CLINICAL RESEARCH STUDY

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Prevalence and Characteristics of Tinnitus among US Adults

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ABSTRACT

BACKGROUND: Tinnitus is common; however, few risk factors for tinnitus are known.

METHODS: We examined cross-sectional relations between several potential risk factors and self-reported tinnitus in 14,178 participants in the 1999-2004 National Health and Nutrition Examination Surveys, a nationally representative database. We calculated the prevalence of any and frequent (at least daily) tinnitus in the overall US population and among subgroups. Logistic regression was used to calculate odds ratios (OR) and 95% confidence intervals (CI) after adjusting for multiple potential confounders.

RESULTS: Approximately 50 million US adults reported having any tinnitus, and 16 million US adults reported having frequent tinnitus in the past year. The prevalence of frequent tinnitus increased with increasing age, peaking at 14.3% between 60 and 69 years of age. Non-Hispanic whites had higher odds of frequent tinnitus compared with other racial/ethnic groups. Hypertension and former smoking were associated with an increase in odds of frequent tinnitus. Loud leisure-time, firearm, and occupational noise exposure also were associated with increased odds of frequent tinnitus. Among participants who had an audiogram, frequent tinnitus was associated with low-mid frequency (OR 2.37; 95% CI, 1.76-3.21) and high frequency (OR 3.00; 95% CI, 1.78-5.04) hearing impairment. Among participants who were tested for mental health conditions, frequent tinnitus was associated with generalized anxiety disorder (OR 6.07; 95% CI, 2.33-15.78) but not major depressive disorder (OR 1.58; 95% CI, 0.54-4.62).

CONCLUSIONS: The prevalence of frequent tinnitus is highest among older adults, non-Hispanic whites, former smokers, and adults with hypertension, hearing impairment, loud noise exposure, or generalized anxiety disorder. Prospective studies of risk factors for tinnitus are needed.

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Tinnitus, derived from the Latin word *tinnire* meaning "to ring," is the perception of noise in the absence of an acoustic stimulus.[1] It is a common condition that is usually subjective, perceived only by the patient, and therefore diagnosis and monitoring rely on self-report.[2] Data from the 1996 National Health Interview Survey (NHIS) showed tinnitus was experienced by approximately 35-50 million adults in the US, with 12 million seeking medical care, and 2-3 million reporting symptoms that were severely debilitating.[3] Cases and proposed etiologies of tinnitus are clinically heterogeneous and, although several treatment options have been tried, no single cure exists for the condition.[4]

Patients who experience tinnitus often report significant associated morbidities. Lifestyle detriment, emotional difficulties, sleep deprivation, work hindrance, interference with social interaction, and decreased overall health have been attributed to tinnitus.[5-7] Although causative relations are yet unknown, patients with tinnitus can have increased risk for depression, anxiety, and insomnia.[5,8,9]

A limited number of risk factors for tinnitus have been suggested, the best described of which include increasing age, hearing loss, and loud noise exposure.[10,11] These asso-

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ciations merit further exploration in a large cohort. Furthermore, the relations between tinnitus and other demographic and health factors are minimally characterized in the current literature. Therefore, we examined the relation between tinnitus and several potential risk factors using data from the National Health and Nutrition Examination Survey (NHANES), a large nationally representative survey.

CLINICAL SIGNIFICANCE

- Tinnitus is a very common and potentially disabling condition, but few risk factors for its development are currently known.
- The relations between tinnitus and other demographic and health factors are minimally characterized in the current literature.
- Because tinnitus currently has no known cure, identifying potentially vulnerable groups and establishing potential risk factors in a large, nationally representative study is important for decreasing the burden of this condition.

