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Tinnitus and its Risk Factors in the Beaver Dam Offspring Study

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Abstract

OBJECTIVE—To assess the prevalence of tinnitus along with factors potentially associated with having tinnitus.

DESIGN—Data were from the Beaver Dam Offspring Study, an epidemiological cohort study of aging.

STUDY SAMPLE—After a personal interview and audiometric examination, participants (n=3267, ages 21-84 years) were classified as having tinnitus if in the past year they reported having tinnitus of at least moderate severity or that caused difficulty in falling asleep.

RESULTS—The prevalence of tinnitus was 10.6%. In a multivariable logistic regression model adjusting for age and sex, the following factors were associated with having tinnitus: hearing impairment (Odds Ratio (OR) = 3.20), currently having a loud job (OR = 1.90), history of head injury (OR = 1.84), depressive symptoms (OR = 1.82), history of ear infection (men, OR = 1.75), history of target shooting (OR = 1.56), arthritis (OR = 1.46), and use of NSAID medications (OR = 1.33). For women, ever drinking alcohol in the past year was associated with a decreased risk of having tinnitus (OR = 0.56).

CONCLUSIONS—These results suggest that tinnitus is a common symptom in this cohort and may be associated with some modifiable risk factors.

Keywords

Tinnitus; Demographics/Epidemiology; Hearing Conservation; Aging

Tinnitus is the perception of sound in the ears or head unrelated to an external source. It can be a symptom of a variety of auditory disorders, and can be very troublesome in its more severe forms. Its exact causal mechanisms, however, are not well understood.

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While there is no single agreed-upon definition of tinnitus, several population-based studies have attempted to estimate the prevalence of this condition. Prevalence estimates generally range from 7 to 20% (Hoffman and Reed, 2004), although a few estimates have been higher. In the Epidemiology of Hearing Loss Study (EHLS), the prevalence of tinnitus among the older adults of Beaver Dam, WI ages 48-92 years was 8.2% (Nondahl et al, 2002). The EHLS also estimated the 5-year incidence (5.7%; Nondahl et al, 2002) and 10-year incidence of tinnitus (12.7%; Nondahl et al, 2010). Longitudinal studies such as these help to increase understanding of the etiology of the symptom over time.

Data from cross-sectional cohort studies on factors associated with having tinnitus are limited. The baseline EHLS reported that female gender, hearing impairment, cardiovascular disease and history of head injury were positively associated with having tinnitus, while age was inversely associated (Nondahl et al, 2002). Sindhusake and colleagues (2003b), using cross-sectional data from the Blue Mountains Hearing Study, reported that poorer hearing, poorer cochlear function, occupational noise exposure, history of middle ear or sinus infections, severe neck injury and migraine were positively associated with having tinnitus. In an earlier study, data from the Supplement on Aging from the 1984 Health Interview Survey (Brown, 1990) showed those reporting “arthritis or rheumatism” had a higher odds of reporting tinnitus.

Tinnitus may represent a heterogeneous disorder that can be caused by or exacerbated by many factors (Tyler et al, 2008). Damage to the auditory system from illness, injury, surgery, or noise exposure may contribute to tinnitus. It is possible that inflammation and vascular damage may play a role in some cases. Depression and anxiety may worsen tinnitus, or be caused by it, or both. Most cross-sectional studies of risk factors associated with tinnitus have been done among older adults. However, with changes in lifestyle and healthcare it is important to study tinnitus in younger adults as well. The purpose of the present study is to estimate the prevalence of tinnitus, along with factors associated with having tinnitus, in a younger cohort of adults.

METHODS

Subjects

The Epidemiology of Hearing Loss Study is an ongoing population-based cohort study started in 1993 in Beaver Dam, Wisconsin to measure hearing outcomes and their risk factors (Cruickshanks et al, 1998). The original cohort was made up of 3,753 participants ranging in age from 48-92 years, who were then followed up every 5 years. In 2005, the offspring of the Epidemiology of Hearing Loss Study participants were enrolled in the Beaver Dam Offspring Study (BOSS), a study of multi-sensory impairments and aging. Data collection occurred during 2005-2008. Details regarding the BOSS study population are reported elsewhere (Zhan et al, 2010). Of the 3,285 participants in the BOSS, 3,267 provided information on tinnitus symptoms and are the focus of this report. BOSS methods were approved by the Health Sciences Institutional Review Board of the University of Wisconsin, and all participants provided written informed consent.

Procedure

The audiometric examination included otoscopic evaluation, screening tympanogram (GSI-37 Autotymp, Grason-Stadler, Inc., Madison, WI), and pure-tone air- and bone-conduction audiometry. Audiometric testing was conducted according to the guidelines of the American Speech-Language-Hearing Association in a sound-treated booth (Industrial Acoustics Company, New York, NY)(ASHA, 2005). A GSI-61 clinical audiometer (Grason-Stadler, Inc., Madison, WI) equipped with TDH-50 earphones (Telephonics, Farmingdale,

NY) and insert earphones was used. The audiometer was calibrated every six months during the study period (ANSI, 2004). Pure-tone air-conduction thresholds were obtained for each ear at 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz. Bone-conduction thresholds were measured at 500, 2000 and 4000 Hz. Masking was used as necessary. All testing was conducted by examiners trained and monitored by a certified audiologist (TST). Ambient noise levels were routinely monitored at the field examination site to ensure that testing conditions complied with ANSI standards (ANSI, 1999).

