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RESEARCH ARTICLE

Hearing Disability Prevalence and Risk Factors in Two Recent National Surveys

Chuan-Ming Li, MD, PhD,[1] Guixiang Zhao, MD, PhD,[2] Howard J. Hoffman, MA,[1] Machell Town, PhD,[2] Christa L. Themann, MA, CCC-A[3]

Introduction: Hearing loss is a worldwide societal and public health concern. Globally, disabling hearing loss affects 538 million adults (men, 12.2%; women, 9.8%). This study examined the prevalence and risk factors associated with deafness or serious difficulty hearing in two nationally representative surveys.

Methods: Data were analyzed in 2017 from the 2016 Behavioral Risk Factor Surveillance System (BRFSS) and the 2014 National Health Interview Survey. The BRFSS collected data through telephone interviews. The 2014 National Health Interview Survey collected face-to-face household interview data that included a hearing health supplement in the Sample Adult Core. Both surveys asked adults aged ≥18 years the disability question on deafness or serious difficulty hearing as defined by the American Community Survey. Weighted prevalence, prevalence ratios, and 95% CIs were calculated. Logistic regression was used to adjust for sociodemographic and geographic characteristics.

Results: Prevalence of deafness or serious difficulty hearing was 5.8% (BRFSS) and 6.0% (National Health Interview Survey); males had a 60% higher prevalence than females. The prevalence was significantly associated with increasing age, lower educational level and income, and was higher among non-Hispanic whites than among non-Hispanic blacks and Hispanics. Deafness or serious difficulty hearing was strongly associated with increasing degree of self-reported trouble hearing in the National Health Interview Survey. The BRFSS state-specific prevalence varied from 3.8% to 13.3%, with higher prevalence in the most public health–challenged states according to America's Health Rankings.

Conclusions: The prevalence of deafness or serious difficulty hearing was approximately 6% in the National Health Interview Survey and BRFSS, but increased considerably for older, less advantaged individuals and in more public health–challenged states.

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INTRODUCTION

Hearing loss is highly prevalent and represents a worldwide societal and public health issue. About half a billion people globally have disabling hearing loss.[1,2] Hearing loss is associated with increased risk for falls, dementia, depression, and other conditions that contribute to poor health status and increased years lived with disability.[3–7] Adult-onset hearing loss is the second leading cause of years lived with disability in high-income countries.[7] Based on audiometric exams with the hearing loss criterion of

From the [1]Epidemiology and Statistics Program, Division of Scientific Programs, National Institute on Deafness and Other Communication Disorders, NIH, Bethesda, Maryland; [2]Population Health Surveillance Branch, Division of Population Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia; and [3]Hearing Loss Prevention Team, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Cincinnati, Ohio

Address correspondence to: Chuan-Ming Li, MD, PhD, Epidemiology and Statistics Program, National Institute on Deafness and Other Communication Disorders, NIH, 6001 Executive Boulevard, Suite 8300, Bethesda MD 20892. E-mail: chuan-ming.li@nih.gov.

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better ear, pure-tone average of four speech-frequency thresholds (0.5, 1, 2, and 4 kHz) ≥20 dB HL (hearing level), an estimated 1.33 billion adults have mild or worse hearing loss.[7]

Older adults are disproportionately affected, with 36% of adults (males 46%, females 27%) aged 65–74 years having hearing loss defined by better ear pure-tone threshold averages >25 dB HL.[8] A recent U.S. study compared hearing loss from 1999–2004 to 2011–2012, based on nationally representative samples of adults aged 20–69 years, and found that sex- and age-specific hearing loss prevalences decreased over time.[9] In spite of the reduced prevalence, Americans are living longer and the currently observed reduction in sex- and age-specific adult hearing loss likely represents delayed onset.[10] Hence, the number of older adults with hearing loss is expected to increase because of aging of the Baby Boomer generation and increasing life expectancy.[11]

In 2008, the American Community Survey implemented six questions for reporting disability.[12–14] These questions have been included in the National Health Interview Survey (NHIS), as part of the Family Disability Questions File, since 2009. The hearing disability question in the Behavioral Risk Factor Surveillance System (BRFSS) was included for the first time in the 2016.

The purpose of this study is to compare estimates of deafness or serious difficulty hearing for U.S. adults based on the 2016 BRFSS and the 2014 NHIS. This study also examines risk associations with sociodemographic factors; other hearing health indicators (NHIS only); and geography (regions and states).

METHODS

Study Sample

The BRFSS is an annual, cross-sectional, state-based telephone survey of non-institutionalized adults residing in the U.S. Data on health risk behaviors, chronic health conditions, healthcare access, and use of clinical preventive services are collected from all 50 states and the District of Columbia. Responses are collected from the sampled person and not through proxy except in rare circumstances. The BRFSS consists of core questions, optional modules that include questions on specific topics, and state-added questions. The 2016 BRFSS included the American Community Survey–defined deafness or serious difficulty hearing question in the core section. Detailed information can be found in the BRFSS 2016 Summary.[15] In 2016, a total of 486,303 adults completed interviews; the state median response rate was 49%. The BRFSS was reviewed by the Human Research Protection Office at the Centers for Disease Control and Prevention, and determined to be exempt research.

