

# Tinnitus prevalence, associated characteristics, and related healthcare use in the United States: a population-level analysis

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## Summary

**Background** Tinnitus is a potentially disabling condition with few treatments. We examined the prevalence and characteristics of tinnitus among demographic groups in the United States (US) and assessed associated factors and tinnitus-related healthcare.

**Methods** We included adults with and without bothersome tinnitus from the nationally representative 2014 National Health Interview Survey (NHIS; raw n = 36,697), the latest year with tinnitus data. We evaluated tinnitus prevalence and characteristics (frequency, severity, duration) overall and among groups defined by sex and race/ethnicity. Logistic regression with adjusted Wald tests were used for comparisons in NHIS-weighted populations by sex and race/ethnicity, and to evaluate associations between demographic/medical characteristics and noise exposure on tinnitus risk.

**Findings** The US prevalence of tinnitus was 11.2% (95% CI: 10.8%, 11.7%; ~27 million people) in 2014. Of those with tinnitus, 41.2% always had symptoms and 28.3% had  $\geq 15$  years symptom duration; the rates were significantly higher among men vs. women and non-Hispanic (nHW) vs. Hispanic Whites (HW), Blacks, or other ethnicity. Significantly more women vs. men and HW vs. nHW reported severe tinnitus. Sex and race/ethnicity, except Asian, were not significantly associated with tinnitus when age, otologic/medical disorders, and noise exposure were included in the model. Significantly lower rates of all minority groups discussed tinnitus with a doctor compared to nHW, and among those who did, Blacks were significantly less likely to receive tinnitus evaluation than nHWs.

**Interpretation** Tinnitus prevalence varies across US demographic groups and racial differences were identified in the delivery of tinnitus-related healthcare.

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**Keywords:** Tinnitus; Hearing loss; Prevalence; Health care equity; United States; National health interview survey; Otologic healthcare

## Introduction

Tinnitus is the perception of phantom sound without an acoustic stimulus, often experienced as buzzing or ringing.<sup>1</sup> The symptoms of tinnitus can range in severity from mild to disabling.<sup>1,2</sup> Bothersome tinnitus negatively impacts sleep quality, concentration, and conversational speech, and has been associated with a higher risk of anxiety and depression.<sup>3–5</sup> Additionally, tinnitus imposes tremendous clinical and economic burdens on patients and health systems, as demonstrated by

tinnitus being the top compensated disability among United States (US) veterans in 2023.<sup>6</sup> There is no cure for tinnitus and the limited available therapies have heterogeneous efficacy and little to no insurance coverage in the US.<sup>7</sup>

Tinnitus is hypothesized to be triggered by damage of cochlear cells via loud noise, ototoxicity, aging, or other insults, and to be durably encoded in the brain.<sup>1</sup> It is strongly associated with other otologic disorders like hearing loss and hyperacusis which have similar

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### Research in context

#### Evidence before this study

Tinnitus, the perception of phantom sound, can present without hearing loss but is often present among those with hearing loss. In severe cases, tinnitus may profoundly impact quality of life. The primary form of tinnitus is subjective; therefore, prevalence estimates rely on self-report survey data. We performed a review of the literature in PubMed, Medline/OVID, and Google Scholar including the terms “tinnitus” AND “prevalence” AND “United States,” “tinnitus” AND “healthcare utilisation”, “tinnitus” AND “healthcare”, as well as “prevalence” and demographic groups in the United States (US) surveyed in the National Health Interview Survey (NHIS). Prior estimates of the prevalence of tinnitus in the US ranged widely from 4 to 30% depending on the population, region, and definition of tinnitus, but were rarely conducted among diverse populations representative of US demographics. Non-Hispanic Whites composed the majority of survey population samples in the US. Thus, estimates of the overall burden of tinnitus in the US, which have been most commonly performed historically, receive the largest contribution from this demographic group and may not reflect the burden of tinnitus among minority groups. Additionally, tinnitus is the least-studied otologic disorder in terms of healthcare equity. Therefore, we used a large (n > 36,500) nationally representative dataset of US adults in the 2014 NHIS, the latest year for which tinnitus data were collected, to analyse tinnitus prevalence, characteristics, and related healthcare by sex and among the main racial/ethnic groups in the US.

#### Added value of this study

We found that the overall prevalence of tinnitus was 11.2%, representing 26.9 million people in 2014, higher than the

estimate of 9.6% using 2007 NHIS data. The overall prevalence of tinnitus was driven by non-Hispanic Whites (13%), and prevalence among other groups ranged from ~14% among American Indian/Alaskan Native or multiple race groups to 4% among Asians. The burden of bothersome tinnitus was more profound among women vs. men overall, and among Hispanic Whites compared to non-Hispanic Whites. With the exception of Asian ethnicity, sex and race/ethnicity were not significantly associated with tinnitus when age, otologic/medical conditions, and noise exposure history were included in a multinomial regression model. Significant, potentially preventable factors included hearing loss, occupational and recreational noise exposure, firearm use, smoking, and comorbidities like arthritis and high cholesterol. Multiple racial differences were identified in the seeking and delivery of otologic care for tinnitus, including significantly lower proportions of all minority groups who discussed tinnitus with a healthcare provider in comparison with non-Hispanic Whites. Further, significantly fewer Black respondents received referrals for tinnitus evaluations, even if they did discuss it, compared with non-Hispanic Whites.

#### Implications of all the available evidence

Tinnitus imposes a substantial burden across demographic groups in the US. However, women and Hispanic Whites report higher rates of severe tinnitus, while Black individuals with tinnitus may be under-served in the clinical treatment of the disorder. The current estimated prevalence of bothersome tinnitus in the 2014 NHIS data is higher than the last estimate using 2007 NHIS data, suggesting an increase in overall prevalence in the US.

pathological origins in the inner ear<sup>8</sup>; some forms of tinnitus (i.e., migraine-associated) are thought to be of central origin.<sup>9</sup> Tinnitus can be a warning sign of sensorineural hearing loss (SNHL) following noise exposure<sup>10</sup> and, although age-related hearing decline is unavoidable, noise-induced SNHL and tinnitus may be prevented via the use of hearing protection.<sup>11</sup> Tinnitus is historically reported to be more common among men vs. women,<sup>12,13</sup> and non-Hispanic Whites compared to other racial/ethnic groups,<sup>3,14</sup> although few studies have examined this question in depth or using nationally-representative datasets.<sup>15</sup> A recent meta-analysis by Jarach and colleagues on the global prevalence of tinnitus observed no difference in the prevalence between men and women, and a strong association with increasing age.<sup>15</sup> To reduce the burden of tinnitus in the US and accelerate research into treatments, there is a need to identify associated characteristics and prevalence across US demographic groups.