METHODS

Study Population

Participants from the NHANES 1999-2000, 2001-2002, and 2003-2004 surveys were included in our study. NHANES provides nationally representative cross-sectional data on the health status of the civilian, non-institutionalized US population. After selection in a complex survey design, participants were interviewed and examined. The design of NHANES has been described previously.[12] Because older individuals, Mexican-Americans, and black individuals were intentionally over-represented, NHANES 1999-2004 were not simple random samples of the US population. Therefore, appropriate sample weights were used to obtain weighted regression estimates, and the final results of our analyses were generalizable to the US population.[12]

Exposure and Outcome Assessment

Questionnaire responses were used to compile the participants' general demographic and medical information. Participants were asked their age, self-identified race/ethnicity, and highest level of education achieved. They were asked if they smoked cigarettes currently, previously, or never. Participants were defined as having hypertension if they had been told by a health professional that they had hypertension or if they had a history of taking an antihypertensive medication. Similarly, they were defined as having diabetes mellitus if they had been told by a health professional that they had diabetes mellitus or if they had a history of taking a diabetes medication. Participants also were queried about the use of specific medications, including cholesterol-lowering medications. They were defined as having dyslipidemia if they reported taking a cholesterol-lowering medication. Body mass index measurement was calculated as weight in kilograms divided by the square of height in meters. Both the weight and height of participants were measured.

Subsamples of participants received additional testing and interviews. Audiometry was performed on half of all participants between the ages of 20 and 69 years (n = 5414). Hearing threshold testing was conducted on both ears of examinees at 7 frequencies (500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz). We defined low-mid frequency hearing impairment as a pure tone mean of >25 decibels at 500, 1000, or 2000 Hz in either ear.[13] We defined high frequency hearing impairment as a pure tone mean of >25 decibels at 3000, 4000, 6000, or 8000 Hz in either ear. The World Health Organization Composite Diagnostic Interview, Version 2.1, was administered to half of all participants between the ages of 20 and 39 years (n = 2265). Based upon responses to these interviews, a composite score was calculated for the presence or absence of a major depressive disorder and generalized anxiety disorder according to a predefined algorithm.[14]

Participants over the age of 20 years were asked questions about hearing and noise exposure. Tinnitus was defined as answering "yes" to the question, "In the past 12 months, have you ever had ringing, roaring, or buzzing in your ears?" This was followed by the question "How often did this happen?" Frequent tinnitus was defined as answering "almost always" or "at least once a day" to this question. To assess noise exposure, participants were asked about the presence or absence of exposure to loud leisure-time, leisure-time firearm, or occupational noise at least once in the past month.

Statistical Analyses

The prevalence of any and frequent tinnitus was calculated among participants with and without each potential risk factor. Logistic regression was performed with sex, age, race/ethnicity, education level, body mass index, smoking status, hypertension, diabetes mellitus, dyslipidemia, leisure-time noise exposure, leisure-time firearm noise exposure, and occupational noise exposure as covariates, and any or frequent tinnitus as the outcome. Low-mid frequency hearing impairment, high frequency hearing impairment, major depressive disorder, and generalized anxiety disorder were entered into the regression model in separate analyses of participants on whom these data were collected. Age and multivariable adjusted odds ratios (OR) with 95% confidence intervals (CI) were calculated using logistic regression models adjusted for potential confounders listed above. All *P*-values were 2-sided.

Data analysis was performed using SAS version 9.1 (SAS Institute Inc., Cary, NC) and SUDAAN version 9.0 (RTI International, Research Triangle Park, NC). Protocols to recruit and study participants of NHANES 1999-2004

were reviewed and approved by the National Center for Health Statistics Institutional Review Board.

RESULTS

Characteristics of participants with any and frequent tinnitus are shown in Table 1. Responses from 14,178 participants in our analytic dataset corresponded to a prevalence among US adults of 25.3% (approximately 50 million) of experiencing any tinnitus, and 7.9% (approximately 16 million) of experiencing frequent tinnitus in the past year. The prevalence of any and frequent tinnitus increased with increasing age, peaking at 31.4% and 14.3%, respectively, at age 60-69 years. Overall, the prevalences of any and frequent tinnitus were higher among male and non-Hispanic white participants. The prevalences of any and frequent tinnitus also were higher among participants with a body mass index $\geq$30 kg/m^2, who were current smokers, or who had a diagnosis of hypertension, diabetes mellitus, or dyslipidemia. Participants with exposure to loud occupational, leisure-time, and firearm noise also had a higher prevalence of any and frequent tinnitus.