The NHIS is the principal source of information on the health of the civilian, non-institutionalized population of the U.S. and is conducted annually by the National Center for Health Statistics, Centers for Disease Control and Prevention. Information from the Sample Adult File; Family Disability Questions File (FDB); Household File; Person File; and Imputed Income File was used in this study. Information about deafness or serious difficulty hearing is included in the FDB, which is administered to a random half sample of respondents in the Person File.[16] Information from the Household, Person, and FDB Files is provided by the family respondent who is not necessarily the sample adult. Sample adults are a randomly selected subset of adults in the Person File (one per family); information in the Sample Adult File is collected from the sample adult himself or herself. The FDB has its own weight, which was used to calculate prevalence estimates.

In 2014, the National Institute on Deafness and Other Communication Disorders, NIH, supported an expanded set of hearing health questions in the NHIS, the Hearing Supplement (HS), which was included on the Sample Adult Core. The first question in the 2014 NHIS-HS asked respondents to rate their hearing ability. In addition, respondents were asked to rank themselves on the Gallaudet Functional Hearing Scale.[17] Both scales are subjective evaluations of hearing ability and were developed circa 1970 as proxy measures in lieu of audiometric exams that could not be implemented in the NHIS. Detailed information about the 2014 NHIS is available in the Survey Description.[16] The 2014 adult questionnaire was completed by 36,697 adults with a final response rate of 58.9%.[16]

The NHIS adheres to Section 308(d) of the Public Health Service Act (42 U.S.C. 242m), which forbids disclosure of any information that may compromise the confidentiality promised to survey respondents. This study is exempt from IRB review because it used de-identified data that are publicly available.

Measures

Using data from the 2016 BRFSS and the 2014 NHIS, this study has examined the prevalence of deafness or serious difficulty hearing by sex, race/ethnicity, age, education, annual family income, geographic region, and state (BRFSS only). The BRFSS asked, *Are you deaf or do you have serious difficulty hearing?* The 2014 NHIS asked the identical question except that it allowed for proxy responses when the family respondent was not the sample person.

The 2014 NHIS-HS was selected to compare responses on the deafness or serious difficulty hearing question with other self-reported hearing health questions: (1) *Have been told you have a hearing problem by friends or relatives?* (2) *Ever used a hearing aid?* (3) *How is your hearing, without using a hearing aid or other amplification device?* Response options: *excellent, good, a little trouble, moderate trouble, a lot of trouble hearing,* and *deaf*. (4) Gallaudet Functional Hearing Scale: *From across a quiet room, without seeing the face of the speaker, are you*: (i) *Able to hear and understand whispering?* If *no*, then (ii) *Talking in a normal voice?* If *no*, then (iii) *Shouting?*[13] (5) *Have trouble hearing when there is background noise?* (6) *Feel frustrated with your hearing when talking to friends or relatives?* Further information about the NHIS-HS questions is available at the website.[16]

Statistical Analysis

The Sample Adult File, FDB, Household File, Person File, and Imputed Income Files were merged. Weighted prevalence estimates were calculated as percentages with 95% CIs using the FDB weight. Logistic regression models were used to estimate prevalence ratios

(PRs) in lieu of ORs, as ORs become increasingly biased estimates of relative risk when prevalences exceed 10%, as occurred for older age categories and self-reported hearing health–related questions.[18–20]

Statistical analyses were performed using SAS, version 9.4, and SUDAAN®, version 11.0, to calculate national estimates and CIs while accounting for the complex sampling designs. Variances used Taylor series approximation for 95% CI estimates. The FDB weight was used in the logistic regression to predict deafness or serious difficulty hearing in the NHIS. Analyses were adjusted for sociodemographic and geographic characteristics.

RESULTS

Among 42,195 NHIS adults in the Family Disability Question File, 669 (1.6%) did not provide valid responses for the hearing disability question and were treated as missing. Among 477,665 BRFSS adults, there were 14,070 (2.9%) who did not have a valid response and were also treated as missing. There were no differences in sex and age between those who did or did not provide valid responses. Weighted, adjusted prevalence estimates for deafness or serious difficulty hearing in the 2016 BRFSS are presented in Table 1. Among adults aged ≥18 years, the prevalence was 5.8% (14.0 million). Males had higher prevalence, 7.2% (95% CI=7.0%, 7.4%), than females, 4.5% (95% CI=4.3%, 4.6%). The adjusted PRs showed that prevalence was significantly higher for non-Hispanic (NH) American Indian/Alaska Native population compared with NH white, whereas the NH white adjusted prevalence was significantly higher compared with NH black and NH Asian. The adjusted prevalence was higher for adults who had not completed high school, whereas adults completing college or more years of education had significantly lower prevalence. The prevalence increased almost exponentially with age, rising from 1.6% for young adults aged 18–29 years to 23.4% for the oldest adults aged ≥80 years, and decreased linearly with annual family income from 8.6% for income <$20,000 to 3.2% for income ≥$75,000. The Northeast region had the lowest prevalence whereas the South had the highest.

The comparison of results from the 2016 BRFSS and the 2014 NHIS provided an opportunity to investigate the empirical validity of the response to deafness or serious difficulty hearing in the NHIS in comparison with their self-reported trouble hearing status (Table 2). The percentages of adults with trouble hearing status were as follows: a little trouble (11.1%); moderate trouble (4.2%); a lot of trouble hearing (2.3%); and deaf (0.3%). However, the contribution to the deafness or serious difficulty hearing sample adults from each of the trouble hearing categories was more evenly distributed: a little trouble 387 (27.8%); moderate trouble 388 (30.5%); a lot of trouble hearing 380 (26.8%)—except for the self-reported deaf 48 (4.5%). Hence, individuals reported as having deafness or serious difficulty hearing represent a broad spectrum of trouble hearing, with nearly the same percentage (26.8% to 30.5%) contributed from the three categories: a little trouble, moderate trouble, or a lot of trouble hearing, whereas the relative contribution from the self-reported deaf was much smaller.

