.0-17.6)	60.1 (52.8-67.0)	20.7 (16.5-25.6)	39.5 (30.2-49.6)

(continued)

Table 1. Prevalence of Speech-Frequency and High-Frequency HI, US Adults Aged 20 to 69 Years, NHANES, 2011-2012 (continued)

Characteristic	Sample No. (Population-Weighted %)[a]	Speech-Frequency HI, % (95% CI)[b]			High-Frequency HI, % (95% CI)[c]		
		Overall[d]	Unilateral[e]	Bilateral[f]	Overall[d]	Unilateral[e]	Bilateral[f]
Occupational noise exposure[h]							
No	2477 (63.7)	11.3 (9.0-14.1)	5.8 (4.5-7.5)	5.5 (4.1-7.3)	25.0 (22.7-27.6)	10.9 (9.1-12.9)	14.2 (12.8-15.7)
Yes							
Loud only (<5 y)	234 (6.3)	8.9 (4.9-15.6)	3.5 (1.3-9.1)	5.0 (3.0-9.6)	28.8 (20.2-39.2)	12.5 (7.9-19.2)	16.3 (11.0-23.4)
Loud only (≥5 y)	233 (6.3)	19.2 (12.2-29.0)	9.2 (4.6-17.7)	10.0 (6.7-14.7)	44.6 (37.7-51.7)	16.3 (9.5-26.6)	28.3 (20.8-37.3)
Very loud (<5 y)	406 (11.5)	14.4 (8.1-24.4)	5.5 (3.1-9.8)	8.9 (4.5-16.7)	33.6 (27.0-40.9)	12.9 (7.5-21.4)	20.7 (14.8-28.2)
Very loud (≥5 y)	427 (11.2)	30.7 (25.1-36.8)	12.8 (8.8-18.4)	17.8 (11.9-25.7)	56.7 (45.6-67.1)	13.9 (10.0-18.9)	42.8 (34.5-51.4)
Unknown	54 (1.0)	6.9 (2.7-16.6)	4.6 (1.5-13.4)	2.3 (0.5-10.8)	27.2 (13.7-46.7)	16.9 (6.6-37.0)	10.3 (4.6-21.4)
Very loud noise exposure outside of work[i]							
No	3359 (87.3)	13.6 (10.7-17.1)	6.2 (4.7-8.2)	7.3 (5.8-9.3)	30.2 (27.2-33.3)	11.8 (10.1-13.8)	18.3 (16.0-20.9)
Yes	470 (12.7)	18.1 (11.3-27.8)	9.4 (5.7-15.3)	8.6 (4.2-17.0)	37.0 (28.4-46.4)	12.4 (8.6-17.6)	24.6 (18.1-32.5)
Firearms, including use for recreation, job, or military							
No	2433 (54.3)	11.4 (9.1-14.2)	6.0 (4.5-8.0)	5.4 (4.3-6.8)	25.9 (23.5-28.6)	11.6 (10.1-13.2)	14.4 (12.7-16.3)
Yes	1395 (45.7)	17.3 (13.6-21.9)	7.3 (5.7-9.5)	10.0 (7.3-13.6)	37.1 (31.9-42.6)	12.3 (9.4-15.9)	24.8 (20.6-29.5)
Lifetime rounds fired (firearms)							
None	2433 (54.3)	11.4 (9.1-14.2)	6.0 (4.5-8.0)	5.4 (4.3-6.8)	25.9 (23.5-28.6)	11.6 (10.1-13.2)	14.4 (12.7-16.3)
<1000	977 (32.6)	14.0 (10.6-18.2)	6.0 (4.2-8.4)	8.0 (5.8-10.9)	32.2 (26.8-38.2)	10.1 (6.3-15.9)	22.1 (17.6-27.4)
≥1000	401 (12.9)	26.0 (19.7-33.4)	10.8 (8.4-13.7)	15.2 (9.4-23.6)	49.7 (40.2-59.2)	18.0 (13.1-24.2)	31.7 (22.5-42.6)

Abbreviations: HI, hearing impairment; HL, hearing level; NHANES, National Health and Nutrition Examination Survey; PTA, pure-tone average.

