The Laryngoscope

The Prevalence and Characteristics of Tinnitus in the Youth Population of the United States

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Objectives/Hypothesis: To evaluate the prevalence, characteristics, and associated risk factors of tinnitus in U.S. adolescents.

Study Design: Cross-sectional analyses of U.S. representative demographic and audiometric data, the National Health and Nutrition Examination Survey (NHANES) 2005 to 2008.

Methods: The study population consisted of 3,520 individuals aged 12 to 19 years with complete tinnitus-related data. Tinnitus was defined as the presence of ringing or buzzing in the ears lasting for at least 5 minutes during the preceding 12 months. In addition, we defined a chronic tinnitus subgroup as being bothered by tinnitus for more than 3 months. Demographic and other data regarding tinnitus, smoking, body mass index (BMI), anemia, hypertension, history of ear infections, tympanostomy tube placement, otoscopy, tympanometry and hearing thresholds, history of firearm use, and recreational and occupational exposure to noise were extracted and analyzed.

Results: Overall, tinnitus lasting 5 minutes or more in the preceding 12 months was reported by 7.5% of the 12- to 19-year-old population. This represents about 2.5 million adolescents in the United States. The prevalence of chronic tinnitus was 4.7%, corresponding to about 1.6 million adolescents in the United States. Multivariable-adjusted analysis revealed that both overall and chronic tinnitus were associated with female gender, low income, exposure to passive smoking, type A tympanogram, and occupational and recreational noise exposure. History of $\geq$3 ear infections and history of tympanostomy tube placement were associated only with overall tinnitus.

Conclusions: Tinnitus afflicts a substantial portion of the youth population. Further investigation of the association between tinnitus and the identified risk factors is warranted.

Key Words: Tinnitus, pediatric population, noise exposure, smoking, loud music, ear infection.

Level of Evidence: N/A.

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INTRODUCTION

Tinnitus is defined as a perception of sound in the absence of external stimuli. Patients often describe it as a ringing or buzzing sound in one or both ears, or even inside the head.[1,2] In a recent nationwide study in the United States, about 50 million individuals (aged 20 years or older) reported having tinnitus in the preceding 12 months, with 16 million reporting tinnitus to occur at least once a day.[3] The association of tinnitus with hearing loss that commonly manifests with increasing age has led to its popular perception as a disease of adulthood. However, the importance of tinnitus as a pediatric disorder cannot be ignored. The reported prevalence of tinnitus in previous studies varies from 7%[4] in 5 to 17 year olds to 34% in 6 to 16 year olds,[5] both in children without any type of hearing loss, and is reported in up to 66%[6] in secondary school children with moderate to severe hearing loss. Until now, studies on pediatric tinnitus have been limited to the perspective of a single institution or a small sample size, and the authenticity of these numbers has never been investigated by means of a population-based database.

Despite a relatively high prevalence in children and adolescents, tinnitus continues to be underappreciated in this population because of underreporting by youth. Although most children with tinnitus are able to describe it if questioned, they often do not proactively complain about what they commonly consider normal.[2] In other instances, adults may underestimate their complaints.[7] Although hearing loss and noise exposure are known risk factors for tinnitus,[3] characteristics and other potential risk factors for tinnitus in the youth population have not been studied well.

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With the emergence and the ubiquity of digital music players and subsequent early-onset hearing loss among the youth population,[8,9] the need to study the prevalence and risk factors for tinnitus in the youth population is more critical than ever. In the current study, we aimed to investigate the prevalence, characteristics, and associated risk factors of tinnitus using a nationally representative population of 12 to 19 year olds by merging the recent datasets of the National Health and Nutrition Examination Survey (NHANES) 2005 to 2006 and 2007 to 2008.

MATERIALS AND METHODS

Datasets

The NHANES is performed and supervised by the National Center for Health Statistics (NCHS) of the Center for Disease Control and Prevention (CDC). The NHANES is an ongoing nationwide survey of noninstitutionalized population of the United States with a sophisticated level of standardization and quality control. Participants are selected based on their age, gender, and racial/ethnic background through a complex statistical process using the most current census information. In simple terms, NHANES divides the United States into communities, neighborhoods, and households. After randomization, households are selected and interviewed to determine their eligibility. Individuals who agree to participate will complete several questionnaires, examinations, and laboratory test components. Documentation of the NHANES instruments, methodologies, and data files that served as the basis for this study is available elsewhere.[10–12] This study was reviewed by the Institutional Review Board at our institution and considered as exempt due to its use of public de-identified data.