The overall prevalence of deafness or serious difficulty hearing was 6.0% (14.1 million) among adults aged ≥18 years in the 2014 NHIS. Males had higher prevalence, 7.3% (95% CI=6.8%, 7.8%), than females, 4.8% (95% CI=4.5%, 5.2%). The prevalence by sociodemographic characteristics and geographic region, as well as the adjusted PRs, for the 2014 NHIS are presented in Table 3. Prevalence of deafness or serious difficulty hearing was significantly higher in NH white compared with Hispanic, NH black, and NH Asian. The prevalence decreased with increasing level of education. The prevalence increased sharply with age from 1.2% for young adults aged 18–29 years to 31.5% for older adults aged ≥80 years. However, for annual family income, the prevalence decreased linearly from 8.7% for income <$20,000 to 3.8% for income ≥$75,000. Prevalence was lowest in the Northeast and highest in the South.

Further evidence of empirical validity for the deafness or serious difficulty hearing question was provided by comparison to the NHIS-HS hearing health questions (Table 3). The prevalence increased with increasing degree of reported trouble hearing. Similar increases in prevalence were seen for increasing levels of the Gallaudet Functional Hearing Scale. The prevalence was higher among those who had been told by friends or relatives they had a hearing problem and much higher if they had ever used a hearing aid. As the frequency of "hearing trouble when background noise is present" increased, so did the prevalence of those who reported deafness or serious difficulty hearing. The prevalence approximately doubled with each level of frustration with their hearing when talking to friends and relatives. The highest prevalence was when they "always" felt frustrated when talking to friends or relatives.

In the 2014 NHIS, there were 27.8% of the sample who reported deaf or serious difficulty hearing and also reported having only a little trouble hearing, whereas 10.5% more reported having good or excellent hearing (Table 2). Given this incongruity, a restricted subsample of individuals who were reported as deaf or had serious difficulty hearing and also reported as having either moderate trouble hearing, a lot of trouble hearing, or who were deaf were analyzed separately. Thus, individuals who reported their hearing as excellent or good or a little trouble hearing were excluded before calculating the PRs shown in the last column of Table 3. Comparing the PRs for the total sample with the subsample showed increased PRs for male sex and age, but negligible differences for race/ethnicity, education, family income, or region. The

Table 1. Weighted Prevalence and Adjusted Prevalence Ratios of Deafness or Serious Difficulty Hearing, 2016 BRFSS

Characteristics[a]	Sample, *n* (weighted %)	Weighted prevalence		Adjusted PR[b] (95%CI)
		% (95% CI)	*p*-value	
All	**463,595**	**5.8 (5.7, 5.9)**		
Sex			<0.001	
Men	201,050 (48.7)	7.2 (7.0, 7.4)		**1.89 (1.81, 1.97)*** **
Women	262,494 (51.3)	4.5 (4.3, 4.6)		1.00 (ref)
Age group, years			<0.001	
18–29	46,876 (20.8)	1.6 (1.4, 1.8)		1.00 (ref)
30–39	50,110 (17.3)	2.0 (1.8, 2.2)		**1.39 (1.20, 1.61)*** **
40–49	58,707 (15.9)	3.3 (3.0, 3.6)		**2.33 (2.03, 2.67)*** **
50–59	88,946 (17.4)	5.5 (5.2, 5.8)		**3.70 (3.27, 4.20)*** **
60–69	109,033 (15.3)	9.0 (8.6, 9.3)		**5.86 (5.20, 6.59)*** **
70–79	72,064 (9.0)	14.0 (13.4, 14.6)		**8.64 (7.66, 9.76)*** **
≥80	37,859 (4.3)	23.4 (22.4, 24.4)		**13.73 (12.15, 15.51)*** **
Race/ethnicity			<0.001	
Non-Hispanic white	358,319 (63.2)	6.7 (6.5, 6.8)		1.00 (ref)
Non-Hispanic black	37,221 (11.6)	3.9 (3.6, 4.3)		**0.61 (0.55, 0.67)*** **
Hispanic	31,708 (15.4)	4.2 (3.9, 4.7)		**0.72 (0.65, 0.79)*** **
Non-Hispanic American Indian/Alaska Native	6,958 (0.9)	10.4 (9.1, 11.9)		**1.55 (1.36, 1.76)*** **
Asian	9,497 (5.1)	2.3 (1.7, 3.1)		**0.57 (0.43, 0.77)*** **
Non-Hispanic other	11,943 (2.0)	6.9 (6.1, 7.9)		**1.29 (1.13, 1.47)*** **
Education			<0.001	
<High school diploma	34,889 (13.6)	9.4 (8.8, 10.0)		**1.77 (1.64, 1.91)*** **
High school diploma	129,767 (28.0)	6.5 (6.3, 6.7)		**1.39 (1.31, 1.47)*** **
Some college	127,744 (31.1)	5.5 (5.3, 5.7)		**1.35 (1.27, 1.43)*** **
≥College degree	169,819 (26.9)	3.6 (3.5, 3.8)		1.00 (ref)
Income			<0.001	
<$20,000	67,595 (15.5)	8.6 (8.2, 9.0)		**2.14 (1.98, 2.33)*** **
$20,000–<$35,000	78,694 (16.7)	7.4 (7.0, 7.7)		**1.74 (1.60, 1.88)*** **
$35,000–<$50,000	56,679 (11.5)	5.7 (5.4, 6.0)		**1.39 (1.28, 1.51)*** **
$50,000–<$75,000	63,447 (12.8)	4.8 (4.5, 5.1)		**1.26 (1.16, 1.37)*** **
≥$75,000	124,761 (28.2)	3.2 (3.0, 3.4)		1.00 (ref)
Region[c]			<0.001	
Northeast	93,461 (17.7)	4.9 (4.7, 5.2)		1.00 (ref)
Midwest	112,736 (21.1)	5.9 (5.7, 6.2)		**1.15 (1.08, 1.22)*** **
South	156,036 (37.9)	6.4 (6.2, 6.6)		**1.28 (1.20, 1.36)*** **
West	101,362 (23.3)	5.4 (5.1, 5.7)		**1.17 (1.09, 1.26)*** **