[a] The total number of US civilian, noninstitutionalized adults aged 20 to 69 y in the 2011-2012 NHANES was 196.6 million.

[b] Speech-frequency HI is defined as PTA of thresholds at 0.5, 1, 2, and 4 kHz greater than 25 decibels (dB) HL.

[c] High-frequency HI is defined as PTA of thresholds at 3, 4, and 6 kHz greater than 25 dB HL.

[d] Overall HI sums unilateral and bilateral HI, which means HI in either or both ears (ie, a worse-ear definition of HI).

[e] Unilateral HI means the PTA in only 1 ear exceeds 25 dB HL.

[f] Bilateral HI means the PTAs in both ears exceed 25 dB HL (ie, a better-ear definition of HI).

[g] Diabetes was defined by a positive response to the following questions: "Have you ever been told by a doctor or other health professional that you have diabetes or sugar diabetes?" or "Are you now taking diabetic pills to lower blood sugar?", or a 2-h fasting glucose level of 126 mg/dL or more (to convert to millimoles per liter, multiply by 0.0555).

[h] Occupational noise exposure is defined as: "exposed at work to loud sounds or noise for 4 or more hours, several days a week". In addition, separate categories distinguish adults who had only loud noise exposure at work ("so loud that they had to raise their voice to be heard") vs those who also had very loud noise exposure at work ("so loud that they had to shout to be understood by someone standing 3 feet away"); see complete wording of the question in the Methods section.

[i] Noise exposure outside of work is defined as: "Outside of a job, have you ever been exposed to very loud noise or music for 10 or more hours a week?" Examples are noise from power tools, lawn mowers, farm machinery, cars, trucks, motorcycles, motor boats, or loud music.

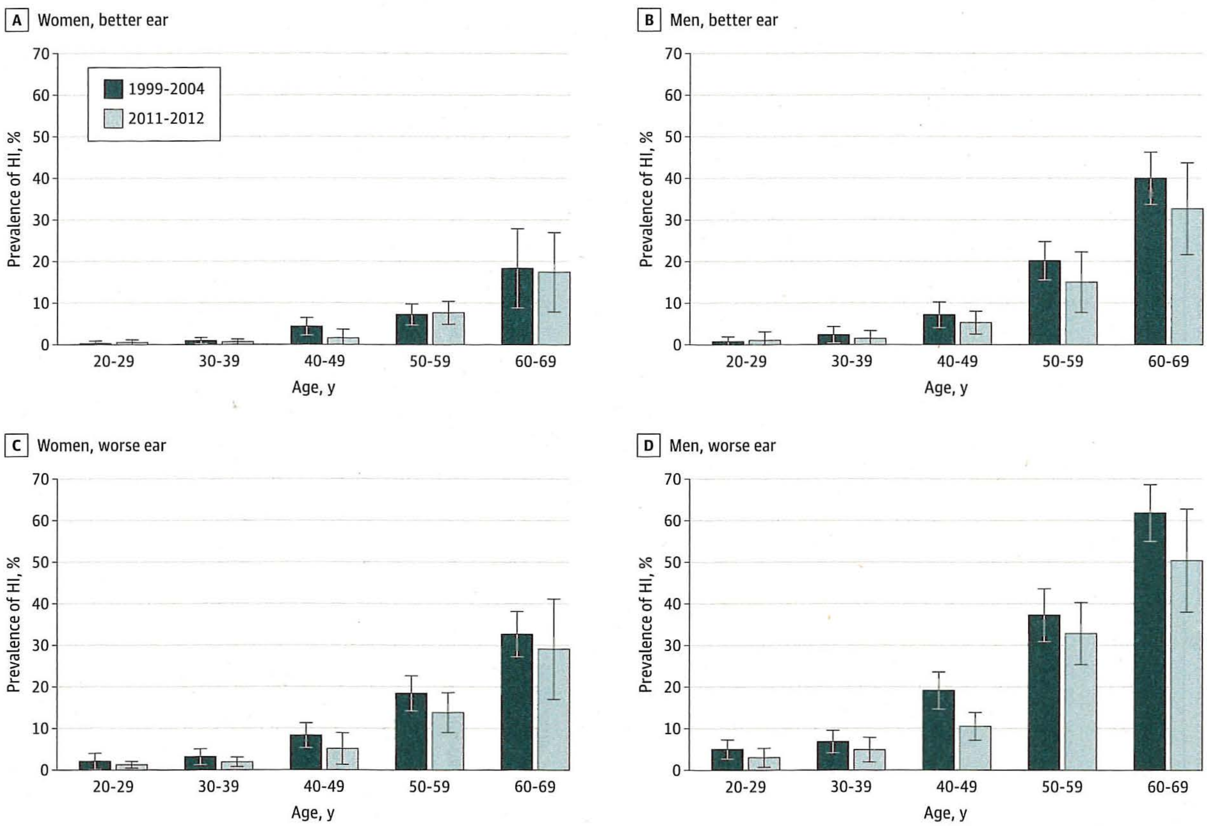
Table 2. Sex- and Age-Adjusted Odds Ratios of Hearing Impairment in the NHANES 2011-2012 vs the NHANES 1999-2004[a]