The age and multivariable-adjusted relations between tinnitus and participant characteristics are summarized in Table 2. After multivariable adjustment, women were significantly more likely to report any, but not frequent, tinnitus. Compared with age <30 years, at age 60-69 years, the odds of any tinnitus (OR 1.67; 95% CI, 1.44-1.94) and frequent tinnitus (OR 5.43; 95% CI, 3.93-7.50) appear to peak. Compared with non-Hispanic whites, non-Hispanic blacks and Hispanics had lower odds of any tinnitus and frequent tinnitus. Both current and former smokers had higher odds of any tinnitus compared with never smokers, but only former smokers had higher odds of frequent tinnitus. Hypertension also was significantly associated with increased odds of any and frequent tinnitus. Participants with exposure to occupational, leisure-time, and firearm noise also had significantly increased odds of reporting any and frequent tinnitus compared with participants without noise exposure.

We examined the relation between hearing insufficiency and tinnitus among 5414 participants who underwent audiometry. Overall, compared with participants without hearing impairment, participants with low-mid frequency hearing impairment had significantly increased odds of reporting any (OR 1.73; 95% CI, 1.38-2.17) and frequent tinnitus (OR 2.37; 95% CI, 1.76-3.21). Similarly, participants with high frequency hearing impairment had increased odds of reporting any (OR 1.49; 95% CI, 1.21-1.84) and frequent tinnitus (OR 3.00; 95% CI, 1.78-5.04).

Among participants who underwent audiometry, we examined the relation between potential risk factors and frequent tinnitus based upon the presence or absence of hearing impairment (Table 3). Among participants without low-mid frequency hearing impairment, the multivariable-adjusted odds of frequent tinnitus appeared to increase with increasing age, and peaked at age 50-59 years (OR 5.79; 95% CI, 2.99-11.21). Compared with non-Hispanic whites, the odds of frequent tinnitus were significantly decreased among Hispanic participants without low-mid or high frequency hearing impairment. Compared with a highest education level less than high school, a highest education level of greater than high school was associated with decreased odds for frequent tinnitus among participants without low-mid frequency (OR 0.60; 95% CI, 0.39-0.91) or high frequency (OR 0.27; 95% CI, 0.13-0.58) hearing impairment. Leisure-time noise exposure was associated with increased odds of frequent tinnitus in participants without low-mid frequency (OR 1.71; 95% CI, 1.00-2.95) or high frequency (OR 3.12; 95% CI, 1.46-6.65) hearing impairment, and occupational noise exposure was associated with increased odds of frequent tinnitus in participants with low-mid frequency (OR 2.22; 95% CI, 1.45-3.42) or high frequency (1.63; 95% CI, 1.16-2.30) hearing impairment.

We examined the relation between generalized anxiety and major depressive disorders and tinnitus among the 2265 participants between the ages of 20 and 39 years, who underwent testing with the World Health Organization Composite Diagnostic Interview. After multivariable adjustment, participants with generalized anxiety disorder had higher multivariate-adjusted odds of any tinnitus (OR 2.66; 95% CI, 1.32-5.34) and frequent tinnitus (OR 6.07; 95% CI, 2.33-15.78). Participants with major depressive disorder had significantly higher age-adjusted odds of any tinnitus (OR 2.65; 95% CI, 1.67-4.21) and frequent tinnitus (OR 3.08; 95% CI, 1.36-6.96), however, after multivariable adjustment, the odds of frequent tinnitus was no longer significant (OR 1.58; 95% CI, 0.54-4.62), whereas the odds of any tinnitus remained significant (OR 2.01; 95% CI, 1.24-3.25).

DISCUSSION

The overall prevalence of tinnitus in the US was 25.3%, corresponding to a national estimate of 50 million adults. This prevalence is consistent with the upper range of the overall estimate previously reported from the NHIS (35-50 million).[3] Similar to data from the Beaver Dam cohort,[11] the prevalence of tinnitus in our study increased with age until the age of 60-69 years, after which it decreased with increasing age. This inverse relationship between age and tinnitus in older age groups has been demonstrated in several previous studies.[7,11,15,16] One possible mechanism for this observation is that tinnitus may be associated with other conditions that confer a selective mortality disadvantage among individuals with tinnitus. The possibility also exists, however, that late symptomatic improvement may be part of the natural history of tinnitus.