Note: Boldface indicates statistical significance (***$p<0.001$) compared to the ref groups.
[a]Some variables had missing data: sex (n=51); race/ethnicity (n=7,949); education (n=1,376); and income (n=72,419).
[b]Adjusted for all other variables listed in the table.
[c]Northeast region includes Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont; Midwest region includes Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin; South region includes Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia; West region includes Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.
BRFSS, Behavioral Risk Factor Surveillance System; PR, prevalence ratio.

PR differences were significantly greater in comparing across the hearing health questions (e.g., for ever having used a hearing aid or having trouble hearing when there is background noise).

The adjusted PR of deafness or serious difficulty hearing for males compared with females was 1.9 (95% CI=1.8, 2.0) for the 2016 BRFSS and 1.8 (95% CI=1.6, 1.9) for the 2014 NHIS. Adjusted PRs increased substantially with each decade of life after age 40 years, increasing from 1.4 (BRFSS) or 1.3 (NHIS) for individuals aged 30–39 years to 13.7 (BRFSS) or 25.4 (NHIS) for adults aged ≥80 years (Tables 1 and 3). The largest PR

Table 2. Weighted Percentage of Deafness or Serious Difficulty Hearing by Self-reported Hearing Status, 2014 NHIS

Reported hearing acuity (without a hearing aid or other amplification device)	Total sample number,[a] *n* (weighted %)	Deaf or have serious difficulty hearing	
		Yes, *n* (weighted %)	No, *n* (weighted %)
Total	18,391 (100.0)	1,343 (100.0)	17,048 (100.0)
Excellent	8,947 (49.4)	47 (3.7)	8,900 (52.9)
Good	6,080 (32.7)	93 (6.8)	5,987 (34.7)
A little trouble	2,076 (11.1)	387 (27.8)	1,689 (9.8)
Moderate trouble	790 (4.2)	388 (30.5)	402 (2.2)
A lot of trouble	449 (2.3)	380 (26.8)	69 (0.4)
Deaf	49 (0.3)	48 (4.5)	1 (0.0)

[a]The total sample number consisted of those who reported hearing status from the Sample Adult File and hearing disability ("deafness or serious difficulty hearing") from the Family Disability Questions File.
NHIS, National Health Interview Survey.

increases occurred in the 2014 NHIS in association with self-reported trouble hearing. The prevalence of deafness or serious difficulty hearing for adults with excellent hearing was 0.5% compared with 82.0% for adults with a lot of trouble hearing and 99.9% for deaf. Other hearing health variables in Table 3 that reflected increased hearing difficulty also had greatly increased PRs.

Weighted prevalence of deafness or serious difficulty hearing by state from the 2016 BRFSS is shown in Table 4. Prevalence estimates ranged from the lowest, 3.8% and 3.9% in Illinois and New York, respectively, to the highest, 10.5% and 13.3% in Kentucky and West Virginia, respectively. West Virginia had the highest prevalence for both males, 17.0%, and females, 9.9%. Seven states had prevalence estimates for males that were at least double the prevalence estimates for females: four were contiguous states in the Midwest or West, Nebraska (male 8.3%, female 4.0%); South Dakota (10.3%, 5.0%); Wyoming (12.7%, 5.6%); and Montana (13.2%, 6.1%), whereas the other three states adjoin each other in the South, Alabama (9.9%, 4.7%); Louisiana (7.6%, 3.2%); and Texas (7.4%, 3.3%). The lowest male-to-female PRs were in the District of Columbia (4.0%, 4.6%) and Alaska (5.8%, 4.9%).

DISCUSSION

The estimated prevalence of deafness or serious difficulty hearing in adults aged 18 years and older was 6.0% (14.1 million) in the 2014 NHIS and 5.8% (14.0 million) in the 2016 BRFSS. Higher prevalence estimates were observed for males, NH whites, those not completing high school, or with family income less than $20,000. Prevalence increased greatly with age and decreased with higher levels of education and family income. These findings are consistent with other recent reports.[9,21]

Hearing disability is strongly linked to age. This study found 67% of those who reported deafness or serious difficulty hearing were aged 60 years and older, which is consistent with earlier reports based on National Health and Nutrition Examination Survey audiometric exams.[8] Older adults with age-related hearing loss are expected to increase in the U.S. due to the aging population of Baby Boomers as well as the expected increase in life span.[9,11] A number of adverse outcomes (e.g., cognitive decline, depression, falls) are associated with hearing loss and increase as the severity worsens.

