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Noise-Induced Hearing Threshold Shift among U.S. Adults and Implications for Noise-Induced Hearing Loss: National Health and Nutrition Examination Surveys

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Abstract

Objectives—To estimate the prevalence and risk factors for Noise-Induced Hearing Threshold Shift (NITS) in the U.S. adult population based on the National Health and Nutrition Examination Surveys (NHANES).

Methods—This study population consisted of 5,418 individuals aged 20 to 69 years who had complete audiologic data from the NHANES database. Stringent criteria were used to define NITS. Prevalence of unilateral, bilateral and total NITS and their association with several sociodemographic and hearing related factors were evaluated.

Results—The prevalence of unilateral, bilateral and total NITS was 9.4%, 3.4% and 12.8% respectively. Prevalence of bilateral NITS was higher in subjects with older age, male gender, white (non-Hispanic) and Hispanic ethnicities, education level less than or equal to high school diploma, married/living with partner status, Mexico as country of birth, service in armed forces, smoking history, diabetes and different kinds of noise exposure. Odds of NITS were only higher in older people, males and smokers.

Conclusion—This study provides comprehensive information on the prevalence of NITS in the U.S. adult population and within the various risk factors. More targeted interventions may be done for educational, preventative, and screening purposes.

Keywords

Noise-Induced Hearing Threshold Shift; Noise-Induced Hearing Loss; National Health and Nutrition Examination Surveys; Audiometric notch

INTRODUCTION

It is estimated that one in ten people worldwide has some type of hearing loss, and that approximately 28 million Americans are affected by this chronic condition. Among all types of hearing loss, Noise-induced hearing loss (NIHL) is the most significant preventable cause in the United States [1], similarly to what is noticeable in many industrial countries.

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Conflict of interest: None

According to the National Institute of Occupational Safety and Health (NIOSH), it is among the top ten work-related problems, and has further been classified by the World Health Organisation (WHO) as the greatest compensable occupational hazard [2]. Multiple population-based studies have been performed to identify trends in hearing loss and potential risk factors in specific subgroups [3, 4]. The National Health and Nutrition Examination Surveys (NHANES) by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC) are a nationally representative dataset collected on a continuous basis with sophisticated levels of standardization and quality control measures unlikely to be matched. The NHANES involve a complex stratified probability design, which is used to examine a nationally representative sample of the United States non-institutionalized civilian population. All surveys, examination, and laboratory measures are collected in a standardized format by a large staff of trained interviewers, technicians and physicians. Additional information regarding the NHANES sampling procedures is readily available at National Center for Health Statistics website.

Noise-induced Hearing Threshold Shift (NITS) is the first sign of NIHL, which appears in audiometry as a notch, and is caused by inner ear's hair cell damage due to environmental noise exposure (occupational, firearms, stereos, toys, etc). Spurious notches are pitfalls of NITS and they lead to misdiagnosis with current methods. NITS is usually defined as an audiometric notch at 3, 4 or 6 kHz and can be transitory or permanent and could be unilateral or bilateral, in contrast to NIHL that is generally bilateral [5]. This study is the first to estimate the prevalence of NITS among various demographic groups of adults using the NHANES datasets, by combining three datasets of NHANES conducted from 1999–2004. With an improved understanding of the significance of NITS, its prevalence and associated factors, more educational, preventive and screening purposes can be enforced.

METHODS

Study Population

Initially, 31,126 individuals were surveyed in NHANES 1999–2004 periods. During these 6 years, audiometric examination was only performed on a subsample of subjects aged 20 to 69 years. The database included 12,054 participants between 20 and 69 years of age. Of these, 5,742 were invited to the examination component of the surveys. From these, 5,418 participants had near complete audiometric measurements and therefore were included in our statistical model. The following demographic and hearing related variables and data that have effect or are suspected to have effect on hearing thresholds were extracted: age, sex, ethnicity, income, education, marital status, country of birth, veteran/military status, smoking history, diabetes and noise exposure (occupational, firearms, and recreational noise).

Although only approximately 16% of the total number of subjects surveyed between 1999 and 2004 had adequate audiometric data to be included in the analyses, there were no significant differences between the study group and the rest of the population regarding the variables of interest. This study was approved by the Institutional Review Board.