Study Population

The tinnitus-related component of the surveys was inquired only from the participants aged 12 years or older during 2005 to 2006, and from the participants aged 12 to 19 years during 2007 to 2008 (4,396 participants). Participants older than 19 years from 2005 to 2006 were removed, leaving 3,526 records. Those with missing tinnitus data were excluded before the analysis.

Tinnitus Assessment

NHANES 2005 to 2008 contained five direct questions about tinnitus. The presence of tinnitus was defined as responding "yes" to the question: "In the past 12 months, have you been bothered by ringing, roaring, or buzzing in your ears or head that lasts for 5 minutes or more?" This question was followed by "How long have you been bothered by this ringing, roaring, or buzzing in your ears or head?" Chronic tinnitus was defined as tinnitus duration of 3 months or more. The next two questions concerned the exacerbation of ringing after loud music and difficulty in sleeping due to tinnitus. The last question inquired: "How much of a problem is this ringing, roaring, or buzzing in your ears or head?" Mild tinnitus was defined as responding "no problem" or "a small problem," moderate tinnitus as responding "a moderate problem," and severe tinnitus as responding "a big problem" or "a very big problem" to the last question.

Hearing Components

After a thorough search of the literature, the following variables were extracted from the hearing components of the datasets: History of 3 or more ear infections, history of tympanostomy tube placement, firearm noise exposure, occupational and recreational noise exposure, otoscopy, tympanometry, and hearing thresholds.

Three different noise exposure data were available: 1) Job exposure to noise was defined as ever exposure to loud noise at work for 5 or more hours a week. 2) Firearms noise exposure was considered positive if they have ever used firearms for target shooting, hunting, or for any other purposes. 3) Recreational noise exposure was characterized as ever exposure to steady loud noise or music for 5 or more hours a week outside of a job. These noise exposure variables and their definitions were provided by the NHANES and were used without any changes.

Audiometric examinations were performed by the NHANES staff in a soundproof room in the Mobile Examination Center (MEC). Earscan acoustic impedance tympanometer (Micro Audiometrics, Murphy, NC) and Interacoustics Model AD 226 microprocessor audiometer (Interacoustics, Assens, Denmark) with standard TDH-39 (Telephonics, Farmingdale, NY) and insert EarTone 3A (Etymotic Research, Elk Grove Village, IL) earphones were used. Detailed information on the instrumentation, technique and calibration methods has been previously released.[13]

Otoscopy results were categorized into normal and abnormal. Abnormal results included the presence of excessive cerumen; impacted cerumen; collapsed ear canals; and deformed, scarred, perforated or infected tympanic membranes. Tympanograms of the participants were classified into normal (type A in both ears) and other. Type A tympanogram was defined using the Jerger criteria[14] where the middle ear pressure was between -99 and $+50$ daPa and the compliance was between 0.3 and 1.6 cc.

Hearing thresholds were obtained at 0.5, 1, 2, 3, 4, 6, and 8 kHz. The audiometry protocol included a retest measurement at 1 kHz. If the test retest difference in a certain record was 10 dB or more, it was considered to be unreliable and coded as missing. For analysis purposes, a hearing threshold of 15 dB was considered to be abnormal as used by Niskar et al.[15] Low-frequency hearing loss was considered present when the average thresholds at 0.5, 1, and 2 kHz was >15 dB. Similarly, average of 3, 4, 6, and 8 kHz thresholds was used to define high-frequency hearing loss. Normal hearing was defined as all thresholds less than or equal 15 dB.

Sociodemographic and Health-Related Components

After a thorough search of the literature, the following demographic and health-related risk factors were extracted to determine if they were associated with tinnitus: age, gender, ethnicity, family income, cigarette smoking history, exposure to passive smoking at household, body mass index (BMI), blood pressure, and hemoglobin.