The results of our study showed that non-Hispanic blacks and Hispanics had lower prevalence of any and frequent tinnitus than non-Hispanic whites. Although decreased prevalence in hearing loss has been reported previously in non-Hispanic blacks and Hispanics compared with non-Hispanic whites,[13] our study is the first to report this asso-

Table 1 Characteristics and Prevalence of Any Tinnitus and Frequent Tinnitus among US Adults with and without Potential Risk Factors

Characteristic	% of US Population	Any Tinnitus, % (95% CI)	*P* Value	Frequent Tinnitus, %* (95% CI)	*P* Value
Demographic characteristics					
Sex					
Male	47.9	26.1 (24.3-27.8)		9.4 (8.4-10.5)	
Female	52.1	24.6 (23.4-25.9)	.13	6.5 (5.7-7.4)	<.01
Age, years					
<30	18.8	20.2 (18.7-21.8)		2.6 (2.0-3.2)	
30-39	20.8	21.6 (19.3-24.1)		4.1 (3.0-5.5)	
40-49	21.7	24.4 (21.7-27.3)		6.6 (5.4-8.1)	
50-59	16.2	30.0 (27.5-32.6)		12.5 (10.5-14.7)	
60-69	10.5	31.4 (29.2-33.7)		14.3 (12.8-16.0)	
70-79	7.9	30.3 (27.4-33.4)		13.8 (11.6-16.4)	
≥80	4.1	28.1 (24.8-31.6)	<.01	12.5 (10.4-14.9)	<.01
Race/ethnicity					
White, non-Hispanic	72.0	27.5 (26.3-28.8)		9.3 (8.5-10.2)	
Black, non-Hispanic	11.1	18.3 (16.7-20.1)		3.4 (2.8-4.4)	
Hispanic	13.0	19.7 (17.9-21.7)		4.8 (3.9-5.8)	
Other	3.9	22.5 (17.6-28.2)	<.01	4.4 (2.5-7.7)	<.01
Education level					
< High school	20.7	27.8 (25.4-30.3)		9.2 (7.7-11.1)	
High school diploma, including GED†	26.2	27.3 (25.1-29.8)		8.0 (6.9-9.3)	
> High school	53.1	23.4 (21.9-24.9)	<.01	7.3 (6.4-8.3)	.12
Cardiovascular risk factors					
Body mass index, kg/m^2					
<25	36.5	23.9 (22.4-25.4)		6.6 (5.6-7.7)	
25-29	33.5	24.5 (23.0-26.0)		8.1 (7.2-9.2)	
≥30	30.0	27.9 (26.0-29.9)	<.01	9.1 (8.1-10.3)	<.01
Smoking status					
Never	50.0	21.8 (20.3-23.4)		6.0 (5.3-6.8)	
Former	25.2	28.6 (26.5-30.7)		12.1 (10.4-14.0)	
Current	24.8	29.0 (26.8-31.2)	<.01	7.4 (6.3-8.6)	<.01
Hypertension					
No	68.1	22.3 (21.2-23.5)		6.0 (5.3-6.7)	
Yes	31.9	32.0 (30.2-33.8)	<.01	12.1 (10.8-13.5)	<.01
Diabetes mellitus					
No	92.6	24.8 (23.6-26.0)		7.6 (6.9-8.3)	
Yes	7.4	31.5 (28.0-35.1)	<.01	11.7 (9.1-14.9)	<.01
Dyslipidemia					
No	89.7	24.7 (23.6-25.9)		7.2 (6.6-7.9)	
Yes	10.3	30.3 (26.4-34.4)	<.01	13.7 (11.0-16.9)	<.01
Noise exposure					
Leisure-time noise exposure					
No	75.3	21.5 (20.4-22.8)		6.7 (6.0-7.6)	
Yes	24.7	36.7 (34.3-39.1)	<.01	11.3 (10.0-12.8)	<.01
Leisure-time firearm noise exposure					
No	91.6	24.0 (23.0-25.2)		7.3 (6.5-8.1)	
Yes	8.4	39.0 (35.4-42.7)	<.01	14.4 (12.3-16.9)	<.01
Occupational noise exposure					
No	64.2	21.5 (20.5-22.6)		5.8 (5.2-6.5)	
Yes	32.2	33.1 (30.9-35.4)		11.9 (10.5-13.4)	
Missing	3.6	23.0 (18.5-28.3)	<.01	8.4 (5.2-13.5)	<.01
Mental health conditions					
Major depressive disorder‡					
No	92.1	19.7 (17.5-22.1)		3.1 (2.3-4.3)	
Yes	7.9	39.5 (30.2-49.6)	<.01	9.3 (4.7-17.8)	.07