Ear	Pure-Tone Frequency (kHz)	Odds Ratio (95% CI)	*P* Value
Better	0.5	0.63 (0.41-0.96)	.03
	1	1.22 (0.88-1.70)	.23
	2	0.79 (0.60-1.05)	.10
	3	0.88 (0.71-1.09)	.23
	4	0.72 (0.60-0.88)	.002
	6	0.82 (0.69-0.98)	.03
	8	1.04 (0.80-1.37)	.75
	PTA of 0.5, 1, 2, and 4	0.75 (0.56-1.00)	.053
	PTA of 3, 4, and 6	0.78 (0.64-0.94)	.01
Worse	0.5	0.62 (0.50-0.76)	<.001
	1	0.94 (0.76-1.17)	.59
	2	0.78 (0.62-0.97)	.02
	3	0.85 (0.71-1.01)	.07
	4	0.81 (0.69-0.95)	.01
	6	0.84 (0.71-0.98)	.03
	8	1.19 (0.95-1.49)	.14
	PTA of 0.5, 1, 2, and 4	0.70 (0.56-0.86)	.001
	PTA of 3, 4, and 6	0.75 (0.65-0.88)	.001

Abbreviations: HL, hearing level; NHANES, National Health and Nutrition Examination Survey; PTA, pure-tone average.

[a] Hearing impairment was defined as a threshold or PTA greater than 25 dB HL.

Figure. Prevalence of Speech-Frequency Hearing Impairment (HI) by Age, NHANES 1999-2004 vs 2011-2012



Comparison of the prevalence of speech-frequency HI among adults for the 1999-2004 vs 2011-2012 cycles of the National Health and Nutrition Examination Survey (NHANES) by age. A, Women, better ear. B, Men, better ear. C, Women, worse ear. D, Men, worse ear. Vertical lines indicate 95% CIs.