Understanding areas of health inequity is also of great importance and is considered an ethical duty of the US

government and healthcare providers.<sup>16,17</sup> The identification and mitigation of such disparities is the focus of the US *Healthy People 2030* initiative to improve health and well-being,<sup>16</sup> and is a key mission of the American Medical Association towards ensuring healthcare equality.<sup>17</sup> However, this topic is greatly understudied in otology and there is limited research that could raise awareness, particularly for invisible disorders like tinnitus. A 2021 systematic review of studies examining health disparities in otology identified tinnitus as the least-represented condition, with just 1.9% of articles discussing it.<sup>18</sup>

Herein, we examine the prevalence, experience, and healthcare related to tinnitus by race/ethnicity and sex using a large (n = 36,697) nationally representative dataset from the 2014 US National Health Interview Survey (NHIS), the most recent year with tinnitus data. Additionally, we describe and compare the characteristics of people with and without tinnitus to identify differential factors which could be incorporated into a logistic regression model evaluating characteristics associated with tinnitus.

## Methods

### Data source

This cross-sectional study included adults (age 18–85 years) in the 2014 NHIS Sample Adult file dataset (raw  $n = 36,697$ ).<sup>19</sup> The demographic composition of the dataset is nationally representative of the domestic US population ([Supplementary Table S1, eMethods](#)). Datasets were acquired from the US Centers for Disease Control and Prevention including the NHIS strata, primary sampling units, and person weights.<sup>20</sup> All NHIS participants provided consent before survey participation. Ethical approval was not required because NHIS data are publicly available for analysis and anonymized.

### Populations

Analyzed groups included respondents with and without tinnitus and hearing loss, and groups defined by sex and race/ethnicity ([Supplementary Figure S1](#)). The population with bothersome tinnitus included those who responded “yes” to: “During the past 12 months, have you been bothered by ringing, roaring, or buzzing in your ears or head that lasts 5 minutes or more?” (raw  $n = 4514$ ). All other respondents composed the population without tinnitus ( $n = 32,183$ ; i.e., answered “no” [ $n = 32,136$ ] or could not be ascertained/refused/didn’t know [ $n = 47$ ]). The survey defined hearing loss as unassisted hearing self-rated worse than “good,” or rated “good” with worse hearing in one ear. For questions analyzed by race/ethnicity, respondents with releasable race were classified into mutually exclusive groups: non-Hispanic White, Hispanic White, Black/African American (Black), American Indian or Alaska Native (AIAN), Asian, or multiple race. A group ‘Other’ was used (e.g., pooling AIAN, multiple race, unreported race) if the raw sample size of a group was  $<50$  for a question. Those with unreported race were included in the analyses of overall prevalence.

### Outcomes

The main outcome was self-reported bothersome tinnitus and the secondary outcome was hearing loss, as defined above. Refer to [Supplementary eMethods](#) for descriptions of survey questions.

### Sample characteristics

Survey responses were used to describe the demographic (e.g., age, sex, race, US census region); medical (e.g., conditions, smoking); and employment characteristics, as well as noise exposure history, of the weighted populations with and without tinnitus. Age was summarized as the cohort mean and by age category (i.e., 18–29 years, 30–39 years, etc.). Characteristics that significantly differed between these populations ( $p < 0.05$ ) were considered for inclusion in the logistic regression model of factors associated with tinnitus. Unassisted hearing quality and age of hearing loss onset

were evaluated for the populations with hearing loss, with and without tinnitus.

### Tinnitus prevalence

NHIS sample design weights were applied to the raw sample sizes to obtain representative prevalence statistics in the weighted population ([Supplementary eMethods](#)). After weighting, prevalence was estimated as the proportion positively reporting tinnitus among the entire population (overall) and among groups defined by sex and race/ethnicity. Population-level estimates were suppressed if the relative standard error was  $>30\%$  of the proportion or if the unweighted (raw) group sample size was  $<50$ .<sup>21,22</sup> The prevalence of tinnitus among males and females within the racial/ethnic groups was reported when feasible.

### Tinnitus characteristics

Among respondents reporting tinnitus, symptom frequency, severity, and duration were summarized overall and by sex, and among race/ethnicity groups in the weighted populations.

### Otologic healthcare

Among respondents with tinnitus, the proportions who had ever discussed their tinnitus with a healthcare provider (HCP), were referred for tinnitus evaluation in the past 5 years, and had tried tinnitus remedies were summarized overall and by sex and race/ethnicity in the weighted populations. Additionally, the proportions with tinnitus and hearing loss who visited a HCP about hearing problems, were referred to an audiologist/otolaryngologist, and ever received a hearing test from a specialist were summarized. Potential barriers to tinnitus healthcare were analyzed among racial/ethnic groups, including use of the internet for health information, concern about healthcare affordability, and ability to afford a specialist.

### Statistics

Complex sampling design was accounted for by using NHIS sample weights in all analyses. Demographic and medical characteristics of the weighted populations with and without tinnitus were compared with Adjusted Wald  $\chi^2$  tests and reported using counts, proportions, and 95% confidence intervals (CIs). Tinnitus prevalence was reported in the weighted population as proportions and 95% CIs and compared between groups by sex and race/ethnicity (vs. non-Hispanic Whites) using logistic regression with adjusted Wald tests.

Associations between tinnitus and sex and race/ethnicity were examined by multinomial logistic regression adjusted for variables associated with tinnitus in this study or the literature (i.e., age, hearing loss, dizziness/imbalance, hyperacusis, high cholesterol, arthritis, noise exposure, and smoking).<sup>23</sup> Relative risk ratios with 95% CIs were reported. The area under

the receiver operating characteristic curve (AUC) was estimated to examine the goodness of fit of the model.<sup>24</sup> A  $p < 0.05$  was considered statistically significant. Data curation and analyses were performed using Stata (v17.0, StataCorp) and Excel (v2306, Microsoft).