We categorized the age of the participants into 12- to 15- and 16- to 19-year-old ranges. Race/ethnicity was recoded as Caucasian (non-Hispanic), African-American (non-Hispanic), Hispanic (Mexican-American and other Hispanic ethnicities), and other (including multiracial). The effect of family income was studied using the poverty/income ratio (PIR). The PIR was calculated by dividing the family income by the poverty guidelines, specific to family size, as well as the appropriate year and state. The NHANES reported PIR was recoded according to the U.S. Department of Agriculture (USDA) food assistance program eligibility cut points as low (PIR less than or equal to 1.3), middle (PIR between 1.31 up to 3.5), and high (PIR more than 3.51).[16] Smoking history was considered positive if the

participant's response was yes when asked if they have ever tried cigarette smoking. Similarly, passive smoking was considered positive if they answered yes to the question "Does anyone smoke inside the home?" BMI was categorized into two groups: less than 25, and equal or more than 25. For each participant, blood pressure was measured at least three times. Hypertension was defined as an average systolic blood pressure more than 130 mmHg. The reported hemoglobin reference range was 11.9 to 16.9 for males and 11.2 to 15.1 for females. Respective values less than the lower limits were considered anemic. Results of the three lab tests were classified according the reference ranges provided by the NHANES.

Statistical Analysis

NHANES reported an adjusted sample weight for each participant based on the complex probabilities of an individual being selected. This sample weight was applied to all statistical analyses. The prevalence and 95% confidence intervals (CI) were calculated for overall and chronic tinnitus and their attributes. Multivariable-adjusted logistic regression was used to calculate odds ratio (OR) for each independent variable and adjusting for all others. The Hosmer and Lemeshow Goodness-of-Fit test was calculated for both the overall and the chronic tinnitus logistic regression analyses. This test is similar to a chi-square test, and indicates the extent to which the model provides a better fit than a null model with no predictors. If the Goodness-of-Fit test is not significant, then the model has adequate fit. A P value of less than 0.05 was considered as level of significance. Statistical analyses were performed using the SAS 9.3 for Windows (SAS Institute Inc., Cary, NC).

RESULTS

After excluding six subjects with missing tinnitus data, 3,520 records comprised the analytic sample (mean age 15.5 years±2.27 SD). Overall, 7.5% of the 12- to 19-year-old participants (95% CI: 5.9–9.2) reported having tinnitus that lasted for 5 minutes or more during the preceding 12 months. The prevalence of chronic tinnitus (more than 3 months) was 4.7% (95% CI: 3.6–5.8). Using the NCHS-provided weights, these percentages extrapolated to 2,523,245 (95% CI: 1,925,105–3,121,385) individuals aged 12 to 19 years with at least one episode of tinnitus. This condition was chronic in 1,567,531 (95% CI: 1,159,580–1,975,483) individuals.

Table I lists the demographics and characteristics of tinnitus in the study sample. Among adolescents with tinnitus, 61.8% were 16 to 19 years old, and 56.9% were females. Tinnitus was moderate or severe in 15.7%; existed for less than 3 months in 37.2%; and was associated with hearing loss in 23.6% and normal hearing thresholds in 76.4%. Exacerbation after loud music and difficulty sleeping existed in 30.3% and 26.4% of adolescents with tinnitus, respectively.

Table II presents the results of unadjusted analysis of tinnitus and its potential risk factors. The analysis revealed that both overall and chronic tinnitus were more prevalent in the subjects with: age of 16 to 19 years, female gender, cigarette smoking history, exposure to passive smoking, history of three or more ear infections, history of tympanostomy tube placement, and occupational and recreational noise exposure. In addition, overall tinnitus was more prevalent in adolescents coming from lower income families.

TABLE I.
Demographics and Characteristics of U.S. Adolescents Aged 12–19 Years With Tinnitus: NHANES 2005–2008.

	Frequency (% 95 confidence interval)
Age	
12–15 years	38.2% (29.7–46.8)
16–19 years	61.8% (53.2–70.3)
Gender	
Female	56.9% (50.2–63.5)
Male	43.1% (36.5–49.8)
Tinnitus duration	
Less than 3 months	37.2% (29.6–44.9)
3 months to 1 year	19.6% (11.0–28.2)
1 to 4 years	22.7% (15.5–29.9)
More than 5 years	20.5% (14.2–26.7)
Exacerbation after loud music	
No	69.7% (59.7–79.7)
Yes	30.3% (20.3–40.3)
Difficulty sleeping	
No	73.6% (66.0–81.3)
Yes	26.4% (18.7–34.0)
Severity	
Mild	84.1% (77.0–91.1)
Moderate	14.2% (7.5–21.0)
Severe	1.7%*
Hearing thresholds	
Normal	76.4% (66.6–86.2)
Low or high frequency hearing loss	23.6% (13.8–33.3)

*Unreliable estimate (sample size <30 or relative standard error ≥0.3).
NHANES=National Health and Nutrition Examination Survey.
Missing values: tinnitus onset=3; exacerbation after loud music=3; hearing thresholds=25.