Audiometric Measurements

Audiometric variables were measured in a specifically designed and equipped Mobile Examination Center (MEC) soundproof room (that travels to survey locations throughout the country). The Interacoustics Model AD 226 microprocessor audiometer was used to obtain air conduction thresholds on all subjects. Air conduction thresholds were measured at 0.5, 1, 2, 3, 4, 6, and 8 kHz from −10 to 120 dB by a trained technician. The protocol included a second measurement at 1 kHz to ensure the test-retest reliability. Therefore, those participants whose absolute value difference between the first and second pure tone audiometry results at 1 kHz was greater than 10 dB for either ear were excluded. This would ensure exclusion of subjects with inconsistency in their responses. A threshold was defined as the lowest intensity signal that would be detected at least 50% of the time after a minimum of three trials (ISO 8253-1). Demographic data were collected at the time of the initial standardized interview. Further details of the measurement techniques have been published at National Center for Health Statistics website [http://www.cdc.gov/nchs/data/nhanes/nhanes_03_04/AU.pdf].

To define NITS, we used a novel and more stringent criteria than usual ones. We considered a notch to be present when each of these criteria was met: 1. The 4 kHz threshold was worse than 20 dB HL (i.e., 25 dB HL or worse); and 2. The 4 kHz threshold was at least 10 dB worse than the 2 kHz threshold; and 3. The 4 kHz threshold was at least 10 dB worse than the 8 kHz threshold. Based on presence of such notch, participants were assigned to unilateral or bilateral NITS, and a total NITS positive group including both was calculated. Furthermore, bilateral NITS was considered as the basis for analysis of NIHL.

Demographic and Hearing Related Variables

Age of participants was categorized in 10-year intervals. Race/ethnicity was re-coded as White (non-Hispanic), Black (non-Hispanic), Hispanic (Mexican-American and other Hispanics) and other race (including multiracial). Income was categorized, based on calculated poverty/income ratio (PIR) in NHANES, into low (PIR less than or equal to 1.3), middle (PIR between 1.4 up to 3.5) and high (PIR more than 3.5). Education was classified into less than high school, high school diploma (includes certificate of General Educational Development, GED, an equivalent degree for those who have not passed high school), and post-secondary. Marital status was recoded into married/living with partner and single (never married, divorced, separated or widowed). Country of birth was categorized into born in the United States, Mexico, and any other location. Service in the armed forces and other hearing related variables were all re-coded into yes/no categories.. Smoking history was considered positive (yes) when the participant's answer was yes to any of the following questions: Smoked at least 100 cigarettes or 20 cigars/pipes/snuff/chewing tobaccos in life. Diabetes status was considered positive if the patient self-reported it or had fasting plasma glucose of equal or more than 126 mg/dL.

Three different noise exposure data were available from the NHANES datasets. Occupational noise was defined as exposure to loud noise at work for at least three months (Occupational noise exposure data were not available from the 2003–2004 NHANES datasets). Firearms noise was identified as exposure to firearms, outside of work, for an average of once a month for an entire year. Recreational noise was characterized as exposure to loud noise, outside of work, such as from power tools or loud music for an average of at least once a month for an entire year. A total noise exposure was also defined when a participant had a positive history of any of above three noise exposure variables.

Statistical Analysis

The prevalence of unilateral, bilateral and total NITS was calculated among total subjects between the ages of 20 to 69 years and within various sociodemographic characteristics, noise exposure and hearing related factors. Age, sex, ethnicity, income, education, marital status, country of birth, service in armed forces, smoking history, diabetes and noise exposures were defined as independent variables, while NITS variables were considered as the binary, dependent variables. Multivariate logistic regression was used to calculate odds ratio for each independent variable, adjusting for all others was made. A p value <0.05 was

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considered as statistically significant. Statistical analyses were performed using the PASW Statistics 18.0 for Windows (SPSS Inc., Chicago, IL).

RESULTS

Data from 12 subjects were excluded because of inconsistency in their responses to test, or retest pure tone audiometry at 1 kHz. This yielded a total sample size of 5406 subjects with complete audiometric testing that entered the statistical analysis. The prevalences of unilateral, bilateral and overall NITS in the whole population were 9.4% (95% confidence interval: 8.62–10.17), 3.4 (95% confidence interval: 2.91–3.88) and 12.8% (95% confidence interval: 11.90–13.69), respectively. Prevalences of bilateral NITS were higher than total population in subjects with: 40–49, 50–59 and 60–69 years old age, male gender, white (non-Hispanic) and Hispanic ethnicities, education level less than high school diploma, Mexico as country of birth, service in armed forces, smoking history, diabetes, and occupational and those with any kind of noise exposures. Detailed prevalence of NITS within each variable is shown in Table 1.