### Role of the funding source

The funders had no role in any part of the study's conduct or manuscript preparation.

## Results

### Characteristics of respondents with and without tinnitus

Of 36,697 total NHIS survey respondents, 4514 reported tinnitus and 32,183 did not report tinnitus (raw Ns, prior to weighting). The sample selection is illustrated in [Supplementary Figure S1](#) and cohort characteristics are compared in the weighted population in [Supplementary Table S2](#).

#### Demographics

The US region and age distribution of those with and without tinnitus significantly differed ([Fig. 1a](#) and [b](#), respectively), and people with tinnitus were on average older than those without tinnitus (mean age: 54.1 [53.4, 54.9] vs. 46.1 [45.7, 46.4] years, respectively;  $p = 0.001$ ) ([Supplementary Table S3](#)). The mean ages of males and females with tinnitus were not significantly different overall or across racial groups, except among Asians (males: 49.1 [44.8, 53.5] vs. females: 56.5 [51.5, 61.6] years;  $p = 0.002$ ).

#### Medical and hearing characteristics

The cohorts with and without tinnitus significantly differed in terms of their smoking history ([Fig. 1c](#)) and the presence of multiple medical conditions, including hypertension, high cholesterol, arthritis, and asthma (all  $p < 0.0001$ ) ([Fig. 1d](#)). Notably, significantly more people with tinnitus reported hearing loss (59.7% vs. 16.7% without tinnitus), hyperacusis (19.8% vs. 4.1%), dizziness/imbalance (39.8% vs. 11.6%), and migraine within the past 3 months (29.1% vs. 13.0%; all  $p < 0.001$ ) ([Fig. 1e](#)). Significantly more people with tinnitus reported all levels of hearing loss compared to those without tinnitus ([Supplementary Figure S2a](#)), with only 18.6% of respondents with tinnitus rating their hearing as 'excellent' as compared with 54.5% of those without tinnitus.

Among respondents with hearing loss, significantly more people with tinnitus reported their age of hearing loss onset to be 20–29 years or 30–39 years (both  $p = 0.02$ ) ([Supplementary Figure S2b](#)). The highest proportion of respondents with tinnitus attributed their hearing loss to noise exposure (39.0% [35.5%, 40.5%]) while those without tinnitus attributed it to aging (33.3% [31.6%, 35.1%]).

#### Noise exposure history

The noise exposure history of people with and without tinnitus is presented in [Supplementary Table S5](#). Significantly more respondents with vs. without tinnitus reported very loud occupational noise exposure (43.0% vs. 18.9%;  $p < 0.0001$ ). Among those with exposure, respondents with tinnitus generally reported longer exposure duration. The use of hearing protection at work was inconsistent for both groups. A similar trend was observed for non-occupational very loud noise exposure  $\geq 10$  times/year (35.7% with tinnitus vs. 19.3% without tinnitus;  $p < 0.0001$ ). Over half of people with tinnitus had ever used firearms (54.5%), significantly more than those without tinnitus (34.3%;  $p < 0.0001$ ). Additionally, people with tinnitus generally estimated a higher number of total lifetime rounds fired than those without tinnitus.

#### US prevalence of tinnitus

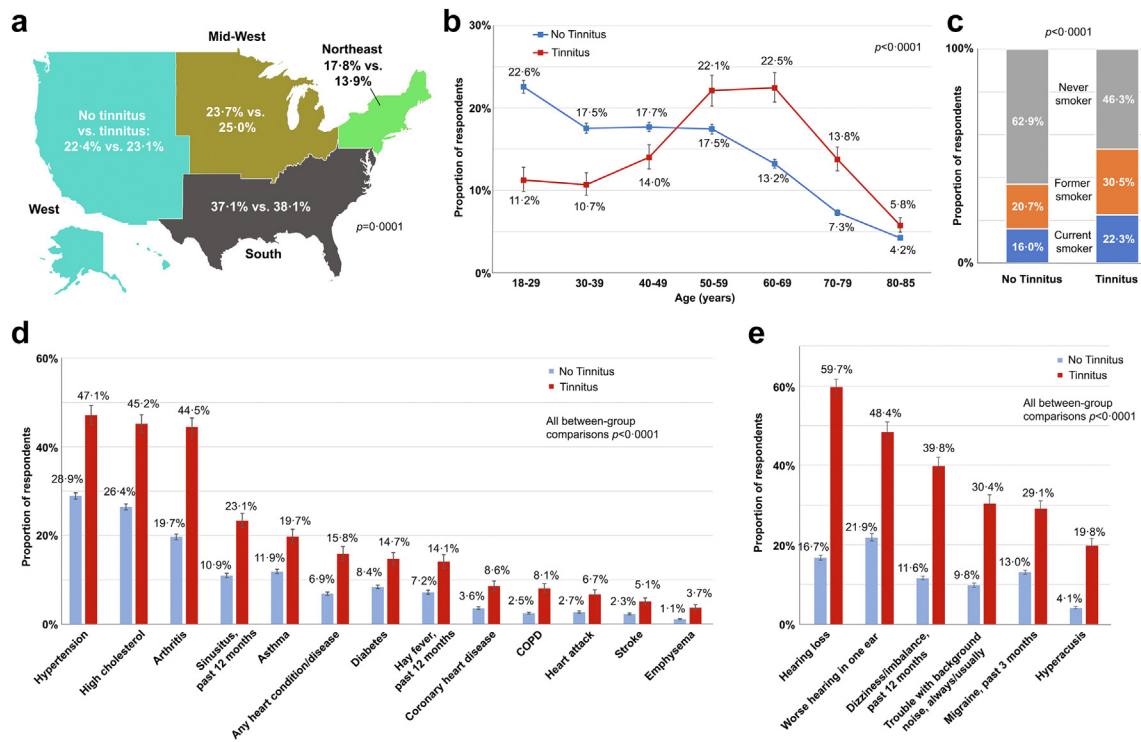
In the weighted sample ( $N = 239.7$  million US adults; 51.8% female), the overall prevalence of tinnitus in 2014 was 11.2% (26.9 [25.6, 28.2] million) ([Table 1](#)). The highest prevalence was among AIANs (14.2% [9.1%, 20.8%]), followed by multiple race (13.7% [10.6%, 17.2%]), non-Hispanic Whites (13.0% [12.4%, 13.6%]), Blacks (8.4% [7.4%, 9.4%]), Hispanic Whites (8.0% [7.0%, 9.0%]), and Asians (4.1% [3.2%, 5.2%]). Hispanic Whites, Blacks, and Asians, but not AIAN or multiple race individuals, had significantly lower prevalence of tinnitus compared with non-Hispanic Whites. The prevalence of tinnitus was significantly higher among males than females overall (12.8% [12.1%, 13.6%] vs. 9.8% [9.2%, 10.4%], respectively) but this trend held only among non-Hispanic Whites (15.3% [14.3%, 16.3%] vs. 10.9% [10.1%, 11.7%]; both  $p < 0.0001$ ) ([Supplementary Table S4](#)).