2 time periods was sufficient to reduce slightly the number of adults aged 20 to 69 years with hearing loss. The continuing decline in the prevalence of HI in adults aged 20 to 69 years may represent delayed onset of age-related hearing loss. Audiometric testing of adults 70 years or older was not conducted during the 1999-2004 or 2011-2012 survey cycles, but

Table 3. Bilateral (Better-Ear) Speech-Frequency Hearing Impairment, US Adults Aged 20 to 69 Years, NHANES, 2011-2012[a]

Characteristic	Prevalence, % (95% CI)[b]	Odds Ratio (95% CI)		
		Unadjusted	Adjusted for Age and Sex	Adjusted for All Variables
Total	7.5 (5.8-9.6)	NA	NA	NA
Demographic Risk Factors				
Sex				
Male	9.9 (7.3-13.3)	2.0 (1.3-3.2)	2.4 (1.4-3.9)	1.8 (1.1-3.0)
Female	5.1 (3.6-7.3)	1 [Reference]	1 [Reference]	1 [Reference]
Age, y				
20-29	0.8 (0.3-2.3)	1 [Reference]	1 [Reference]	1 [Reference]
30-39	0.9 (0.4-2.1)	1.2 (0.3-4.6)	1.2 (0.3-4.6)	1.1 (0.3-4.4)
40-49	3.4 (2.1-5.6)	4.4 (1.3-15.4)	4.4 (1.3-15.3)	3.3 (0.8-13.3)
50-59	11.2 (7.5-16.6)	15.6 (4.2-58.2)	16.2 (4.4-59.9)	13.4 (2.8-63.5)
60-69	24.7 (20.2-29.9)	40.5 (13.4-122.3)	43.3 (14.5-128.9)	39.5 (10.5-149.4)
Race/ethnicity				
Non-Hispanic white	9.0 (7.1-11.5)	2.3 (1.4-3.8)	2.0 (1.2-3.1)	2.3 (1.3-3.9)
Non-Hispanic black	4.1 (2.7-6.2)	1 [Reference]	1 [Reference]	1 [Reference]
Mexican American	4.3 (3.3-5.7)	1.1 (0.7-1.8)	1.7 (1.1-2.7)	1.4 (0.8-2.3)
Non-Hispanic Asian	4.7 (2.8-7.8)	1.2 (0.6-2.2)	1.4 (0.8-2.6)	2.1 (1.1-4.2)
Other Hispanic	3.9 (1.9-7.7)	1.0 (0.4-2.1)	1.2 (0.6-2.2)	1.2 (0.6-2.3)
Other race/ethnicity	7.4 (2.3-21.2)	1.9 (0.5-6.8)	1.7 (0.7-4.2)	1.4 (0.6-3.3)
Educational level				
Less than high school	11.3 (8.5-14.8)	3.1 (1.8-5.3)	3.8 (2.2-6.7)	4.2 (2.1-8.5)
High school	9.5 (6.5-13.5)	2.5 (1.3-4.9)	3.0 (1.5-5.8)	2.8 (1.2-6.9)
Some college or associate degree	8.3 (5.5-12.4)	2.2 (1.2-4.2)	2.8 (1.5-5.3)	2.4 (1.2-4.9)
College graduate or higher	4.0 (2.6-6.0)	1 [Reference]	1 [Reference]	1 [Reference]
Cardiovascular Risk Factors				
Smoking status				
Nonsmoker	5.8 (4.2-7.9)	1 [Reference]	1 [Reference]	1 [Reference]
<20 pack-years	2.7 (1.6-4.6)	0.5 (0.2-0.9)	0.5 (0.3-1.0)	0.5 (0.2-1.0)
≥20 pack-years	14.6 (12.0-17.7)	2.8 (2.1-3.7)	1.5 (1.0-2.1)	1.0 (0.7-1.5)
Unknown	10.7 (4.2-24.9)	2.0 (0.7-5.7)	2.2 (0.7-7.0)	2.0 (0.6-6.2)
History of hypertension				
No	5.6 (4.1-7.6)	1 [Reference]	1 [Reference]	1 [Reference]
Yes	11.6 (9.1-14.7)	2.2 (1.6-3.0)	1.0 (0.7-1.4)	0.9 (0.6-1.3)
History of diabetes				
No	6.8 (5.1-8.9)	1 [Reference]	1 [Reference]	1 [Reference]
Yes	14.6 (12.0-17.6)	2.4 (1.7-3.3)	1.1 (0.8-1.6)	1.1 (0.7-1.7)
Noise Exposures				
Occupational				
No	5.5 (4.1-7.3)	1 [Reference]	1 [Reference]	1 [Reference]
Yes				
Loud only (<5 y)	5.4 (3.0-9.6)	1.0 (0.5-2.0)	1.2 (0.6-2.5)	1.0 (0.5-2.2)
Loud only (≥5 y)	10.0 (6.7-14.7)	1.9 (1.1-3.4)	1.5 (0.7-3.1)	1.2 (0.5-2.6)
Very loud (<5 y)	8.9 (4.5-16.7)	1.7 (0.8-3.4)	2.0 (0.9-4.5)	1.5 (0.7-3.3)
Very loud (≥5 y)	17.8 (11.9-25.7)	3.7 (2.1-6.7)	2.5 (1.4-4.5)	1.5 (0.9-2.7)
Unknown	2.3 (0.5-10.8)	0.4 (0.1-2.2)	0.4 (0.1-2.8)	0.5 (0.1-3.1)
Very loud noise exposure outside of work				
No	7.3 (5.8-9.3)	1 [Reference]	1 [Reference]	1 [Reference]
Yes	8.6 (4.2-17.0)	1.2 (0.6-2.5)	1.4 (0.7-2.8)	1.0 (0.6-1.7)