Hispanic and NH black adults have higher overall prevalence of disability than NH whites.[22–24] By contrast, the prevalence of hearing loss is lower among Hispanic and NH black adults than among NH whites,[25–27] which is consistent with findings in the present study. The difference between NH white and NH black adults exist even after adjustment for noise exposure and SES.[28] Some studies have suggested black individuals have significantly greater cochlear melanin content than white individuals, which may underlie the decreased risk of age-related hearing loss observed in epidemiologic studies.[29] The physiological basis for racial/ethnic differences remains under study.

Both the 2014 NHIS and 2016 BRFSS showed higher prevalence of deafness or serious difficulty hearing in the South and lower prevalence in the Northeast. States in the East South Central (Alabama, Kentucky, Mississippi, and Tennessee) and West Virginia had the highest prevalence of deafness or serious difficulty hearing. This finding is in line with the 2016 America's Health Rankings Annual Report, which analyzed a comprehensive set of behaviors, community, environmental, and other factors to provide a holistic view of the nation's health. The East South Central subregion is at or near the top of the list of Most Public Health Challenged States in the 2016 annual report; for example, Mississippi ranked 50th on the list of healthiest states, Alabama 47th, Kentucky 45th, Tennessee 44th, and West Virginia 43rd.[30]

Table 3. Weighted Prevalence and Adjusted Prevalence Ratios of Deafness or Serious Difficulty Hearing, 2014 NHIS

Characteristics	Sample[a] *n* (weighted %)	Weighted prevalence		Adjusted PR (95% CI)[b]	
		% (95% CI)	*p*-value	Full sample	Sub-sample[c]
All	41,339 (100.0)	6.0 (5.7, 6.3)			
Socio-demographic and geographic characteristics					
Sex			<0.001		
Male	19,531 (48.2)	7.3 (6.8, 7.8)		**1.75 (1.60, 1.93)*****	**1.85 (1.66, 2.06)*****
Female	21,808 (51.8)	4.8 (4.5, 5.2)		ref	ref
Age, years			<0.001		
18–29	8,500 (21.4)	1.2 (0.9, 1.5)		ref	ref
30–39	7,232 (16.8)	1.3 (1.1, 1.7)		1.27 (0.94, 1.72)	**1.60 (1.13, 2.27)*****
40–49	7,293 (17.1)	2.3 (1.9, 2.8)		**2.26 (1.68, 3.03)*****	**2.81 (1.95, 4.04)*****
50–59	7,597 (18.2)	5.2 (4.6, 5.9)		**4.80 (3.69, 6.25)*****	**6.62 (4.80, 9.12)*****
60–69	5,704 (14.0)	10.0 (9.0, 11.1)		**8.78 (6.88, 11.21)*****	**12.53 (9.14, 17.18)*****
70–79	3,204 (8.0)	17.0 (15.3, 18.8)		**14.02 (10.84, 18.13)*****	**18.92 (13.86, 25.81)*****
≥80	1,809 (4.5)	31.5 (28.7, 34.4)		**25.40 (19.67, 32.79)*****	**38.89 (28.66, 52.76)*****
Race/ethnicity			<0.001		
Hispanic	7,898 (15.0)	3.7 (3.2, 4.3)		**0.70 (0.60, 0.83)*****	**0.68 (0.56, 0.82)*****
Non-Hispanic black	5,107 (11.6)	3.9 (3.3, 4.5)		**0.63 (0.53, 0.74)*****	**0.54 (0.44, 0.66)*****
Non-Hispanic white	24,532 (65.9)	7.1 (6.1, 6.9)		ref	ref
Non-Hispanic Asian	2,702 (5.4)	3.7 (2.9, 4.7)		**0.72 (0.57, 0.91)****	**0.68 (0.53, 0.89)****
Non-Hispanic American Indian /Alaska Native	282 (0.5)	6.5 (4.1, 10.3)		1.02 (0.65, 1.59)	1.18 (0.74, 1.86)
Non-Hispanic other	818 (1.6)	4.0 (2.6, 6.1)		0.84 (055, 1.27)	0.80 (0.49, 1.31)
Education			<0.001		
<High school diploma	5,312 (11.1)	9.8 (8.8, 10.9)		**1.60 (1.34, 1.90)*****	**1.63 (1.34, 1.97)*****
High school diploma	12,153 (28.8)	6.9 (6.4, 7.5)		**1.36 (1.18, 1.56)*****	**1.38 (1.18, 1.61)*****
Some college	12,323 (30.1)	5.5 (5.0, 6.1)		**1.38 (1.19, 1.61)*****	**1.42 (1.19, 1.68)*****
≥College degree	11,011 (28.6)	4.1 (3.6, 4.6)		ref	ref
Family income			<0.001		
<$20,000	6,896 (15.5)	8.7 (7.8, 9.6)		**1.67 (1.43, 1.97)*****	**1.48 (1.23, 1.77)*****
$20,000–<$35,000	6,802 (15.7)	8.8 (7.9, 9.8)		**1.49 (1.29, 1.72)*****	**1.41 (1.20, 1.66)*****
$35,000–<$50,000	5,770 (13.8)	5.9 (5.2, 6.8)		1.15 (0.99, 1.35)	1.13 (0.94, 1.35)
$50,000–<$75,000	7,284 (17.5)	5.9 (5.2, 6.7)		**1.25 (1.06, 1.47)****	**1.24 (1.04, 1.47)****
≥$75,000	14,587 (37.5)	3.8 (3.4, 4.2)		ref	ref
Region[d]			0.024		
Northeast	6,784 (17.3)	5.0 (4.4, 5.7)		ref	ref
Midwest	8,391 (22.8)	6.0 (5.4, 67)		**1.19 (1.01, 1.40)***	1.18 (0.99, 1.41)
South	14,379 (37.7)	6.4 (5.9, 7.0)		**1.35 (1.18, 1.56)*****	**1.29 (1.11, 1.51)*****
West	11,785 (22.2)	6.1 (5.4, 6.9)		**1.37 (1.17, 1.61)** ***	**1.35 (1.13, 1.60)*****
Hearing health questions					
Have been told you have a hearing problem by friends or relatives			<0.001		
Yes	2,948 (15.8)	33.9 (31.8, 36.0)		**11.41 (9.53, 13.66)*****	**26.97 (19.89, 36.68)*****
No	15,419 (84.2)	1.9 (1.6, 2.2)		ref	ref
Ever used a hearing aid			<0.001		
Yes	827 (4.4)	72.7 (68.5, 76.4)		**12.32 (10.67, 14.23)*****	**24.04 (19.47, 29.68)*****
No	17,564 (95.6)	4.0 (3.7, 4.4)		ref	ref
Reported hearing acuity (without a hearing aid or other amplification device)			<0.001		
Excellent	8,947 (49.4)	0.5 (0.4, 0.8)		ref	
Good	6,080 (32.7)	1.5 (1.2, 1.9)		**2.21 (1.42, 3.41)*****	
A little trouble	2,076 (11.1)	17.7 (15.8, 19.8)		**23.22 (15.67, 34.41)*****	