#### Logistic regression analysis of factors associated with tinnitus

Sex was not significantly associated with tinnitus when age, otologic and certain medical conditions, and noise exposure history were included in a multinomial logistic regression model ([Fig. 2](#), [Supplementary Table S6](#)). Asian race/ethnicity was a protective factor for tinnitus, while no other race/ethnicities were significantly associated with tinnitus in the model. Hearing loss had the strongest association, followed by dizziness/imbalance, hyperacusis, and very loud occupational noise exposure. Other significant factors included arthritis, ever using firearms, ever being exposed to very loud non-work noise  $\geq 10$  times/year, high cholesterol, age 50–79 years, and ever being a smoker. The AUC was 0.83 (95% CI: 0.82, 0.83), indicating excellent predictive performance of the model ([Supplementary Figure S3](#)).

#### Tinnitus symptoms by demographic group

Among those with tinnitus, 28.3% reported symptom duration of  $\geq 15$  years, 41.2% always experienced



**Fig. 1: Demographic and clinical characteristics of United States adults with and without tinnitus.** (a) Distribution of people without vs. with tinnitus across United States census areas. (b) Age distribution of people with (red) and without (blue) tinnitus, by age category. (c) Proportions of survey respondents with and without tinnitus who were current, former, or never smokers. Smoking status was unknown for 36 respondents with tinnitus (0.9%) and 151 without tinnitus (0.5%). (d) Proportions of survey respondents with (red) and without (blue) tinnitus who reported that a healthcare provider had ever told them they had the listed medical conditions; sinusitis and hay fever were within the last 12 months. (e) Proportions of survey respondents with (red) and without (blue) tinnitus who reported that they had hearing-related symptoms, dizziness/imbalance within the last 12 months, or migraine within the last 3 months. All comparisons were conducted among the weighted population using single Adjusted Wald  $\chi^2$  tests for each category to avoid multiplicity. Error bars in panels b, d, and e represent 95% confidence intervals. The raw Ns of the comparative cohorts were 32,183 without tinnitus and 4514 with tinnitus; the only exception is that the comparison in (e) for 'worse hearing in one ear' was conducted among respondents reporting other than 'excellent' unassisted hearing quality (15,461 without tinnitus and 3736 with tinnitus). Refer to [Supplementary Table S2](#) for full numerical results. Source: 2014 National Health Interview Survey Adult Sample File.

symptoms, and 7.8% reported severe tinnitus (i.e., was a big/very big problem) (Table 2, Supplementary Table S5). Males had longer duration and more frequent tinnitus than females overall, with significantly more reporting  $\geq 15$  years duration (32.7% vs. 22.8%) and always experiencing symptoms (46.1% vs. 35.2%; both  $p < 0.0001$ ). However, significantly more females than males reported severe tinnitus (9.1% vs. 6.7%;  $p = 0.02$ ). Compared to non-Hispanic Whites, significantly fewer Hispanic Whites, Black, and 'Other' ethnicity respondents had tinnitus symptom duration of  $>15$  years (31.6% vs. 16.5%, 16.3%, and 23.6%, respectively; all  $p < 0.05$ ). Additionally, more non-Hispanic Whites with tinnitus reported almost always experiencing symptoms compared to all other groups (Supplementary Table S7). However, significantly more

Hispanic Whites reported severe tinnitus than non-Hispanic Whites (12.1% vs. 7.1%;  $p = 0.01$ ).

### Otologic healthcare by demographic group

#### Tinnitus-related healthcare

Approximately half of people with tinnitus reported ever discussing it with an HCP (52.4%), and the rates for males and females were similar (Table 3). However, significantly lower rates of Hispanic White (47.0%), Black (43.4%), or 'Other' ethnicity (42.2%) individuals discussed their tinnitus with an HCP compared to non-Hispanic Whites (55.0%; all  $p < 0.05$ ). Of those who did discuss their tinnitus with an HCP in the past 5 years, 42.8% overall were evaluated for tinnitus by a specialist. However, significantly fewer Black respondents with tinnitus who discussed it with an HCP were evaluated



Bothered by tinnitus for >5 min in the past 12 months	Estimated prevalence of bothersome tinnitus in the US population in 2014			Logistic regression	
	Raw n with tinnitus/total raw n	Estimated n (95% CI) after weighting	Prevalence, % (95% CI)	Coef (95% CI)	p
<b>Overall<sup>a</sup></b>	4514/36,697	26,917,759 (25,608,556; 28,226,962)	11.23% (10.78%, 11.70%)	–	–
Male	2279/16,398	14,784,747 (13,778,568; 15,790,926)	12.80% (12.06%, 13.56%)	ref	ref
Female	2235/20,299	12,133,012 (11,362,588; 12,903,436)	9.77% (9.22%, 10.35%)	–0.30 (–0.40, –0.21)	<0.0001 <sup>c</sup>
<b>Race/ethnicity</b>				<b>Group vs. non-Hispanic White</b>	
Hispanic White	454/5427	2,632,335 (2,294,487; 2,970,183)	7.95% (7.02%, 8.97%)	–0.55 (–0.69, –0.41)	<0.0001 <sup>c</sup>
Non-Hispanic White	3265/22,750	20,421,714 (19,219,723; 21,623,705)	12.98% (12.36%, 13.62%)	ref	ref
Black	502/5173	2,458,930 (2,141,019; 2,776,841)	8.38% (7.40%, 9.44%)	–0.49 (–0.63, –0.35)	<0.0001 <sup>c</sup>
AIAN	62/377	277,378 (157,204; 397,552)	14.24% (9.11%, 20.82%)	0.11 (–0.35, 0.57)	0.65
Asian	113/2129	563,536 (419,086; 707,986)	4.10% (3.16%, 5.22%)	–1.25 (–1.50, –0.99)	<0.0001 <sup>c</sup>
Multiple race	112/734	527,754 (384,157; 671,351)	13.68% (10.64%, 17.21%)	0.06 (–0.22, 0.34)	0.67
Race not released <sup>b</sup>	6/75	NR	NR	–	–