Multivariate analysis revealed that increase in age has a strong linear association with all types of NITS (Table 2). Male gender was significantly associated with higher odds of all types NITS. Positive history of smoking also significantly increased odds of bilateral and overall NITS. Post-secondary education, black (non-Hispanic), Hispanic and ethnicities other than white (non-Hispanic) had lower odds in some types of NITS. Income, marital status, country of birth, service in arm forces, diabetes and exposure to any of noise categories were not associated with significant higher odds. Detailed multivariate analysis is shown in Table 2.

DISCUSSION

The diagnosis of NIHL requires the presence of NITS in the context of noise exposure. NITS is traditionally defined as an audiometric notch at 3, 4, or 6 kHz [4, 6]. Although, this definition is useful for NITS screening purposes it is insufficient as criteria for NIHL and may lead to false positive results in that context [7]. The underlying issue here is the presence of spurious notches (especially at 6 kHz) or other causes for threshold shifts (head injury, genetic disorders, idiopathic, etc). The spurious notch at 6 kHz has been thought to be associated with the calibration issues of that frequency on the devices used for testing [7]. Therefore, we sought to address this concern, by using criteria that are more stringent for calculation of NITS without considering the threshold at 6 kHz. The criteria are based on the senior author’s 10 years of experience in the diagnosis of NIHL where a consistent notch with a minimum depth of 10 dB can be found in nearly all patients with NIHL at 4 kHz. It is also noteworthy that we did not equate all audiometric notches (unilateral and bilateral) with NIHL. Where inference about NIHL was made, we only considered presence of bilateral notches to exclude possible spurious notches. A limitation with almost all of NITS studies is that the presence of presbycusis will efface the notch, especially at 8 kHz and even though guidelines have been developed to detect such effacement, still distinguishing a noise-induced component in people with presbycusis is not definitive [6].

The prevalence of NITS, using our criteria, was 12.8% among the U.S. population of 20–69 year old, which corresponds to approximately 23 million Americans based on 2000 U.S. Census Bureau. This includes 9.4% unilateral and 3.4% bilateral cases. Looking at Table 1, we observe that prevalence of bilateral NITS are higher within several sub-populations. These include subjects in age groups 30–39, 40–49, 50–59 and 60–69 years, male gender, non-Hispanic white and Hispanic ethnicities, education level less than high school diploma, Mexico as country of birth, service in armed forces, smoking history and history of noise exposure. This emphasizes the importance of preventive strategies for these groups. Our data showed that the prevalence of bilateral and overall NITS in total population rises slightly from early to middle adulthood and decreases in late adulthood (Table 1). These trends are in agreement with the cumulative effect of noise exposure on hearing early in life and the masking effect of presbycusis, as previously discussed. The prevalence of NIHL varies depending on the specific study population [8]. Parving et al. assessed the prevalence of NIHL to be 45%, but considered a population of Danish men limited to 49 to 69 years of age and only included males exposed to industrial noise [9]. In our study, the prevalence of bilateral NITS among a nation-wide sample of 20–69 years old adults was 3.4%. As we discussed above, diagnosis of NIHL depends on presence of bilateral NITS and positive history of noise exposure (when there is no evident complicating factor or diagnostic competitors, e.g., presbycusis or genetic hearing loss). As seen in Table 1, prevalence of bilateral NITS among subjects with positive history of any kind of reported noise exposures was 5.1%. Considering the fact that in large surveys, questions might be too broad or some participants might not recall the proper history (recall or systematic bias), it is difficult to calculate the exact prevalence of NIHL. The more conservative method would be to consider the prevalence of bilateral NITS in the whole population as an estimation of the prevalence of NIHL in society (3.4%). However, this number does not consider the portion of the population with unilateral NIHL from rifle shooting, etc.

We conducted a multivariate analysis to assess the probable risk factors of all types of NITS. Given bilateral NITS as the basis of our diagnostic criteria for NIHL, rising age, male gender and positive smoking history were significantly associated with higher odds and post-secondary education with lower odds of NIHL. The effects of age and gender have been well established before [3, 8, 10] and our results indicate the same. Another finding of the current study was positive association of smoking history with increased odds of bilateral and overall NITS. Although some previously published studies have found such association [11], the effect of smoking on NITS in adults has not been strongly supported with evidence yet. The underlying mechanism of this association is not yet understood, but a recent animal studies showed a synergistic effect between smoking exposure and noise exposure [12].