In the multivariable-adjusted analysis, as shown in Table III, only some of the above risk factors were associated with higher odds of overall and chronic tinnitus. Males had lower odds of reporting both overall tinnitus (OR 0.58, 95% CI: 0.39–0.86) and chronic tinnitus (OR 0.46; 95% CI: 0.25–0.85). Likewise, the adolescents from high income families had lower odds of reporting both overall tinnitus (OR 0.39; 95% CI: 0.22–0.70) and chronic tinnitus (OR 0.49; 95% CI: 0.26–0.91). Passive smoking was associated with higher odds of reporting both overall tinnitus (OR 1.95; 95% CI: 1.23–3.11) and chronic tinnitus (OR 1.76; 95% CI: 1.00–3.10). The adolescents with history of ear infections and tympanostomy tube placement had increased odds of reporting tinnitus (OR 1.95; 95% CI: 1.21–3.12 and OR 2.19; 95% CI: 1.08–4.45, respectively). The odds of chronic tinnitus increased as well, but were not statistically significant. The odds of overall and chronic tinnitus were higher among those with recreational noise exposure (OR 2.08; 95% CI: 1.35–3.18 and OR 2.17: 95% CI: 1.30–3.62, respectively). Finally, abnormal tympanogram was associated with lower odds of reporting overall and chronic

TABLE II.
Prevalence and Characteristics of Overall and Chronic Tinnitus Among U.S. Adolescents Aged 12–19 Years With and Without Potential Risk Factors (significant *P* values are bold).

Variables		Frequency in Sample Population (%)	Prevalence of Overall Tinnitus, % (% 95 CI)	*P* Value	Prevalence of Chronic Tinnitus, % (% 95 CI)	*P* value
Age groups (years)						
	12–15	50.9%	5.7% (3.7–7.6)		3.0% (1.8–4.1)	
	16–19	49.1%	9.5% (7.2–11.8)	**0.01**	6.5% (4.4–8.5)	**0.006**
Gender						
	Female	49.0%	8.7% (6.4–11.1)		5.7% (4.0–7.3)	
	Male	51.0%	6.4% (4.9–7.9)	**0.02**	3.8% (2.7–4.8)	**0.02**
Ethnicity						
	Caucasian	61.6%	8.3% (6.0–10.5)		5.4% (3.9–6.8)	
	African-American	15.1%	6.1% (4.6–7.7)		3.2% (2.0–4.4)	
	Hispanic	17.2%	7.6% (5.3–9.9)		4.0% (2.1–5.9)	
	Other (including multiracial)	6.1%	3.5%*	0.07	3.4%*	0.1
Income						
	Low (PIR $\leq$1.3)	28.5%	9.6% (6.8–12.4)		5.8% (3.7–8.0)	
	Middle (1.3 $<$PIR $\leq$3.5)	36.3%	8.2% (4.9–11.5)		4.8% (2.9–6.8)	
	High (PIR $>$3.5)	35.2%	4.7% (3.2–6.2)	**0.01**	3.5%*	0.2
Cigarette smoking						
	No	63.5%	6.1% (4.3–8.0)		3.8% (2.4–5.2)	
	Yes	36.5%	10.7% (7.9–13.5)	**0.003**	6.4% (4.4–8.3)	**0.04**
Passive smoking						
	No	80.6%	6.1% (4.6–7.5)		3.7% (2.6–4.7)	
	Yes	19.4%	13.0% (7.9–18.1)	**0.001**	8.1% (4.8–11.4)	**0.004**
History of 3 or more ear infections						
	No	61.5%	5.0% (3.8–6.3)		3.2% (2.0–4.5)	
	Yes	38.5%	11.2% (7.6–14.8)	**0.0002**	6.7% (4.3–9.1)	**0.009**
History of tympanostomy tube						
	No	88.5%	6.3% (5.0–7.7)		3.8% (2.7–4.8)	
	Yes	11.5%	15.3% (7.2–23.3)	**0.001**	10.1%*	**0.001**
Firearm noise exposure						
	No	74.3%	7.0% (5.3–8.7)		4.4% (2.8–5.5)	
	Yes	25.7%	8.9% (5.5–12.4)	0.2	6.3% (3.8–8.8)	0.1
Job exposure to loud noise						
	No	90.8%	6.9% (5.1–8.7)		4.3% (3.1–5.5)	
	Yes	9.2%	13.6% (9.0–18.2)	**0.004**	8.6%*	**0.01**
Recreational noise exposure						
	No	74.4%	5.0% (3.7–6.3)		3.0% (2.0–4.0)	
	Yes	25.6%	14.8% (10.7–18.9)	**<0.0001**	9.5% (7.2–11.9)	**<0.0001**
BMI (kg/m^2)						
	BMI $<$25	69.2%	7.4% (5.5–9.2)		4.2% (3.0–5.4)	
	25 $\leq$BMI	30.8%	8.17% (6.3–10.1)	0.3	5.8% (3.9–7.8)	0.1
Hypertension						
	No	96.6%	4.5% (5.8–9.1)		4.6% (3.5–5.6)	
	Yes	3.4%	9.9%*	0.3	4.8%*	0.8
Otoscopy						
	Normal	83.7%	7.3% (5.4–9.1)		4.6% (3.3–5.9)	
	Abnormal	16.3%	9.3% (5.9–12.6)	0.2	4.8%*	0.8
Tympanometry						
	Type A	81.9%	7.7% (5.9–9.6)		4.7% (3.5–5.9)	
	Other types	18.1%	7.3% (4.1–10.5)	0.8	4.5 (2.4–6.7)	0.8