Caption: Sample weights provided by the NHIS were applied to the raw sample size (total N = 36,697) to estimate the numbers and proportions with bothersome tinnitus in the US population in 2014, overall, by sex, and by race/ethnicity groups. The prevalence of tinnitus was compared between males vs. females overall using logistic regression and between race/ethnicity groups vs. non-Hispanic Whites with multinomial logistic regression; coefficients and p-values (adjusted Wald test) are reported. The prevalence of any bothersome tinnitus was higher among men vs. women overall, and was highest among AIAN individuals, followed by multiple race and non-Hispanic White individuals. Refer to [Supplementary Table S3](#) for comparisons of tinnitus prevalence by sex within race/ethnic groups. Abbreviations: AIAN, American Indian/Alaska Native; CI, confidence interval; Coef, logistic regression coefficient; NHIS, National Health Interview Survey; NR, not reported; ref, reference; US, United States. <sup>a</sup>Calculated among all 2014 NHIS respondents (refer to [Figure S1](#) for sample selection). Bothersome tinnitus was defined as those who answered “yes” to the question: “During the past 12 months, have you been bothered by ringing, roaring, or buzzing in your ears or head that lasts 5 minutes or more?” A total of 47 (0.13%) respondents refused to answer (n = 9), their answer was not ascertained (n = 2), or they didn’t know (n = 36) and were not considered to have reported tinnitus. <sup>b</sup>Race was not releasable for 75 (0.20%) respondents ([Supplementary Figure S1b](#)). This group is included in the estimate of overall US prevalence, but prevalence is not separately reported for those with unreleased race in accordance with NHIS guidance on reliable estimates (the standard error > 30% of the proportion). <sup>c</sup>p < 0.05. Source: 2014 NHIS Sample Adult File.

**Table 1: Prevalence of tinnitus in the US (2014), overall and by demographic group.**

by a specialist compared to non-Hispanic Whites (40.6% vs. 43.3%;  $p = 0.02$ ). Overall, 18.2% of respondents with tinnitus reported ever trying a treatment for it, and the rate was significantly higher for females than males overall (21.4% vs. 15.6%;  $p = 0.0006$ ) and was significantly lower among ‘Other’ ethnicity individuals vs. non-Hispanic Whites (11.0% vs. 18.6%;  $p = 0.01$ ).

**Hearing-related healthcare among those with tinnitus**

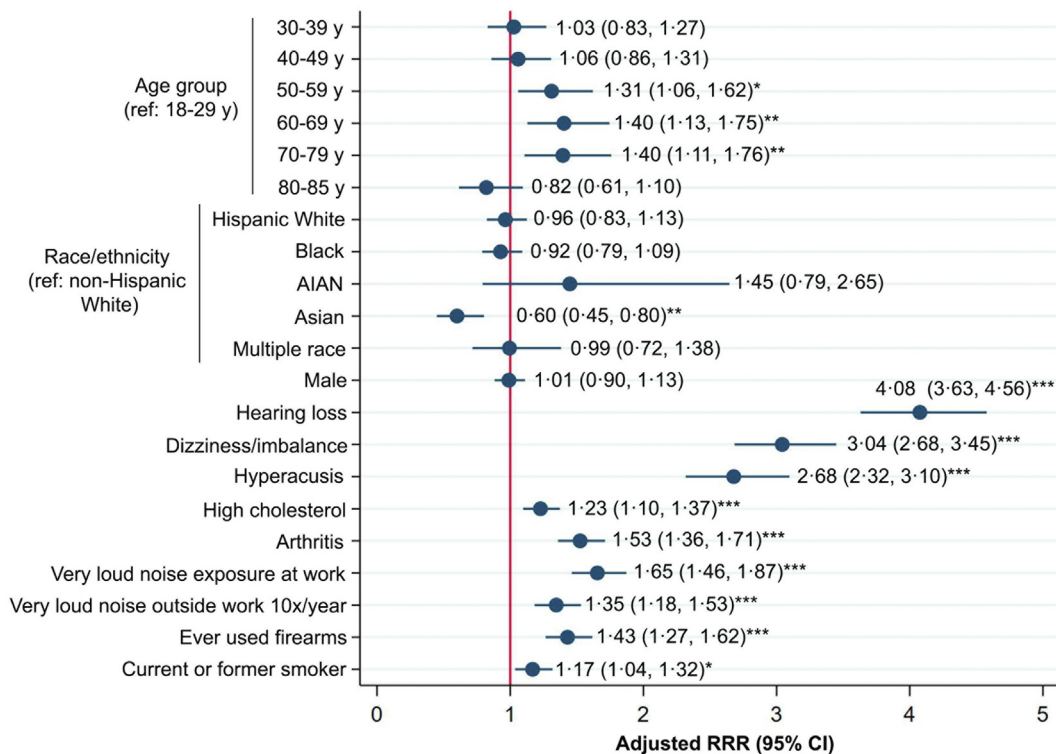
Among all respondents with tinnitus, 62.3% reported ever seeing an HCP about a hearing problem ([Table 3](#)), and the proportions were similar between sexes and among racial groups. Among respondents with tinnitus who did see an HCP for a hearing problem in the past 5 years, significantly fewer Blacks saw or were referred to an audiologist/hearing aid dispenser than non-Hispanic Whites (28.7% vs. 49.5%;  $p < 0.0001$ ). Among all respondents with tinnitus, 70.2% had ever received a hearing test by a specialist and the rate was significantly higher for males vs. females (74.6% vs. 64.8%;  $p < 0.0001$ ). Compared to non-Hispanic Whites, significantly lower proportions of Hispanic Whites or Blacks with tinnitus had ever received a hearing test from a specialist (72.8% vs. 60.4% and 60.1%, respectively; both  $p < 0.0001$ ).