Table 1 Continued

Characteristic	% of US Population	Any Tinnitus, % (95% CI)	*P* Value	Frequent Tinnitus, %* (95% CI)	*P* Value
Generalized anxiety disorder†					
No	96.9	20.3 (18.2-22.7)		3.1 (2.2-4.3)	
Yes	3.1	49.7 (34.3-65.2)	<.01	20.4 (11.1-34.4)	.01
Hearing impairment					
Low-mid frequency hearing impairment§					
No	81.8	22.6 (21.0-24.3)		4.8 (4.1-5.7)	
Yes	18.2	37.3 (33.6-41.1)	<.01	16.2 (13.9-18.7)	<.01
High frequency hearing impairment§					
No	53.3	19.4 (17.4-21.6)		2.2 (1.5-3.3)	
Yes	46.7	30.2 (28.0-32.5)	<.01	10.9 (9.7-12.3)	<.01

CI = confidence interval.
*Experiencing tinnitus at least once daily.
†General Educational Development tests.
‡Among the 2265 participants aged 20-39 years who had mental health screening in the National Health and Nutrition Examination Survey (NHANES) 1999-2004.
§Among the 5414 participants aged 20-69 years who had audiometry testing in NHANES 1999-2004.

ciation between race/ethnicity and tinnitus. The fact that significant associations between race/ethnicity and tinnitus were maintained in participants without hearing impairment suggests a mechanism for tinnitus that is independent of hearing impairment.

The significant associations between tinnitus and smoking and hypertension in this study suggest that vascular disease might have a greater contribution to the etiology of tinnitus than previously reported. Associations between cigarette smoking and hearing loss have previously been suggested,[13] but data on the association between smoking and tinnitus remains scant.[17] Our data showed that current and past smoking confer increased odds of experiencing tinnitus. Although multiple past studies have analyzed the relation between cardiovascular disease and tinnitus,[9,11,18] information on the association between hypertension and tinnitus has, up to now, been limited to cases of pulsatile tinnitus from vascular etiologies. These cases likely represent a minority of patients with tinnitus, as most patients with tinnitus present with subjective, sensorineural tinnitus.[19]

Loud noise exposure is generally considered an important risk factor for developing tinnitus. In our study, history of leisure-time, occupational, and firearm noise exposure were all associated with increased odds of tinnitus. The relation between noise exposure and frequent tinnitus, however, differed depending on the presence or absence of hearing impairment. Occupational noise exposure was associated with increased odds of frequent tinnitus in participants with hearing impairment, while leisure-time noise exposure was associated with increased odds of frequent tinnitus in participants without hearing impairment. Occupational noise exposure has been reported to be strongly associated with both tinnitus and hearing loss,[20] possibly due to its chronic effects on inner hair cell, outer hair cell, and acoustic nerve function.[21] However, after an acute acoustic trauma, tinnitus is reported in the initial stages in 90% of the cases,[22] and often persists even when the hearing loss is temporary.[23] The differential vulnerability of cochlear and central components to duration and intensity of noise exposure may explain the variability between tinnitus and hearing loss in noise-exposed subjects.

Our results demonstrate an important relation between tinnitus and mental health, as both anxiety and major depressive disorder were associated with increased odds of tinnitus. Participants with a history of either major depressive disorder or generalized anxiety disorder had greater than twice the odds of reporting any tinnitus compared with those not affected by these disorders. In addition, participants with a history of generalized anxiety disorder had >6 times the odds of reporting tinnitus compared with unaffected participants. Although our study is the first nationally representative study to find an association between tinnitus and mental health disorders, numerous smaller studies have reported similar associations.[24-26] The cause for these associations is not yet known. Tinnitus can result in sleep deprivation, decreased work productivity, and overall lifestyle detriment.[5-7] These factors might cause psychological distress and bring about or worsen symptoms of anxiety and depression.[8] Major depressive disorder and generalized anxiety disorder, on the other hand, may exacerbate tinnitus, and their treatment might alleviate tinnitus.[27]