TABLE II.
(*Continued*)

Variables		Frequency in Sample Population (%)	Prevalence of Overall Tinnitus, % (% 95 CI)	*P* Value	Prevalence of Chronic Tinnitus, % (% 95 CI)	*P* value
Low frequency hearing loss						
	No	90.7%	7.4% (5.7–9.2)		4.5% (3.5–5.5)	
	Yes	9.3%	9.9%*	0.1	6.3%*	0.2
High frequency hearing loss						
	No	82.9%	7.1% (5.2–9.1)		4.1% (2.9–5.3)	
	Yes	17.1%	10.1% (5.0–14.3)	0.1	7.5% (3.8–11.1)	0.05
Anemia						
	No	98.2%	7.7% (5.8–9.6)		4.8% (3.5–6.1)	
	Yes	1.8%	18.0%*	0.09	14.7%*	0.1

*Unreliable estimate (sample size <30 or relative standard error ≥0.3).
BMI=body mass index; CI=confidence interval.
Prevalence of overall and chronic tinnitus within each exposure factors are row percentages.

tinnitus (OR 0.53; 95% CI: 0.32–0.87 and OR 0.49; 95% CI: 0.27–0.89). The Hosmer and Lemeshow Goodness-of-Fit test for overall and chronic tinnitus was 0.936 and 0.417, respectively, indicating a good fit for the model assumptions.

DISCUSSION

The prevalence of overall and chronic tinnitus among 12 to 19 year olds in the United States was 7.5% and 4.7%, respectively, corresponding to about 2.5 and 1.6 million individuals. The prevalence of tinnitus in the pediatric population has been investigated in a few epidemiological studies before. In a sample of 7-year-old Swedish children, the prevalence of tinnitus has been reported to be 12%.[17] In a study by Aksoy et al., 15.1% of 6- to 16-year-old school students reported to have tinnitus.[18] In both studies, tinnitus was defined as ever having noise in the head or ear. Mills et al. studied a sample of British children attending routine school and community medical examination and found that tinnitus was present in 29% of them.[19] Although the prevalence of both overall and chronic tinnitus in this study was lower than the previous reports, it is difficult to make a direct comparison due to the differences in subjects' age bracket and definition of tinnitus. These numbers still represent a substantial subset of the youth population. Given the NHANES sampling process, it may be a true representation of the prevalence in the United States.

Moderate or severe tinnitus was present in 15.9% of those who suffered from tinnitus, which is comparable to the 12% reported by Savastano[5] on a sample of 1,100 Italian children of 6 years and older. In the current study, we found that 76.4% tinnitus sufferers had normal hearing. Tinnitus exacerbation after loud music occurred in 30.3%, difficulty in sleeping in 26.4%, and hearing loss in 23.6%. These percentages exceed those reported by Aksoy et al.,[18] where nighttime tinnitus and hearing loss were present in 14.9% and 5.2%, respectively.