**Discussion**

This large, population-level study of people with bothersome tinnitus in the 2014 NHIS identified differences

in the rates of prevalence, tinnitus characteristics (i.e., duration, frequency, and severity), and use of tinnitus-related healthcare across demographic groups in the US. The overall prevalence of tinnitus (11.2%) was driven by non-Hispanic Whites (13%), who composed 62% of the current sample, and the prevalence among other groups varied from 14% among AIANs to 4% among Asians. Ultimately, the rates of tinnitus were not significantly different between non-Hispanic Whites and AIAN or multiple race individuals, although the rates for Asian and Black individuals were significantly lower. Additionally, by describing and comparing the characteristics of people with and without tinnitus, we identified differences in these populations (e.g., noise exposure history and the rates of otologic conditions, arthritis, high cholesterol, firearm use, and smoking). After incorporating these factors into a model evaluating associations with tinnitus, there were no significant associations between tinnitus and sex nor race/ethnicity, except for Asian ethnicity.

Prior estimates of the overall US prevalence of tinnitus vary from 4% to 30% depending on the population or definitions of tinnitus,<sup>3,12,14,15,25,26</sup> although our estimates overall (11.2% [10.8%, 11.7%]) and among men (12.8% [12.1%, 13.6%]) are higher than the 2007 estimates also using NHIS data (9.6% [9.1%, 10.1%] and 10.5% [9.8%, 11.3%], respectively).<sup>12</sup> Tinnitus has been previously reported to be more common among non-Hispanic Whites<sup>3</sup> and males.<sup>12</sup> However a recent meta-analysis of global tinnitus prevalence by Jarach and



**Fig. 2: Multinomial logistic regression model of factors associated with tinnitus.** A multinomial logistic regression model was developed including categories of age group, race/ethnicity, hearing loss, dizziness imbalance, hyperacusis, high cholesterol, arthritis, very loud occupational noise exposure, very loud non-occupational noise exposure at least 10 times a year, ever using firearms, and being a current or former smoker. The base outcome was no tinnitus. The dependent variable was tinnitus, defined in the survey as being bothered by ringing, buzzing, or roaring in the ears/head that lasted at least 5 min in the past 12 months. All respondents with complete data on the listed variables were included in the model (n observations = 34,190; weighted population n = 222,850,027). The model F (21,280) = 123.78, ( $p < 0.0001$ ). The area under the receiver operating characteristic curve was 0.83 (95% CI: 0.82, 0.83), indicating excellent fit (curve in [Supplementary Figure S3](#)). Abbreviations: AIAN, American Indian/Alaska Native; CI, confidence interval; RRR, relative risk ratio; ref, reference; y, years. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ . Source: 2014 National Health Interview Survey Adult Sample File.

colleagues<sup>15</sup> found no difference in the prevalence between sexes, consistent with the results of our analysis when considering factors like noise exposure, otologic conditions, and other comorbidities. A unique aspect of our study is the analysis of the US prevalence of tinnitus by racial/ethnic group using the large, representative NHIS data. Additionally, the size of the current sample can support the findings of prior studies with smaller samples that have identified factors associated with tinnitus. In particular, the number of people with tinnitus in this study ( $n = 4514$ ) is larger compared with almost all of the US studies included in the meta-analysis by Jarach and colleagues.<sup>15</sup>

There were numerous differences between the populations with and without tinnitus in terms of age, medical comorbidities, and noise exposure history, many of which have been previously noted.<sup>23</sup> When controlling for these variables in a logistic regression model, there were no significant associations between tinnitus and sex or race/ethnicity; the one exception

was lower risk among Asians. This observation, as well as the lower prevalence of tinnitus in Asian-Americans in this study, is similar to prior reports.<sup>14</sup> Notably, the strongest associations with tinnitus were the presence of other otologic disorders and very loud occupational noise exposure, consistent with prior reports.<sup>23,27</sup> The association between tinnitus and arthritis has also been noted in prior epidemiological studies.<sup>26,28,29</sup> Although the exact pathological link between the two is unclear, rheumatoid arthritis can cause autoimmune inner ear disease that presents as hearing loss and tinnitus via damage to the vasculature or sensory cells of the inner ear.<sup>30</sup> Additionally, it is possible that certain medications commonly used for arthritis or other disorders could exacerbate tinnitus. Optimal treatment of comorbidities, an improved understanding of the potential ototoxicity of medications, and a heightened awareness of the need for hearing protection in noisy environments may all positively impact the burden of tinnitus in the US.

Experienced tinnitus for >5 min in the past 12 months	Characteristics of tinnitus symptoms among respondents with bothersome tinnitus, raw N = 4514			
	Duration, ≥15 Years		Frequency, almost always	
	% (95% CI) after weighting	Coef (95% CI)	Adjusted Wald P % (95% CI) after weighting	Adjusted Wald P % (95% CI) after weighting
<b>Overall</b>	28.27% (26.41%, 30.21%)	<b>Male vs. female</b>	41.19% (38.91%, 43.50%)	7.80% (6.82%, 8.91%)
Male	32.74% (29.85%, 35.77%)	ref	46.07% (42.83%, 49.32%)	6.73% (5.57%, 8.13%)
Female	22.83% (20.59%, 25.24%)	-0.87 (-1.14, -0.61)	35.24% (32.42%, 38.14%)	9.11% (7.68%, 10.78%)
<b>Race/ethnicity</b>		<b>Group vs. non-Hispanic White</b>	<b>Group vs. non-Hispanic White</b>	<b>Group vs. non-Hispanic White</b>
Non-Hispanic White	31.56% (29.22%, 33.99%)	ref	46.44% (43.55%, 49.35%)	7.07% (5.97%, 8.35%)
Hispanic White	16.45% (12.39%, 21.52%)	-1.18 (-1.61, -0.75)	26.29% (21.75%, 31.41%)	12.09% (8.81%, 16.37%)
Black	16.33% (12.72%, 20.72%)	-1.40 (-1.82, -0.98)	20.70% (15.96%, 26.42%)	8.74% (6.29%, 12.01%)
Other <sup>a</sup>	23.55% (17.45%, 30.99%)	-0.60 (-1.10, -0.11)	28.55% (22.06%, 36.06%)	8.86% (5.12%, 14.91%)

Adjusted Wald P values are shown in bold. <sup>a</sup>Other included American Indian/Alaska Native, Asian, multiple race, and race not released. <sup>b</sup>p < 0.05. Source: 2014 National Health Interview Survey Sample Adult File.