(continued on next page)

Table 3. Weighted Prevalence and Adjusted Prevalence Ratios of Deafness or Serious Difficulty Hearing, 2014 NHIS *(continued)*

Characteristics	Sample[a] *n* (weighted %)	Weighted prevalence		Adjusted PR (95% CI)[b]	
		% (95% CI)	*p*-value	Full sample	Sub-sample[c]
Moderate trouble	790 (4.2)	51.0 (46.5, 55.4)		**64.82 (43.86, 95.82)*****	
A lot of trouble	449 (2.3)	82.0 (77.3, 85.9)		**112.88 (77.83, 163.70)*****	
Deaf	49 (0.3)	99.9 (92.4, 100.0)		**157.06 (109.25, 225.80)*****	
Gallaudet Functional Hearing Scale			<0.001		
(a) Can hear and understand whispering from across a quiet room without seeing face of speaker	14,541 (35.2)	2.3 (2.0, 2.7)		ref	ref
(b) If "no" to (a): Can hear and understand talking in a normal voice across a quiet room without seeing face of speaker	2,639 (6.1)	15.6 (14.0, 17.4)		**3.75 (3.18, 4.42)*****	**6.03 (4.56, 7.98)*****
(c) If "no" to (a) and (b): Can hear and understand shouting across a quiet room without seeing face of person shouting	683 (1.6)	54.0 (49.0, 59.0)		**12.33 (10.18, 14.94)*****	**29.18 (21.83, 39.02)*****
(d) If "no" to (a), (b), and (c)	260 (0.6)	70.5 (63.4, 76.8)		**17.04 (13.50, 21.52)*****	**43.87 (31.33, 61.43)*****
Have trouble hearing when there is background noise			<0.001		
Never	10,201 (55.9)	1.3 (1.0, 1.6)		ref	ref
Seldom	4,074 (22.0)	3.7 (3.1, 4.6)		**2.29 (1.73, 3.03)*****	**5.41 (2.88, 10.16)*****
About half the time	1,735 (9.4)	17.2 (15.0, 19.6)		**7.78 (6.13, 9.87)*****	**23.79 (13.78, 41.07)*****
Usually	1,256 (6.8)	24.4 (21.6, 27.4)		**10.83 (8.60, 13.63)** ***	**39.43 (23.05, 67.45)*****
Always	1,092 (5.7)	38.0 (34.4, 41.7)		**17.17 (13.83, 21.31)*****	**72.53 (43.36, 121.33)*****
Feel frustrated with your hearing when talking to friends or relatives			<0.001		
Never	5,760 (60.6)	5.1 (4.5, 5.8)		ref	ref
Seldom	2,072 (22.9)	14.3 (12.5, 16.3)		**2.38 (1.97, 2.87)*****	**3.17 (2.37, 4.2)*****
About half the time	805 (8.4)	30.4 (26.3, 34.7)		**4.72 (3.88, 5.75)*****	**8.07 (6.11, 10.65)*****
Usually	453 (4.4)	45.3 (39.5, 51.2)		**6.69 (5.48, 8.18)*****	**12.55 (9.46, 16.66)*****
Always	331 (3.3)	70.1 (63.2, 76.2)		**10.83 (9.17, 12.89)*****	**22.79 (17.85, 29.10)*****

Note: Boldface indicates statistical significance (*$p<0.05$; **$p<0.01$; ***$p<0.001$) compared to the ref groups.
[a]Subjects with missing data for any sociodemographic variables were omitted from the analysis.
[b]The prevalence ratio was computed by conducting multivariable-adjusted logistic regression analyses. Two separate analyses were conducted: one analysis was conducted for sociodemographic variables that included age, sex, race/ethnicity, education, income, and region in the model; the other analysis was conducted for hearing-related variables, which included corresponding hearing variable plus above sociodemographic variables in the model.
[c]The participants who reported both "deaf or had serious difficulty hearing" and "Excellent" or "Good" or "A little trouble hearing" were excluded from this analysis.
[d]Northeast region includes Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont; Midwest region includes Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin; South region includes Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia; West region includes Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.
NHIS, National Health Interview Survey; PR, prevalence ratio.