Unadjusted analysis of the demographic data points showed that the prevalence of tinnitus was higher among older, female, and low income adolescents. Female gender and low family income remained associated with tinnitus throughout the multivariable-adjusted analysis as well. This higher prevalence of tinnitus among certain subsets of the youth population is probably secondary to the high rate of listening to loud music among these subsets of youth population. A recent study demonstrated an increased incidence of high-frequency hearing loss and tinnitus among females of low economic status.[20] Higher rate of listening to loud music among female adolescents has been established before,[21,22] and it may also be the case for the adolescents from low income families. These findings warrant further investigations as some studies did not find such associations.[18,23]

Interestingly, the unadjusted analysis revealed that both overall tinnitus and chronic tinnitus were more prevalent in adolescents who smoked or were passively exposed to smoking. Furthermore, exposure to passive smoking remained highly associated with tinnitus through the multivariable-adjusted analysis. Data regarding the association between cigarette smoking and tinnitus is sparse. A few studies have found higher prevalence of tinnitus among smoker adults.[3,24] Smoking has also been linked to hearing loss in adults,[25] and vascular diseases are suggested to contribute to the pathology. However, the association between tinnitus, hearing loss, and smoking in the pediatric population remains controversial. One previous study has reported higher prevalence of tinnitus among 15- to 16-year-old smoker students,[26] but such association has not been reported previously in the case of passive smoking.

Both overall and chronic tinnitus were more prevalent in adolescents with history of occupational and recreational noise exposures in the unadjusted analysis. Only recreational noise exposure remained associated with higher odds of having tinnitus in the multivariable-

TABLE III.
Multivariable-Adjusted Analysis of Overall and Chronic Tinnitus Among Adolescents Aged 12–19 Years With and Without Potential Risk Factors (significant differences are bold).

Variables		Overall Tinnitus Odds Ratio (% 95 CI)	Chronic Tinnitus Odds Ratio (% 95 CI)
Age Groups (years)			
	12–15	1	1
	16–19	1.43 (0.82–2.48)	1.86 (0.87–3.98)
Gender			
	Female	1	1
	Male	**0.58 (0.39–0.86)**	**0.46 (0.25–0.85)**
Ethnicity			
	Caucasian	1	1
	African-American	0.79 (0.52–1.21)	0.61 (0.33–1.11)
	Hispanic	1.26 (0.79–2.00)	0.79 (0.40–1.56)
	Other (including multiracial)	0.54 (0.20–1.47)	0.81 (0.25–2.58)
Income			
	Low (PIR $\leq$1.3)	1	1
	Middle (1.3 $<$PIR $\leq$3.5)	0.81 (0.47–1.38)	0.72 (0.38–1.37)
	High (PIR $>$3.5)	**0.39 (0.22–0.70)**	**0.49 (0.26–0.91)**
Cigarette smoking			
	No	1	1
	Yes	1.21 (0.74–1.98)	0.96 (0.47–1.97)
Passive smoking			
	No	1	1
	Yes	**1.95 (1.23–3.11)**	**1.76 (1.00–3.10)**
History of 3 or more ear infections			
	No	1	1
	Yes	**1.95 (1.21–3.12)**	1.48 (0.82–2.68)
History of tympanostomy tube			
	No	1	1
	Yes	**2.19 (1.08–4.45)**	2.05 (0.94–4.48)
Firearm noise exposure			
	No	1	1
	Yes	1.01 (0.59–1.73)	1.07 (0.58–1.97)
Job exposure to loud noise			
	No	1	1
	Yes	1.07 (0.56–2.06)	1.21 (0.57–2.60)
Recreational noise exposure			
	No	1	1
	Yes	**2.08 (1.35–3.18)**	**2.17 (1.30–3.62)**
BMI (kg/m^2)			
	BMI $<$25	1	1
	25 $\leq$BMI	1.07 (0.83–1.39)	1.35 (0.85–2.14)
Hypertension			
	No	1	1
	Yes	1.00 (0.57–1.78)	1.00 (0.46–2.16)
Anemia			
	No	1	1
	Yes	1.40 (0.41–4.79)	1.92 (0.52–7.03)
Otoscopy			
	Normal	1	1
	Abnormal	1.52 (0.96–2.42)	1.32 (0.73–2.41)

TABLE III.
(*Continued*)