**Table 2: Longest duration, highest frequency, and worst severity of tinnitus, overall and stratified by sex and race/ethnicity.**

The overall proportion reporting severe tinnitus was 7.8%, slightly higher than in Bhatt et al. using 2007 NHIS data (7.2%),<sup>12</sup> and was significantly higher in females vs. males and in Hispanic vs. non-Hispanic Whites. This may be reflected in the higher utilization of tinnitus treatment by females compared with males overall, although neither females nor Hispanic Whites were more inclined to discuss tinnitus with an HCP. Indeed, Hispanic Whites, Blacks, and AIAN/multiple race individuals all discussed their tinnitus with an HCP at significantly lower rates than non-Hispanic Whites. A troubling finding is that significantly fewer Black respondents with tinnitus who did discuss it with an HCP were evaluated for tinnitus or hearing problems compared to non-Hispanic Whites. The lower rates of all hearing-related healthcare among Black and Hispanic White individuals with tinnitus and hearing loss also point to otologic healthcare disparities that could be a focus of future health equity initiatives. Indeed, an objective of the Healthy People 2030 initiative in the US, which is informed by NHIS data, is to increase the proportion of adults with tinnitus who see a specialist.<sup>16</sup>

Certain barriers to tinnitus healthcare, such as limited availability of information about tinnitus or healthcare unaffordability, may partially underlie the differences in healthcare seeking and use among the demographic groups. Although racially minoritised groups generally used the internet to a significantly lesser extent than non-Hispanic Whites for health information (all *p* < 0.004, except Asians), similar proportions with tinnitus across race/ethnicity groups used the internet to specifically look for tinnitus information (Supplementary Table S10). This reflects a similar level of recognition of and desire for information about their symptoms and points to a valuable modality to reach underserved populations. However, a common theme was greater concern about healthcare costs, and lower utilization of specialists due to cost, among some minoritised populations with tinnitus (Supplementary Table S11). Specifically, significantly higher proportions of Black and Hispanic Whites with tinnitus reported being somewhat or very concerned about healthcare affordability, and being unable to afford to see a specialist in the past year, compared to non-Hispanic Whites. The inability to afford a specialist visit may be particularly impactful due to the inconsistent insurance coverage for hearing loss and tinnitus counseling, screening, and treatment, placing a higher economic burden on patients to cover these costs or forgo tinnitus healthcare. This may partially explain why, despite experiencing a higher rate of severe tinnitus, significantly fewer Hispanic Whites discussed tinnitus with an HCP compared with non-Hispanic Whites.

These data highlight that women and US minoritised populations are deeply impacted by tinnitus, and that efforts should be made to avoid their under-



Experienced tinnitus for >5 min in the past 12 months	Otologic healthcare among respondents with bothersome tinnitus, raw N = 4514								
	Tinnitus-related								
	Ever discussed tinnitus with a HCP, yes			Evaluated for tinnitus by a specialist <sup>a</sup> in the past 5 years, yes <sup>b</sup>			Ever tried a treatment for tinnitus, yes		
	% (95% CI) after weighting	Coef (95% CI)	Adjusted Wald P	% (95% CI) after weighting	Coef (95% CI)	Adjusted Wald P	% (95% CI) after weighting	Coef (95% CI)	Adjusted Wald P
<b>Overall</b>	52.35% (50.24%, 54.45%)	<b>Male vs. female</b>		42.79% (40.01%, 45.62%)	<b>Male vs. female</b>		18.21% (16.79%, 19.72%)	<b>Male vs. female</b>	
Male	51.86% (48.98%, 54.73%)	ref	–	42.68% (38.64%, 46.83%)	ref	–	15.57% (13.73%, 17.61%)	ref	–
Female	52.95% (50.15%, 55.73%)	0.04 (–0.11, 0.20)	0.58	42.92% (38.89%, 47.06%)	0.03 (–0.19, 0.25)	0.76	21.42% (19.03%, 24.02%)	0.39 (0.17, 0.61)	<b>0.0006<sup>e</sup></b>
<b>Race/ethnicity</b>	<b>Group vs. non-Hispanic White</b>			<b>Group vs. non-Hispanic White</b>			<b>Group vs. non-Hispanic White</b>		
Non-Hispanic White	54.82% (52.30%, 57.32%)	ref	–	43.29% (39.94%, 46.70%)	ref	–	18.61% (16.84%, 20.53%)	ref	–
Hispanic White	46.99% (41.17%, 52.90%)	–0.31 (–0.56, –0.07)	<b>0.01<sup>e</sup></b>	41.08% (32.96, 49.72%)	–0.26 (–0.58, 0.05)	0.10	16.56% (12.90%, 20.99%)	–0.14 (–0.46, 0.19)	0.40
Black	43.36% (37.63%, 49.27%)	–0.46 (–0.72, –0.02)	<b>0.001<sup>e</sup></b>	40.57% (33.05%, 48.56%)	–0.38 (–0.68, –0.07)	<b>0.02<sup>e</sup></b>	20.73% (16.57%, 25.61%)	0.13 (–0.17, 0.44)	0.38
Other <sup>c</sup>	42.24% (34.89%, 49.97%)	–0.51 (–0.84, –0.17)	<b>0.003<sup>e</sup></b>	40.92% (29.91%, 52.92%)	–0.40 (–0.82, 0.03)	0.07	11.02% (7.32%, 16.26%)	–0.61 (–1.09, –0.13)	<b>0.01<sup>e</sup></b>
	Hearing-related								
	Ever saw a HCP about hearing problems, yes			Saw or was referred to audiologist/hearing aid specialist in past 5 years, yes <sup>d</sup>			Ever received a hearing test by a specialist <sup>a</sup> , yes		
<b>Overall</b>	62.26% (59.76%, 64.70%)	<b>Male vs. female</b>		46.24% (42.99%, 49.52%)	<b>Male vs. female</b>		70.17% (68.00%, 72.26%)	<b>Male vs. female</b>	
Male	64.31% (60.48%, 67.96%)	ref	–	48.89% (44.21%, 53.59%)	ref	–	74.55% (71.84%, 77.08%)	ref	–
Female	59.76% (56.61%, 62.84%)	–0.20 (–0.41, 0.01)	0.07	42.96% (38.62%, 47.42%)	–0.23 (–0.49, 0.03)	0.08	64.84% (61.77%, 67.79%)	–0.48 (–0.66, –0.30)	<b>&lt;0.0001<sup>e</sup></b>
<b>Race/ethnicity</b>	<b>Group vs. non-Hispanic White</b>			<b>Group vs. non-Hispanic White</b>			<b>Group vs. non-Hispanic White</b>		
Non-Hispanic White	63.76% (60.67%, 66.75%)	ref	–	49.52% (45.74%, 53.31%)	ref	–	72.81% (70.19%, 75.28%)	ref	–
Hispanic White	57.12% (50.85%, 63.17%)	–0.26 (–0.54, 0.03)	0.07	40.93% (31.22%, 51.41%)	–0.35 (–0.79, 0.10)	0.13	60.36% (54.39%, 66.04%)	–0.57 (–0.86, –0.28)	<b>&lt;0.0001<sup>e</sup></b>
Black	59.08% (53.21%, 64.71%)	–0.20 (–0.47, 0.06)	0.14	28.66% (21.00%, 37.79%)	–0.90 (–1.34, –0.47)	<b>&lt;0.0001<sup>e</sup></b>	60.14% (53.67%, 66.27%)	–0.60 (–0.88, –0.32)	<b>&lt;0.0001<sup>e</sup></b>
Other <sup>c</sup>	55.60% (47.77, 63.16%)	–0.35 (–0.69, –0.001)	0.05	38.28% (24.71%, 53.96%)	–0.43 (0.33, –1.09)	0.20	67.80% (60.43%, 74.37%)	–0.24 (–0.60, 0.12)	0.19