Several strengths and limitations of our study should be considered. Data from NHANES is comprehensive and nationally representative, drawing from a large and diverse sample of participants. The study is, however, cross-sectional, making causative relationships impossible to determine. Tinnitus is most often a subjective complaint without a means of objective diagnosis. Therefore, comparisons between participants and studies are difficult. But, during the period of this study, consistency was maintained in

Table 2 Age and Multivariate Adjusted Odds Ratios and 95% Confidence Intervals of the Prevalence of Any and Frequent Tinnitus among US Adults According to NHANES 1999-2004

	Any Tinnitus		Frequent Tinnitus	
Characteristic	Age-adjusted OR (95% CI)	Multivariate-adjusted OR* (95% CI)	Age-adjusted OR (95% CI)	Multivariate-adjusted OR* (95% CI)
Demographic characteristics				
Sex				
Male	Referent	Referent	Referent	Referent
Female	0.91 (0.82-1.00)	1.28 (1.15-1.42)	0.62 (0.52-0.74)	0.92 (0.76-1.11)
Age, years				
<30	Referent	Referent	Referent	Referent
30-39	1.09 (0.93-1.27)	1.10 (0.94-1.28)	1.62 (1.07-2.45)	1.56 (1.02-2.38)
40-49	1.28 (1.07-1.53)	1.24 (1.04-1.47)	2.69 (1.91-3.80)	2.44 (1.71-3.49)
50-59	1.69 (1.44-1.99)	1.58 (1.33-1.88)	5.43 (3.97-7.43)	4.68 (3.45-6.33)
60-69	1.81 (1.56-2.09)	1.67 (1.44-1.94)	6.38 (4.86-8.37)	5.43 (3.93-7.50)
70-79	1.72 (1.44-2.06)	1.57 (1.29-1.92)	6.13 (4.65-8.07)	5.19 (3.65-7.39)
≥80	1.54 (1.28-1.86)	1.47 (1.17-1.85)	5.45 (4.07-7.31)	4.94 (3.50-6.96)
Race/ethnicity				
White, non-Hispanic	Referent	Referent	Referent	Referent
Black, non-Hispanic	0.62 (0.55-0.69)	0.63 (0.55-0.71)	0.41 (0.31-0.54)	0.43 (0.32-0.57)
Hispanic	0.70 (0.61-0.80)	0.76 (0.67-0.86)	0.62 (0.50-0.77)	0.67 (0.52-0.86)
Other	0.80 (0.59-1.08)	0.93 (0.67-1.29)	0.53 (0.30-0.92)	0.57 (0.32-1.02)
Education level				
< High school	Referent	Referent	Referent	Referent
High school diploma, including GED	1.01 (0.87-1.18)	0.87 (0.75-1.01)	0.96 (0.75-1.23)	0.78 (0.59-1.02)
> High school	0.84 (0.73-0.96)	0.79 (0.70-0.88)	0.95 (0.75-1.19)	0.80 (0.63-1.02)
Cardiovascular risk factors				
Body mass index, kg/m^2				
<25	Referent	Referent	Referent	Referent
25-29	0.99 (0.91-1.09)	0.94 (0.86-1.03)	1.16 (0.99-1.36)	0.96 (0.81-1.14)
≥30	1.20 (1.07-1.34)	1.08 (0.94-1.23)	1.38 (1.13-1.68)	1.12 (0.92-1.36)
Smoking status				
Never	Referent	Referent	Referent	Referent
Former	1.30 (1.16-1.46)	1.14 (1.01-1.28)	1.70 (1.41-2.06)	1.37 (1.12-1.67)
Current	1.54 (1.31-1.81)	1.34 (1.14-1.57)	1.49 (1.18-1.89)	1.21 (0.96-1.52)
Hypertension				
No	Referent	Referent	Referent	Referent
Yes	1.48 (1.35-1.62)	1.41 (1.28-1.55)	1.35 (1.13-1.61)	1.27 (1.08-1.49)
Diabetes mellitus				
No	Referent	Referent	Referent	Referent
Yes	1.20 (1.01-1.41)	1.09 (0.91-1.31)	1.07 (0.81-1.42)	0.98 (0.75-1.28)
Dyslipidemia				
No	Referent	Referent	Referent	Referent
Yes	1.09 (0.89-1.33)	0.89 (0.72-1.10)	1.24 (0.94-1.62)	0.97 (0.74-1.26)
Noise exposure				
Leisure-time noise exposure				
No	Referent	Referent	Referent	Referent
Yes	2.36 (2.10-2.67)	2.03 (1.77-2.32)	2.37 (1.99-2.81)	1.73 (1.40-2.12)
Leisure-time firearm noise exposure				
No	Referent	Referent	Referent	Referent
Yes	2.02 (1.73-2.35)	1.28 (1.07-1.53)	2.19 (1.77-2.72)	1.25 (1.00-1.57)
Occupational noise exposure				
No	Referent	Referent	Referent	Referent
Yes	1.82 (1.63-2.03)	1.52 (1.35-1.71)	2.31 (1.99-2.69)	1.71 (1.41-2.07)
Missing	1.02 (0.78-1.35)	1.02 (0.77-1.37)	1.20 (0.72-2.00)	1.35 (0.81-2.24)