The prevalences of deafness or serious difficulty hearing for males were more than twofold higher than for females in seven states: Alabama, Louisiana, Montana, Nebraska, North Dakota, Texas, and Wyoming. The reasons for the wide gender gap in these states requires further investigation.

The strengths of this study include the large sample sizes that are statistically representative of the U.S. population.

Table 4. Weighted Prevalence of Deafness or Serious Difficulty Hearing by State and Sex, 2016 BRFSS

	All adults		Men		Women	
States	*n*	% (95% CI)	*n*	% (95% CI)	*n*	% (95% CI)
All	**463,595**	**5.8 (5.7, 5.9)**	**201,050**	**7.2 (7.0, 7.4)**	**262,494**	**4.5 (4.3, 4.6)**
Alabama	6,854	7.2 (6.5, 8.0)	2,731	9.9 (8.6, 11.4)	4,123	4.7 (4.1, 5.5)
Alaska	2,843	5.3 (4.3, 6.7)	1,335	5.8 (4.3, 7.7)	1,508	4.9 (3.5, 6.8)
Arizona	10,642	7.5 (6.9, 8.3)	4,423	9.0 (8.0, 10.2)	6,219	6.1 (5.3, 7.1)
Arkansas	5,165	9.1 (7.9, 10.4)	1,943	12.0 (10.0, 14.2)	3,222	6.3 (5.1, 7.8)
California	10,814	4.7 (4.2, 5.2)	5,177	5.2 (4.5, 6.1)	5,636	4.1 (3.5, 4.8)
Colorado	13,779	4.5 (4.1, 4.9)	6,254	5.3 (4.7, 6.0)	7,524	3.6 (3.2, 4.1)
Connecticut	10,760	5.0 (4.5, 5.5)	4,616	6.1 (5.3, 7.0)	6,144	4.0 (3.5, 4.6)
Delaware	3,963	6.5 (5.7, 7.5)	1,765	7.7 (6.3, 9.2)	2,198	5.5 (4.4, 6.8)
District of Columbia	3,803	4.3 (3.6, 5.2)	1,570	4.0 (3.2, 5.1)	2,227	4.6 (3.5, 5.9)
Florida	35,617	6.1 (5.7, 6.6)	15,035	7.4 (6.7, 8.2)	20,579	4.9 (4.4, 5.5)
Georgia	5,216	5.2 (4.6, 6.0)	2,131	6.6 (5.5, 7.9)	3,084	4.0 (3.3, 4.8)
Hawaii	7,879	6.4 (5.7, 7.2)	3,674	7.5 (6.4, 8.7)	4,204	5.3 (4.4, 6.5)
Idaho	5,101	4.4 (3.8, 5.0)	2,131	5.6 (4.6, 6.7)	2,970	3.2 (2.5, 4.0)
Illinois	4,648	3.8 (3.3, 4.4)	2,043	4.6 (3.8, 5.7)	2,605	3.0 (2.4, 3.8)
Indiana	10,787	5.1 (4.6, 5.7)	4,445	6.1 (5.4, 7.0)	6,342	4.2 (3.5, 4.9)
Iowa	7,077	6.5 (5.9, 7.1)	3,130	8.0 (7.1, 9.1)	3,946	4.9 (4.2, 5.8)
Kansas	11,694	7.0 (6.5, 7.6)	5,146	9.1 (8.3, 10.1)	6,545	5.0 (4.4, 5.6)
Kentucky	10,071	10.5 (9.7, 11.3)	4,110	13.1 (11.8, 14.6)	5,961	7.9 (7.1, 8.9)
Louisiana	5,092	5.4 (4.7, 6.2)	1,907	7.6 (6.4, 9.1)	3,185	3.2 (2.6, 4.0)
Maine	9,825	6.3 (5.7, 7.1)	4,187	8.5 (7.3, 9.7)	5,638	4.4 (3.7, 5.1)
Maryland	17,865	4.1 (3.7, 4.5)	7,307	4.9 (4.2, 5.6)	10,558	3.4 (3.0, 3.8)
Massachusetts	8,111	5.8 (5.1, 6.6)	3,808	6.7 (5.6, 7.8)	4,302	4.9 (4.1, 5.9)
Michigan	11,748	7.1 (6.5, 7.7)	5,233	8.1 (7.3, 9.0)	6,515	6.2 (5.5, 6.9)
Minnesota	16,430	6.0 (5.6, 6.4)	7,773	7.7 (7.1, 8.4)	8,657	4.4 (3.9, 4.9)
Mississippi	5,039	9.1 (8.1, 10.2)	1,929	11.8 (10.1, 13.8)	3,109	6.6 (5.7, 7.8)
Missouri	6,987	6.8 (6.0, 7.6)	3,001	8.5 (7.3, 9.9)	3,983	5.1 (4.3, 6.0)
Montana	5,885	9.7 (8.8, 10.7)	2,677	13.2 (11.7, 14.9)	3,206	6.1 (5.1, 7.2)
Nebraska	14,912	6.1 (5.6, 6.6)	6,517	8.3 (7.5, 9.1)	8,395	4.0 (3.5, 4.6)
Nevada	4,265	7.0 (6.0, 8.1)	1,928	8.1 (6.7, 9.8)	2,337	5.9 (4.7, 7.4)
New Hampshire	6,283	6.8 (6.1, 7.6)	2,796	8.2 (7.1, 9.6)	3,487	5.4 (4.6, 6.4)
New Jersey	7,413	5.3 (4.6, 6.0)	3,183	6.2 (5.2, 7.5)	4,230	4.4 (3.6, 5.3)
New Mexico	5,873	7.5 (6.6, 8.4)	2,539	8.5 (7.2, 9.9)	3,334	6.5 (5.4, 7.8)
New York	32,709	3.9 (3.5, 4.3)	14,404	4.7 (4.1, 5.4)	18,305	3.2 (2.7, 3.7)
North Carolina	6,410	5.9 (5.3, 6.7)	2,918	7.3 (6.3, 8.4)	3,489	4.7 (3.9, 5.6)
North Dakota	5,584	4.8 (4.2, 5.5)	2,547	6.3 (5.3, 7.3)	3,037	3.4 (2.7, 4.3)
Ohio	12,142	6.8 (6.2, 7.5)	5,040	8.5 (7.4, 9.6)	7,102	5.3 (4.6, 6.1)
Oklahoma	6,771	9.4 (8.6, 10.2)	2,742	12.0 (10.7, 13.4)	4,029	6.8 (6.0, 7.9)
Oregon	5,181	5.5 (4.9, 6.2)	2,305	7.3 (6.2, 8.5)	2,870	3.7 (3.1, 4.5)
Pennsylvania	6,658	5.3 (4.6, 6.0)	3,082	6.7 (5.7, 7.9)	3,576	3.9 (3.2, 4.8)
Rhode Island	5,323	5.6 (4.9, 6.4)	2,182	7.0 (5.8, 8.3)	3,141	4.4 (3.6, 5.3)
South Carolina	10,987	7.0 (6.4, 7.7)	4,512	8.9 (7.9, 10.0)	6,475	5.3 (4.6, 6.0)
South Dakota	5,690	7.7 (6.6, 8.8)	2,455	10.3 (8.6, 12.4)	3,235	5.0 (4.1, 6.2)
Tennessee	5,976	7.7 (6.9, 8.6)	2,545	9.5 (8.2, 11.1)	3,429	6.0 (5.2, 7.0)
Texas	11,327	5.3 (4.6, 6.2)	4,648	7.4 (6.2, 8.9)	6,679	3.3 (2.6, 4.1)
Utah	10,704	5.2 (4.8, 5.8)	4,964	6.4 (5.7, 7.2)	5,724	4.1 (3.5, 4.7)
Vermont	6,379	6.4 (5.7, 7.1)	2,822	7.6 (6.6, 8.9)	3,557	5.2 (4.4, 6.1)
Virginia	8,815	5.6 (5.1, 6.2)	3,832	6.9 (6.0, 7.8)	4,983	4.4 (3.8, 5.1)
Washington	13,958	5.5 (5.1, 5.9)	6,280	6.9 (6.3, 7.7)	7,678	4.1 (3.6, 4.6)