Noise exposure categories (occupational, firearms, recreational and any of them) were not associated with higher odds of NITS. Another conducted study on NHANES databases that evaluated NITS in the youth population and used the less stringent criteria to define NITS (any audiometric notch at 3, 4 or 6 kHz) also did not show a higher odds ratio of NITS with noise exposure [13]. Our unreported analysis of NHANES database using the traditional NITS criteria also did not reveal such association on multivariate logistic regression. In general, multivariate regression analysis will underestimate the effects of variables that are either inadequately measured or have non-linear effects. For instance, the NHANES question about occupational noise was “Thinking of all the jobs you have ever had, have you ever been exposed to loud noise at work for at least three months? By loud noise I mean noise so loud that you had to speak in a raised voice to be heard”. Many people with only 3 months of noise exposure never really had hazardous exposures. Additionally, some might not recall their history properly (recall bias). Consequently, some of the participants responding positively to this question will have only short-term exposure and some will have long-term exposure. This leads to a heterogenic population of positive responders. Short-term noise-exposure responders will likely not have a NITS since the development of a 4 kHz notch takes multiple exposures. Other plausible reasons include: use of hearing protections, effect of presbycusis or high rate of missing values from occupational noise exposure from NHANES 2003–2004 (1893 missing values). However, prevalence of NITS categories was higher in all the noise exposure categories.

Despite some limitations, the use of the NHANES dataset yield population-based measures that could be generalizable to countries with similar sorts of collecting demographics. Additionally, logistic regression will underestimate the effect of variables that are either inadequately measured or have non-linear effects that were discussed above. Despite these limitations, the process of NHANES, the level of standardization, quality assurance and quality control and the design which is supportive of a nation-wide sample, makes it a unique database to examine different evaluations of prevalence and association.

CONCLUSION

This analysis is the first to characterize the demographics of NITS in the U.S. adult population based on the most recent NHANES data. Older males were the most affected demographic group. Risk factors can be targeted through various educational, preventative, and screening interventions. Further analyses to examine other possible modifiable risk factors that could be associated with bilateral NITS, including occupational and non-occupational exposures to noise may help to elicit more predictive factors of NIHL.

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Table 1

Estimated Prevalence of unilateral, bilateral and overall Noise-Induced Hearing Threshold Shift (NITS) among U.S. Adults aged 20–69 years and within Sociodemographic Characteristics, Noise exposure, and other potential hearing related factors: NHANES 1999–2004 (N=5406).

Variables		**Frequency in population (%)**	**Prevalence of Unilateral NITS (%95 CI)**	**Prevalence of Bilateral NITS (%95 CI)**	**Prevalence of Overall NITS (%95 CI)**
Total population			9.4 (8.62–10.17)	3.4 (2.91–3.88)	12.8 (11.90–13.69)
Age groups (years)					
	20–29	1257 (23.3)	4.5 (3.35–5.64)	1 (0.44–1.55)	5.4 (4.15–6.64)
	30–39	1128 (20.9)	**7.8 (6.23–9.36)**	**3.6 (2.52–4.68)**	**11.4 (9.54–13.25)**
	40–49	1089 (20.1)	**11 (9.14–12.85)**	**4 (2.83–5.16)**	**15.1 (12.97–17.22)**
	50–59	881 (16.3)	**12.5 (10.31–14.68)**	**5.3 (3.82–6.77)**	**17.8 (15.27–20.32)**
	60–69	1051 (19.4)	**12.7 (10.68–14.71)**	**3.7 (2.55–4.84)**	**16.4 (14.16–18.63)**
Sex					
	Female	2863 (53)	4.3 (3.55–5.04)	0.7 (0.39–1.00)	5 (4.20–5.79)
	Male	2543 (47)	**15.1 (13.70–16.49)**	**6.4 (5.44–7.35)**	**21.5 (29.90–23.09)**
Ethnicity					
	White, non-Hispanic	2537 (46.9)	9.8 (8.64–10.95)	**3.6 (2.87–4.32)**	13.4 (12.07–14.72)
	Black, non-Hispanic	1095 (20.3)	8.8 (7.12–10.47)	1.9 (1.09–2.70)	10.7 (8.86–12.53)
	Hispanic	1553 (28.7)	9.5 (8.04–10.95)	**4 (3.02–4.97)**	13.5 (11.80–15.19)
	Other (including multiracial)	221 (4.1)	7.2 (3.79–10.60)	3.6 (1.14–6.05)	10.9 (6.70–15.00)
Income					
	Low (PIR ≤ 1.3)	1392 (28.2)	9.5 (7.95–11.04)	3.4 (2.44–4.35)	12.9 (11.13–14.66)
	Middle (1.3<PIR≤3.5)	1800 (36.5)	9.3 (7.95–10.64)	3.2 (2.38–4.01)	12.4 (10.87–13.92)
	High (PIR>3.5)	1739 (35.3)	9.1 (7.74–10-45)	3.6 (2.72–4.47)	12.7 (11.13–14.26)
Education					
	Less than High School	1594 (29.5)	**11.2 (9.65–12.74)**	**4.5 (3.48–5.51)**	**15.7 (13.91–17.48)**
	High School Diploma (Includes GED)	1233 (22.8)	9.9 (8.23–11.56)	3.9 (2.81–4.98)	13.8 (11.87–15.72)
	Post-Secondary	2577 (47.7)	8 (6.95–9.04)	2.4 (1.80–2.99)	10.5 (9.31–11.68)
Marital Status					
	Never Married/Divorced/Separated/Widowed	3365 (64.7)	7.5 (6.61–8.38)	2 (1.52–2.47)	9.4 (8.41–10-38)