(continued)

Table 3. Bilateral (Better-Ear) Speech-Frequency Hearing Impairment, US Adults Aged 20 to 69 Years, NHANES, 2011-2012[a] (continued)

Characteristic	Prevalence, % (95% CI)[b]	Odds Ratio (95% CI)		
		Unadjusted	Adjusted for Age and Sex	Adjusted for All Variables
Firearms, including use for recreation, job, or military				
No	5.4 (4.3-6.8)	1 [Reference]	1 [Reference]	1 [Reference]
<1000 lifetime rounds fired	8.0 (5.8-10.9)	1.5 (1.1-2.1)	1.4 (0.9-2.1)	1.4 (0.8-2.2)
≥1000 lifetime rounds fired	15.2 (9.4-23.6)	3.1 (1.7-5.7)	2.4 (1.4-4.2)	1.8 (1.1-3.0)
Noise exposure based on all noise exposures except firearms[c]				
No noise	5.5 (4.1-7.3)	1 [Reference]	1 [Reference]	1 [Reference]
Loud job noise only	7.7 (5.5-10.7)	1.4 (0.9-2.4)	1.4 (0.8-2.5)	1.1 (0.6-2.0)
Loud and very loud job noise	12.2 (7.9-18.5)	2.4 (1.4-4.1)	2.0 (1.1-3.6)	1.4 (0.7-2.5)
Loud job noise, very loud job noise, and loud noise outside of work	15.6 (7.3-30.4)	3.2 (1.3-8.2)	3.2 (1.4-7.3)	2.1 (1.0-4.4)

Abbreviations: HI, hearing impairment; HL, hearing level; NA, not applicable; NHANES, National Health and Nutrition Examination Survey.

[a] Speech-frequency hearing impairment was defined by the pure-tone average of thresholds at 0.5, 1, 2, and 4 kHz greater than 25 decibels HL in the better ear.

[b] Percent weighted by SUDAAN.

[c] Included in a separate model in place of the following 3 variables: loud occupational noise, very loud occupational noise, and loud noise outside of work.

this group has a much higher prevalence of HI than any of the age groups shown in Table 1,[15,16] and their relative numbers are expected to continue growing rapidly.[17]

This finding of declining age-adjusted prevalence of HI, combined with both earlier reports showing improvement of hearing between 1959-1962 and 1999-2004,[1,16] and similar findings by others, such as the hearing loss studies conducted in Beaver Dam, Wisconsin,[18] suggests a beneficial trend that spans at least half a century. Explanations for this trend are speculative, but could include reduction in exposure to occupational noise (fewer manufacturing jobs, more use of hearing protection devices), less smoking, and better management of other cardiovascular risk factors, such as hypertension and diabetes. Less plausible explanations, especially for beneficial changes in the most recent decade, might include fewer ear infections that are managed better as well as improved diet.