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Table 4. Weighted Prevalence of Deafness or Serious Difficulty Hearing by State and Sex, 2016 BRFSS *(continued)*

	All adults		Men		Women	
States	*n*	**% (95% CI)**	*n*	**% (95% CI)**	*n*	**% (95% CI)**
West Virginia	7,065	13.3 (12.5, 14.3)	3,117	17.0 (15.6, 18.5)	3,948	9.9 (8.9, 10.9)
Wisconsin	5,037	5.8 (5.0, 6.7)	2,287	7.3 (6.1, 8.7)	2,750	4.4 (3.4, 5.6)
Wyoming	4,438	9.2 (8.1, 10.5)	1,924	12.7 (10.9, 14.8)	2,514	5.6 (4.4, 7.1)

BRFSS, Behavioral Risk Factor Surveillance System.

In addition, the BRFSS provided estimates of deafness or serious difficulty hearing by individual states, which have not been reported previously.

Limitations

This study has several limitations. Information based on self-report in the two surveys may be less accurate than that based on objective physical measurements.[31,32] Because responses to deafness or serious difficulty hearing are subjective, the potential for bias exists. However, several large epidemiologic studies have reported good sensitivity for self-reported hearing measures overall.[33,34] In addition, despite general limitations associated with self-reported information, the BRFSS data have been found to provide reliable and valid estimates on most health outcomes[35] that are comparable with those from other national health surveys, including the NHIS and the National Health and Nutrition Examination Survey.[36] These results demonstrate that prevalence estimates from the BRFSS correspond well with those from the NHIS, except for people aged 70 years and older who had a reduced prevalence of reported hearing disability. This lower prevalence of deafness or serious difficulty hearing in the BRFSS among older adults could have resulted from the BRFSS being conducted entirely via telephone, unlike the NHIS that is conducted by U.S. census workers in face-to-face household interviews. However, the overall similarity in the estimates of deafness or serious difficulty hearing between the two surveys provides reassurance that the telephone modality of the BRFSS did not substantially affect the overall prevalence of reported hearing disability.

CONCLUSIONS

The prevalence of deafness or serious difficulty hearing in U.S. adults is approximately 6% and is considerably higher in the most public health challenged states based on America's Health Rankings. Higher prevalence is associated with males, older age, NH white race, lower education, and family income. These findings indicate the need to investigate further the underlying causes of hearing loss and to promote prevention efforts and rehabilitative services for individuals and communities disproportionately affected by hearing disability.

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