Variables		Frequency in population (%)	Prevalence of Unilateral NITS (%95 CI)	Prevalence of Bilateral NITS (%95 CI)	Prevalence of Overall NITS (%95 CI)
	Married/Living with Partner	1833 (35.3)	**10.5 (9.09–11.90)**	4.1 (2-19–5.00)	**14.6 (12.98–16.21**)
Country of Birth					
	United States	4092 (75.7)	9.3 (8.41–10.19)	3 (2.47–3.52)	12.3 (11.29–13.30)
	Mexico	769 (14.2)	10.3 (8.15–12.44)	**5.1 (3.54–6.65)**	15.3 (12.75–17.84)
	Any Other Location	542 (10)	8.5 (6.15–10.84)	3.9 (2.27–5.52)	12.4 (9.62–15.17)
Service in Armed Forces					
	No	4782 (88.5)	8.6 (7.80–9.39)	3 (2.51–3.48)	11.5 (10.59–12.40)
	Yes	623 (11.5)	**15.6 (12.75–18.44)**	**6.6 (4.65–8.54)**	**22.2 (18.93–25.46)**
Smoking History					
	No	2571 (47.6)	6.6 (5.64–7.55)	1.9 (1.37–2.42)	8.5 (7.42–9.57)
	Yes	2833 (52.4)	**11.9 (10.70–13.09)**	**4.7 (3.92–5.47)**	**16.6 (15.22–17.97)**
Diabetes					
	No	4893 (90.6)	9.1 (8.29–9.90)	3.4 (2.89–3.90)	12.5 (11.57–13.42)
	Yes	510 (9.4)	12(9.17–14.82)	3.5 (2.90–5.09)	15.5 (12.35–18.64)
Occupational Noise					
	No	2347 (66.8)	8.4 (7.27–9.52)	3 (2.30–3.69)	11.4 (10.11–12.68)
	Yes	1166 (33.2)	**13 (11.06–14.93)**	**6.1 (4.72–7.47)**	**19.1 (16.84–21.35)**
Firearms Noise					
	No	5040 (93.3)	9.1 (8.30–9.89)	3.2 (2.71–3.68)	12.3 (11.39–13.20)
	Yes	361 (6.7)	12.7 (9.26–16.13)	6.1 (3.63–8.56)	**18.8 (14.76–22.83)**
Recreational Noise					
	No	4141 (76.7)	8.6 (7.74–9.45)	3.1 (2.57–3.62)	11.7 (10.72–12.67)
	Yes	1257 (23.3)	**11.9 (10.11–13.69)**	4.3 (3.17–5.42)	**16.1 (14.06–18.13)**
Any of above Noise Exposures					
	No	1903 (48.4)	8 (6.78–9.21)	2.6 (1.88–3.31)	10.6 (9.21–11.98)
	Yes	2027 (51.6)	**12 (10.58–13.41)**	**5.1 (4.14–6.05)**	**17.1 (15.46–18.73)**

*Prevalence is reported as row percentage.

*Numbers in Bold are significant within exposure levels to the independent variable.