Male sex and non-Hispanic white race/ethnicity continue to be significant risk factors for HI, even after accounting for risk factors that might be more prevalent in non-Hispanic white men, such as noise exposure. The typical noise exposures of men and women are different, especially at high levels of exposure.[19] Although we controlled for noise exposure and sex in the multivariable analyses, it remains possible the questions about noise exposure were inadequate to represent lifetime noise exposure, in which case there may have been residual confounding.[20,21] Despite this concern, we suspect there are major contributions that are genetic and probably not amenable to clinical intervention.[22-24] On the other hand, lower educational level is a risk factor for many adverse health outcomes and could be linked to less access to medical care in childhood, poorer diet, and other concomitant factors of lower socioeconomic status, including increased noise exposure.

Our finding of nonsignificance for cardiovascular risk factors and occupational noise in the fully adjusted model contrasts with the report by Agrawal et al.[25] This difference cannot be attributed to sample size (3831 for our study vs 3527 for the analysis by Agrawal et al[25]), but could be associated with better medical management of these risk factors in recent years, as well as more consistent use of hearing protection in industry.[26-29] Recreational shooting, which often occurs without hearing protection, remains a significant risk factor for speech-frequency and high-frequency HI, in both the better and worse ears. In this study, we analyzed lower (<1000 lifetime firearm rounds) and higher (≥1000 lifetime firearm rounds) gunfire exposure separately and found that only the higher exposure was associated with HI in the unadjusted and adjusted analyses (Table 3). Recall bias must be considered in all these analyses: for example, people who know they have HI could be more likely to remember and report high levels of recreational shooting or other use of firearms.

Limitations

One limitation of our study is the necessarily abbreviated NHANES questionnaires used for exposure to occupational and recreational noise as well as other risk factors. One can question their adequacy for capturing information on noise exposure across the adult lifespan. We doubt this problem is sufficient to invalidate our findings when comparing results from NHANES 2011-2012 with 1999-2004,[14] since the questions about noise exposure and other risk factors were similar. An innovation in the 2011-2012 questionnaire was the distinction between exposure to loud ("need to speak in a raised voice to be heard/understood") vs very loud ("need to shout to be heard/understood") noise. Associations by degree and extent of noise exposure are evident, illustrating face validity between self-reported exposure and expected increases in prevalence and risk estimates.

Age, even after adjustment for other risk factors thought to be important, has the strongest association with HI, although the Figure suggests a different pattern of age-related hearing loss for men and women, with earlier age of onset and more pronounced HI for men. These differences may have a genetic basis; alternatively, they could be in part attributable, despite our adjustment for self-reported noise exposure, to more sustained exposure to higher-intensity noise in men.

Another question regarding the higher prevalence of HI in men vs women is whether there have been relative changes during this period: is the gap widening or closing? The overall prevalence of speech-frequency HI for men was 21.2% (17.9 million) in 1999-2004[14] and 18.6% (16.1 million) in 2011-2012

Table 4. Bilateral (Better-Ear) High-Frequency Hearing Impairment, US Adults Aged 20 to 69 Years, NHANES, 2011-2012[a]