Caption: Proportions are calculated among all respondents (including those with 'unknown' responses, i.e., refused, not ascertained, or didn't know on the question) with tinnitus. Logistic regression with adjusted Wald tests were used to compare groups with complete data for the question. Regression coefficients and p-values are reported. Abbreviations: CI, confidence interval; Coef, coefficient; HCP, healthcare provider; NHIS, National Health Interview Survey; US, United States. <sup>a</sup>A medical specialist in otologic disorders, such as an Ear, Nose and Throat doctor (otolaryngologist), audiologist, neurologist, otologist, neuro-otologist, etc. <sup>b</sup>Among those who had ever discussed their tinnitus with a HCP. <sup>c</sup>Other<sup>c</sup> included American Indian/Alaska Natives, Asian, multiple race individuals, and race not released. <sup>d</sup>Among those who had ever discussed a hearing problem with a HCP. <sup>e</sup>p < 0.05. Source: 2014 National Health Interview Survey Sample Adult File.

**Table 3: Otologic healthcare among respondents with tinnitus, overall and stratified by sex and race/ethnicity.**

representation in clinical trials of tinnitus therapy or under-treatment in clinical settings. Additionally, the higher prevalence of tinnitus in this 2014 NHIS study vs. the prior 2007 NHIS study by Bhatt and colleagues suggests an increase in tinnitus prevalence, which may be attributable to the aging US population or, potentially, increased awareness of tinnitus. Of note, in contrast with the data used in Bhatt et al., this study's data were collected during or after the implementation of the Affordable Care Act (ACA) provisions in 2010–2014, which reformed and greatly expanded healthcare coverage across the US. Prior to the ACA, ~33% of Hispanic and 20% of Black Americans were uninsured.<sup>31,32</sup> However, there were large gains in healthcare coverage across all racial/ethnic groups under the ACA, with Hispanic people experiencing the largest decline in their uninsured rate during 2010 (32.6%) to 2016 (19.1%). With more people insured, there is increased ability to discuss health concerns like tinnitus with an HCP and receive referral or evaluation.

The results of this study should be considered in the light of several limitations. The data were extracted from the 2014 NHIS and may not reflect current tinnitus prevalence or healthcare/referral practices of physicians. However, this year was the latest for which questions on tinnitus were available, and the data still provide a valuable, more recent snapshot of tinnitus prevalence and related healthcare as well as a benchmark for future estimates. The more frequent inclusion of tinnitus-related questions in the NHIS in upcoming years can provide more recent data, and could potentially provide greater granularity regarding the features of tinnitus (i.e., querying on constant or disabling tinnitus). As a retrospective cohort study based on self-reported survey data, there is the potential for recall bias or that respondents failed to fully understand their diagnoses told to them by a HCP or their tinnitus management, referral, or evaluation. Similarly, self-reported conditions may be over- or underestimated. The cross-sectional nature of this study precludes establishing causal or temporal relationships between tinnitus and associated factors; for example, hypertension, high cholesterol, and arthritis were each reported by >40% of people with tinnitus, but in the absence of diagnosis date, a temporal link with tinnitus cannot be determined. Future studies using healthcare claims data or electronic medical records, which provide diagnostic codes and dates of medical services, are recommended. Additionally, future studies are recommended to examine the characteristics and healthcare among people with severe vs. any bothersome tinnitus.

In conclusion, this study found differences in the prevalence, characteristics, and healthcare associated with tinnitus among various demographic groups in the US, and a higher overall prevalence in 2014 compared to

2007. The results also highlight differences in the experience of tinnitus and delivery tinnitus-related healthcare across groups and the need to improve the rates of referral and evaluation among underserved populations.

#### Contributors

S Batts conceived of and designed the study with K Stankovic; accessed, extracted, and processed the data; performed the analyses; prepared the tables and figures, and wrote and edited the manuscript drafts. K Stankovic supervised the project, critically reviewed the methods and results, contributed to writing the manuscript drafts, and had final responsibility for the decision to submit for publication. Both authors provided intellectual input into all aspects of this study, have accessed and verified the data, and approved the final version of the manuscript for publication.

#### Data sharing statement

The NHIS Sample Adult File datasets are freely available for download by interested researchers at the Centers for Disease Control and Prevention website: <https://www.cdc.gov/nchs/nhis/index.htm>. Information about the underlying data source is available in the [Supplementary eMethods](#).

#### Declaration of interests

The authors have no conflicts to report.

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#### Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.lana.2023.100659>.

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