Variables		Overall Tinnitus Odds Ratio (% 95 CI)	Chronic Tinnitus Odds Ratio (% 95 CI)
Tympanometry			
	Type A	1	1
	Other types	**0.53 (0.32–0.87)**	**0.49 (0.27–0.89)**
Low frequency hearing loss			
	No	1	1
	Yes	1.00 (0.54–1.86)	1.05 (0.48–2.30)
High frequency hearing loss			
	No	1	1
	Yes	1.10 (0.60–2.02)	1.71 (0.81–3.61)

Missing Values: income=234; cigarette smoking=405; passive smoking=41; BMI=149; hypertension=267; anemia=459; history of 3 or more ear infections=27; history of tympanostomy tube=17; firearm noise exposure=1; recreational noise exposure=2; otoscopy=335; tympanometry=375; low frequency hearing loss=368; high frequency hearing loss=368.

BMI=body mass index; CI=confidence interval.

adjusted analysis. This finding emphasizes the need to further study the impact of noise on hearing condition of youth population as stated above, especially listening to loud music (mp3 players, concerts, etc.), that has been found to worsen during the last decade.[27–29] The increased prevalence of tinnitus in adolescents with recreational noise exposure is of great importance due to its preventability. Promotion of hearing health in schools, including hearing-loss prevention education as recommended by CDC, could help to reduce the prevalence of both hearing loss and tinnitus over time.[30]

Traditionally, tinnitus in younger populations is thought to have a larger share of etiologies, such as congenital abnormalities of the inner ear, eustachian tube dysfunction, otitis media, cerumen impaction or foreign bodies in external ear canal, and ototoxic medication.[31] In our unadjusted analysis, both tinnitus categories were more prevalent among those who had a history of three or more ear infections or tympanostomy tube placement. However, the multivariable-adjusted analysis revealed that they were less likely to cause chronic tinnitus. Abnormal findings on otoscopy and audiometry were not associated with tinnitus. Hearing loss occurs mostly due to noise and aging, and it appears to be of less significance in the youth tinnitus as shown by other studies as well.[18] Adolescents with bilateral type A tympanogram were more likely to report both overall and chronic tinnitus. Although the tympanogram would generally reflect recent pathologies, it maybe hypothesized that engaging in regular listening to music and the passage of acoustic energy to the inner ear is more likely in adolescents with normal middle ear pressure. A thorough search of literature was unable to find similar findings in other studies, and this remains to be investigated in future.

The primary limitation of the current study is that the tinnitus survey content of the NHANES does not include audiometric analysis of tinnitus. Ideally, this survey would include data on lateralization, pitch, and loudness of the tinnitus and other psychoacoustic assessments. Another limitation to the current study was that the anxiety and depression data were not obtained from the participants aged 12 to 19 years during the NHANES 2005–2006 and 2007–2008. Given the association of anxiety and depression with tinnitus, data on this would have further elucidated the burden of the condition. During 1999–2004, the NHANES inquired about ever having tinnitus, while in 2005–2008 this was replaced with asking about being bothered by tinnitus. This difference in definition may limit the comparability of this study with others. The comprehensive multivariable nature of the NHANES (consisting of several questionnaires, examinations, and tests) makes it difficult to measure every variable for subspecialty conditions. Despite these limitations, the NHANES benefits from being a nationally representative sample of the U.S. population, and facilitates a systematic epidemiological study of tinnitus in youth population.

It is difficult to determine the actual burden of tinnitus in the pediatric population because its documentation is uncommon.[1] Tinnitus in children and adolescents may not be a debilitating condition as it could be in the elderly. However, it is believed that tinnitus in adolescents can present with or worsen due to problems with sleep[18] and social, educational,[32] and behavioral[23] issues. Therefore, a comprehensive approach to pediatric tinnitus should address all of these conditions. The current study establishes a foundation for broader and longitudinal studies of pediatric tinnitus in the future. Further efforts should focus on finding effective and preventative solutions to the current dilemma that could easily affect the health and productivity of adolescents.

CONCLUSION

Approximately, 2.5 million individuals aged 12 to 19 years in the United States have experienced at least one episode of tinnitus, and this condition is chronic in about 1.6 million individuals in the same age category. Exacerbation after loud music and difficulty sleeping exist in almost one-third of adolescents with tinnitus. Major risk factors for chronic tinnitus are female gender, low family

income, passive smoking, and recreational noise exposure.

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