Characteristic	Prevalence, % (95% CI)[b]	Odds Ratio (95% CI)		
		Unadjusted	Adjusted for Age and Sex	Adjusted for All Variables
Total	19.1 (16.6-21.9)	NA	NA	NA
Demographic Risk Factors				
Sex				
Male	27.6 (23.0-32.8)	3.2 (2.3-4.5)	4.8 (3.3-6.9)	3.8 (2.7-5.4)
Female	10.6 (8.6-13.0)	1 [Reference]	1 [Reference]	1 [Reference]
Age, y				
20-29	2.1 (1.0-4.2)	1 [Reference]	1 [Reference]	1 [Reference]
30-39	3.0 (1.7-5.3)	1.5 (0.6-3.8)	1.5 (0.5-3.9)	1.2 (0.5-3.4)
40-49	14.7 (11.0-19.4)	8.1 (3.8-17.3)	8.7 (4.3-17.8)	6.9 (3.3-14.2)
50-59	30.8 (25.2-37.1)	21.1 (8.8-50.4)	25.3 (11.1-57.8)	20.5 (8.7-48.6)
60-69	50.1 (43.7-58.5)	49.4 (20.4-119.7)	68.3 (28.2-165.5)	63.6 (24.8-163.4)
Race/ethnicity				
Non-Hispanic white	21.4 (18.7-24.5)	2.1 (1.5-2.9)	1.9 (1.3-2.6)	2.2 (1.5-3.1)
Non-Hispanic black	11.7 (9.3-14.6)	1 [Reference]	1 [Reference]	1 [Reference]
Mexican American	15.1 (12.5-18.0)	1.3 (1.0-1.9)	2.4 (1.7-3.5)	2.0 (1.3-3.1)
Non-Hispanic Asian	13.9 (10.0-18.4)	1.2 (0.8-1.9)	1.5 (1.4-3.4)	2.4 (1.6-3.6)
Other Hispanic	16.8 (11.9-23.2)	1.5 (0.9-2.5)	2.2 (1.4-3.4)	2.4 (1.4-4.0)
Other race/ethnicity	21.6 (13.1-33.5)	2.1 (1.1-3.8)	2.2 (1.2-4.2)	1.9 (1.0-3.5)
Educational level				
Less than high school	28.2 (24.2-32.6)	2.3 (1.6-3.3)	3.2 (1.9-5.4)	2.9 (1.7-4.9)
High school	25.1 (21.8-28.7)	2.0 (1.3-2.9)	2.4 (1.5-4.0)	2.2 (1.3-3.6)
Some college or associate degree	16.3 (12.1-21.6)	1.1 (0.8-1.7)	1.5 (0.9-2.3)	1.2 (0.7-2.0)
College graduate or higher	14.6 (11.4-18.4)	1 [Reference]	1 [Reference]	1 [Reference]
Cardiovascular Risk Factors				
Smoking status				
Nonsmoker	14.8 (11.9-18.3)	1 [Reference]	1 [Reference]	1 [Reference]
<20 pack-years	13.1 (8.7-19.1)	0.9 (0.5-2.0)	1.0 (0.5-2.0)	0.9 (0.4-1.8)
≥20 pack-years	34.8 (31.2-38.5)	3.1 (2.1-3.7)	1.5 (1.0-2.1)	1.1 (0.8-1.6)
Unknown	12.6 (7.1-21.4)	0.8 (0.4-1.7)	0.7 (0.3-1.6)	0.6 (0.3-1.2)
History of hypertension				
No	14.2 (11.9-17.9)	1 [Reference]	1 [Reference]	1 [Reference]
Yes	29.6 (26.2-33.3)	2.5 (2.1-3.1)	1.1 (0.9-1.4)	1.0 (0.8-1.4)
History of diabetes				
No	17.0 (15.0-19.2)	1 [Reference]	1 [Reference]	1 [Reference]
Yes	39.5 (30.2-49.6)	3.2 (2.2-4.7)	1.6 (1.0-2.5)	1.5 (0.9-2.6)
Noise Exposures				
Occupational				
No	14.2 (12.8-15.7)	1 [Reference]	1 [Reference]	1 [Reference]
Yes				
Loud only (<5 y)	16.3 (11.0-23.4)	1.2 (0.7-1.9)	1.2 (0.7-2.1)	1.0 (0.6-1.9)
Loud only (≥5 y)	28.3 (20.8-37.3)	2.4 (1.5-3.8)	1.7 (0.9-3.3)	1.3 (0.7-2.5)
Very loud (<5 y)	20.7 (14.8-28.2)	1.6 (1.1-2.3)	1.7 (1.0-2.8)	1.3 (0.8-2.3)
Very loud (≥5 y)	42.8 (34.5-51.4)	4.5 (3.2-6.3)	2.8 (1.9-4.0)	2.0 (1.3-2.9)
Unknown	10.3 (4.6-21.4)	0.7 (0.3-1.7)	0.7 (0.2-3.3)	0.8 (0.3-2.5)
Very loud noise exposure outside of work				
No	18.3 (16.0-20.9)	1 [Reference]	1 [Reference]	1 [Reference]
Yes	24.6 (18.1-32.5)	1.5 (1.0-2.1)	1.7 (1.1-2.7)	1.4 (0.9-2.2)