* CI: Confidence Interval

Table 2

Multivariate adjusted Odds Ratio analysis of unilateral, bilateral and overall Noise-Induced Hearing Threshold Shift among U.S. Adults aged 20–69 years by Sociodemographic Characteristics, Noise exposure, and other potential hearing related factors: NHANES 1999–2004

Variables		Unilateral NITS OR (95% CI)	Bilateral NITS OR (95% CI)	Overall NITS OR (95% CI)
Age groups (years)				
	20–29	1	1	1
	30–39	**1.79 (1.16–2.76)**	**3.22 (1.53–6.77)**	**2.21 (1.51–3.24)**
	40–49	**2.73 (1.80–4.13)**	**3.37 (1.61–7.07)**	**3.12 (2.14–4.53)**
	50–59	**3.17 (2.02–4.98)**	**4.25 (1.95–9.28)**	**3.80 (2.54–5.70)**
	60–69	**3.57 (2.16–5.89)**	**3.35 (1.40–8.00)**	**3.86 (2.45–6.09)**
Sex				
	Female	1	1	1
	Male	**3.85 (2.77–5.36)**	**7.04 (3.54–13.97)**	**4.76 (3.53–6.42)**
Ethnicity				
	White, non-Hispanic	1	1	1
	Black, non-Hispanic	**0.64 (0.44–0.94)**	0.64 (0.35–1.17)	**0.61 (0.44–0.86)**
	Hispanic	0.79 (0.53–1.20)	0.49 (0.24–1.02)	**0.67 (0.46–0.98)**
	Other (including multiracial)	**0.37 (0.14–0.97)**	0.71 (0.23–2.18)	**0.45 (0.21–0.95)**
Income				
	Low (PIR ≤ 1.3)	1	1	1
	Middle (1.3<PIR≤3.5)	0.94 (0.64–1.36)	1.05 (0.63–1.77)	0.99 (0.73–1.35)
	High (PIR>3.5)	0.83 (0.56–1.21)	1.06 (0.59–1.88)	0.87 (0.62–1.23)
Education				
	Less than High School	1	1	1
	High School Diploma (Includes GED)	0.94 (0.64–1.36)	0.70 (0.40–1.20)	0.83 (0.59–1.15)
	Post-Secondary	**0.68 (0.47–0.97)**	**0.39 (0.23–0.67)**	**0.53 (0.39–0.72)**
Marital Status				
	Never Married/Divorced/Separated/Widowed	1	1	1
	Married/Living with Partner	1.06 (0.79–1.43)	1.59 (0.96–2.63)	1.21 (0.93–1.58)
Country of Birth				
	United States	1	1	1
	Mexico	1.11 (0.67–1.83)	2.21 (0.97–5.02)	1.39 (0.89–2.18)
	Any Other Location	0.88 (0.55–1.43)	1.34 (0.66–2.73)	1 (0.65–1.51)
Service in Armed Forces				
	No	1	1	1
	Yes	0.94 (0.65–1.34)	1.14 (0.68–1.90)	1 (0.73–1.37)
Smoking History				
	No	1	1	1

Variables		Unilateral NITS OR (95% CI)	Bilateral NITS OR (95% CI)	Overall NITS OR (95% CI)
	Yes	1.20 (0.92–1.57)	**1.87 (1.19–2.95)**	**1.40 (1.10–1.79)**
Diabetes				
	No	1	1	1
	Yes	0.74 (0.44–1.25)	1.05 (0.52–2.13)	0.81 (0.52–1.26)
Occupational Noise				
	No	1	1	1
	Yes	0.96 (0.61–1.49)	0.75 (0.40–1.42)	0.87 (0.59–1.29)
Firearms Noise				
	No	1	1	1
	Yes	0.96 (0.61–1.52)	0.99 (0.52–1.87)	0.97 (0.65–1.44)
Recreational Noise				
	No	1	1	1
	Yes	1.09 (0.76–1.57)	0.84 (0.50–1.40)	1 (0.73–1.38)
Any of above Noise Exposures				
	No	1	1	1
	Yes	1.06 (0.63–1.79)	1.84 (0.86–3.90)	1.29 (0.82–2.03)

*NITS: Noise-Induced Hearing Threshold Shift; CI: Confidence Interval; OR: Odds Ratio

#Bold numbers indicate a $p<0.05$.

*Missing values:

- Income: 475
- Education: 2
- Marital status: 208
- Country of birth: 2
- Service in armed forces: 1
- Smoking history: 2
- Diabetes: 3
- Occupational noise: 1893
- Firearms noise: 5
- Recreational noise: 8
- Any noise exposure: 1476