NHANES = National Health and Nutrition Examination Survey; OR = odds ratio; CI = confidence interval; GED = General Educational Development test.

*Multivariate-adjusted model controlled for the following potential confounders: sex (male, female); age (<30, 30-39, 40-49, 50-59, 60-69, 70-79, ≥80 years); race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, other); education level (< high school, high school, > high school); body mass index (<25, 25-29, ≥30 kg/m^2); smoking status (never, former, current); history of hypertension (no, yes); history of diabetes mellitus (no, yes); taking a cholesterol lowering medication (no, yes); leisure-time noise exposure (no, yes); leisure-time firearm noise exposure (no, yes); and occupational noise exposure (no, yes, missing).

Table 3 Odds Ratios (OR) and 95% Confidence Intervals (CI) for Frequent Tinnitus among US Adults Aged 20-69 Years, Stratified by Presence or Absence of Low-mid Frequency and High Frequency Hearing Impairment, Derived from 5414 NHANES 1999-2004 Participants with an Audiometry Examination

		Low-mid Frequency Hearing Impairment		High Frequency Hearing Impairment	
Characteristic	% of US Population	No Multivariate-adjusted OR* (95% CI)	Yes Multivariate-adjusted OR* (95% CI)	No Multivariate-adjusted OR* (95% CI)	Yes Multivariate-adjusted OR* (95% CI)
Demographic characteristics					
Sex					
Male	48.8	Referent	Referent	Referent	Referent
Female	51.2	0.63 (0.38-1.03)	1.01 (0.59-1.73)	1.11 (0.51-2.44)	0.83 (0.54-1.28)
Age, years					
<30	21.3	Referent	Referent	Referent	Referent
30-39	23.6	1.48 (0.63-3.52)	1.03 (0.14-7.57)	1.90 (0.82-4.40)	1.03 (0.27-3.92)
40-49	24.7	2.82 (1.40-5.68)	0.86 (0.12-6.29)	1.97 (0.68-5.72)	1.55 (0.42-5.78)
50-59	18.5	5.79 (2.99-11.21)	1.20 (0.19-7.54)	1.35 (0.35-5.27)	2.75 (0.84-9.00)
60-69	11.9	4.12 (1.99-8.53)	1.08 (0.19-6.00)	0.08 (0.01-0.81)	2.30 (0.72-7.39)
Race/ethnicity					
White, non-Hispanic	70.2	Referent	Referent	Referent	Referent
Black, non-Hispanic	11.6	0.33 (0.20-0.54)	0.57 (0.30-1.07)	0.59 (0.28-1.26)	0.36 (0.21-0.62)
Hispanic	14.2	0.41 (0.22-0.76)	1.04 (0.44-2.48)	0.33 (0.13-0.85)	0.71 (0.40-1.27)
Other	4.0	0.14 (0.02-0.95)	1.29 (0.55-3.05)	0.07 (0.01-0.38)	0.72 (0.26-2.00)
Education level					
< High school	18.6	Referent	Referent	Referent	Referent
High school diploma, including GED	25.1	0.49 (0.28-0.87)	0.86 (0.33-2.20)	0.41 (0.15-1.10)	0.71 (0.37-1.36)
> High school	56.3	0.60 (0.39-0.91)	1.05 (0.50-2.19)	0.27 (0.13-0.58)	0.94 (0.56-1.55)
Cardiovascular risk factors					
Body mass index, kg/m^2					
<25	35.5	Referent	Referent	Referent	Referent
25-29	33.2	0.76 (0.48-1.19)	1.11 (0.68-1.79)	0.81 (0.41-1.57)	0.87 (0.60-1.26)
≥30	31.3	1.00 (0.61-1.64)	1.25 (0.62-2.52)	0.57 (0.23-1.40)	1.19 (0.78-1.81)
Smoking status					