(continued)

Table 4. Bilateral (Better-Ear) High-Frequency Hearing Impairment, US Adults Aged 20 to 69 Years, NHANES, 2011-2012[a] (continued)

Characteristic	Prevalence, % (95% CI)[b]	Odds Ratio (95% CI) Unadjusted	Adjusted for Age and Sex	Adjusted for All Variables
Firearms, including use for recreation, job, or military				
No	14.4 (12.7-16.3)	1 [Reference]	1 [Reference]	1 [Reference]
<1000 lifetime rounds fired	22.1 (17.6-27.4)	1.7 (1.3-2.2)	1.4 (0.9-2.1)	1.4 (0.9-2.3)
≥1000 lifetime rounds fired	31.7 (22.5-42.6)	2.8 (1.6-4.7)	1.5 (1.0-2.5)	1.3 (0.7-2.3)
Noise exposure based on all noise exposures except firearms[c]				
No noise	14.2 (12.8-15.7)	1 [Reference]	1 [Reference]	1 [Reference]
Loud job noise only	22.3 (17.3-28.3)	1.7 (1.2-2.5)	1.5 (0.9-2.5)	1.2 (0.7-1.9)
Loud and very loud job noise	30.1 (23.7-37.4)	2.6 (2.0-3.5)	2.0 (1.4-2.9)	1.5 (1.0-2.3)
Loud job noise, very loud job noise, and loud noise outside of work	34.1 (24.3-45.5)	3.1 (2.0-5.0)	2.9 (1.6-5.0)	2.4 (1.4-4.2)

Abbreviations: HI, hearing impairment; HL, hearing level; NA, not applicable; NHANES, National Health and Nutrition Examination Survey.

[a] High-frequency hearing impairment is defined by the pure-tone average of thresholds at 3, 4, and 6 kHz greater than 25 decibels HL in the better ear.

[b] Percent weighted by SUDAAN.

[c] Included in a separate model in place of the following 3 variables: loud occupational noise, very loud occupational noise, and loud noise outside of work.

(Table 1), an 11.4% decline. Changes for women were similar: speech-frequency HI was 10.9% (9.7 million) in 1999-2004[14] and 9.6% (8.4 million) in 2011-2012, a 12.7% decline. Hence, there was no difference in relative decline of the prevalence of HI between men and women.

Conclusions

No intervention has yet been shown to prevent the progression of age-related hearing loss. Hearing aids can improve speech communication, but they are not used by most people with hearing loss.[30,31] Several studies, including in countries that subsidize the cost of hearing aids, have demonstrated many barriers to the use of hearing aids other than cost: self-perceived disability, self-perceived likelihood of benefit or lack of benefit, and comfort and appearance of the hearing aid.[32,33] Reducing obstacles to use of hearing aids through educating patients about the importance of amplification, training health care professionals to understand and overcome patients' perceived barriers, improving the quality and affordability of hearing aid devices, and increasing access to hearing health services[34-37] are important public health objectives in view of the high prevalence of hearing loss in the US adult population.

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