Never	49.5	Referent	Referent	Referent	Referent
Former	23.8	1.41 (0.91-2.21)	1.24 (0.84-1.82)	0.65 (0.22-1.99)	1.42 (1.01-2.00)
Current	26.8	0.96 (0.61-1.52)	1.16 (0.66-2.03)	1.08 (0.45-2.59)	1.01 (0.68-1.48)
Hypertension					
No	73.1	Referent	Referent	Referent	Referent
Yes	26.9	0.91 (0.59-1.39)	1.88 (1.23-2.88)	1.03 (0.44-2.42)	1.27 (0.90-1.80)
Diabetes mellitus					
No	93.5	Referent	Referent	Referent	Referent
Yes	6.5	1.29 (0.52-3.21)	1.01 (0.60-1.70)	3.44 (0.73-16.19)	1.02 (0.58-1.79)
Dyslipidemia					
No	92.3	Referent	Referent	Referent	Referent
Yes	7.7	1.12 (0.62-2.01)	1.36 (0.72-2.57)	4.39 (0.78-24.74)	1.08 (0.76-1.52)
Noise exposure					
Leisure-time noise exposure					
No	73.3	Referent	Referent	Referent	Referent
Yes	26.7	1.71 (1.00-2.95)	1.30 (0.86-1.98)	3.12 (1.46-6.65)	1.42 (0.93-2.15)
Leisure-time firearm noise exposure					
No	92.0	Referent	Referent	Referent	Referent
Yes	8.0	1.33 (0.61-2.91)	0.80 (0.46-1.38)	0.09 (0.02-0.46)	1.44 (0.91-2.27)
Occupational noise exposure					
No	63.7	Referent	Referent	Referent	Referent
Yes	33.4	1.36 (0.89-2.10)	2.22 (1.45-3.42)	1.34 (0.72-2.50)	1.63 (1.16-2.30)
Missing	2.9	2.59 (1.12-5.98)	1.03 (0.24-4.46)	0.11 (0.02-0.60)	2.48 (1.06-5.81)

NHANES = National Health and Nutrition Examination Survey; GED = General Education Development test.

*Multivariate-adjusted model controlled for the following potential confounders: sex (male, female); age (<30, 30-39, 40-49, 50-59, 60-69, 70-79, ≥80 years); race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, other); education level (< high school, high school, > high school); body mass index (<25, 25-29, ≥30 kg/m^2); smoking status (never, former, current); history of hypertension (no, yes); history of diabetes mellitus (no, yes); taking a cholesterol lowering medication (no, yes); leisure-time noise exposure (no, yes); leisure-time firearm noise exposure (no, yes); and occupational noise exposure (no, yes, missing).

assessing the presence and quality of tinnitus among participants.

In conclusion, our results offer insight into the prevalence of tinnitus and identify potentially vulnerable groups. We have demonstrated that, although the prevalence of tinnitus is generally higher at older ages, it also is frequently reported in young adults. Likewise, the potential risk factors for developing tinnitus are significant even in the younger adults. Therefore, opportunities may exist to prevent tinnitus, starting at a younger age. As no known cure exists for tinnitus, it is important to investigate potentially modifiable risk factors for tinnitus. Future research should examine the prospective relations between smoking, hypertension, noise exposure, and mental health conditions and tinnitus.

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