A questionnaire about health history (including tinnitus) and occupational and leisure time noise exposure was administered as an interview. Participants were asked, “In the past year have you had buzzing, ringing, or noise in your ears?” (No/Yes/Unknown). Examiners were instructed to record “no” if a participant reported hearing an odd or unusual noise on a single occasion in the past year. Participants responding positively to this question were then asked, “How severe is this noise in its worst form?” (Mild/Moderate/Severe/Unknown), and “Does this noise cause you to have problems getting to sleep?” (No/Yes/Unknown). A person was classified as having tinnitus if he/she reported having “buzzing, ringing, or noise” in the ears in the past year that was at least moderate in severity or that caused problems getting to sleep (Nondahl et al, 2002; Nondahl et al, 2010).

Potential risk factors were evaluated for their association with having tinnitus. Risk factors primarily included variables related to: 1) auditory function and possible injuries to the auditory system, including from noise exposure, 2) symptoms of anxiety/depression, and 3) cardiovascular disease (CVD) and its risk factors. These major categories were primarily selected based on findings in the parent study and other epidemiological studies (Brown, 1990; Nondahl et al, 2002; Sindhusake et al, 2003b).

Specific variables related to auditory function and injuries included hearing impairment (average of air-conduction hearing thresholds at .5, 1, 2 and 4 kHz > 25 dB in the worse ear), history of head injury (skull fracture; concussion; broken nose; or loss of consciousness due to a head injury), history of otosclerosis, history of ear surgery (tympanoplasty, stapedectomy, or mastoidectomy), possible middle ear effusion, and history of ear infection. Possible middle ear effusion was defined as 1) Peak Y_{tm} = 0 acoustic mmhos in either ear, or 2) Peak Y_{tm} = 0.1 to 0.2 acoustic mmhos in one ear and a) the opposite ear Peak Y_{tm} was > 0.8 acoustic mmhos or b) the participant reported at least one of the following: a head cold, sinus infection, or sinus problems in the past week; or an earache, pressure, fullness, or discharge in an ear in the past year.

Noise exposure variables included exposure to firearms through hunting (ever, past year) or target shooting (ever, past year), regular participation in loud hobbies (ever, past year: woodworking, metalworking, chain sawing, driving loud recreational vehicles, or doing yard work with power tools), current (within past year) occupational noise exposure (had to speak in a loud voice in order to be heard by another person two feet away), and history of occupational noise exposure. History of occupational noise exposure was considered to be present if the participant had (1) a full-time job that required speaking in a loud voice in order to be heard by another person two feet away; (2) driven a tractor on a farm, at least half the time without a cab; or (3) military duties as a pilot or crew member on an aircraft or crew member on a tracked vehicle; had worked in the engine room aboard a ship; had spent time on weapons ranges at least seven times a year; used grenades, mortars, or shoulder-held grenade launchers; or used a weapons system requiring more than one person for operation (Popelka et al, 2000). Education, a marker of socioeconomic status often related to noise exposure and risk of CVD, was also examined.

Specific variables related to symptoms of anxiety/depression included current use of anti-anxiety medications, current use of anti-depressant medications, and depressive symptoms (a score ≥ 16 out of 60 from the Center for Epidemiologic Studies Depression Scale (CES-D); Radloff, 1977).

We hypothesized that inflammation and microvascular damage to the inner ear may be associated with tinnitus. We therefore evaluated the effects of CVD and its traditional risk factors along with selected medications, including alcohol consumption (past year, and heavy drinking history), current use of antihypertensive medication, diabetes (self-report of doctor-diagnosis or hemoglobin A1c ≥ 6.5 percent), history of surgery on the carotid arteries, history of CVD (myocardial infarction, stroke, or angina), hypertension (systolic ≥ 140 mmHg, diastolic ≥ 90 mmHg, or physician diagnosis of hypertension with current use of antihypertensive medication), current use of non-steroidal anti-inflammatory medications (NSAIDs), obesity (body mass index ≥ 30 kg/m^2), physician diagnosis of peripheral vascular disease, regular exercise, smoking status (never/ever; packyears; years since stopped smoking), and serum total and HDL cholesterol. History of arthritis was also examined due to its link to inflammatory processes.

Statistical analyses were completed with the SAS System (SAS Institute Inc., Gary, NC). Linear trends in prevalence by age group were tested with the Mantel-Haenszel Chi-Square test. Differences in the distribution of various participant characteristics by tinnitus status were assessed with the chi-square test for general association or Fisher's Exact Test (categorical variables) or with the *t*-test (continuous variables). Logistic regression was used to model the association between various factors and having tinnitus. Factors that were significantly associated with tinnitus in age- and sex-adjusted models were then examined together in a single model, and a manual backwards elimination selection procedure was used to reduce the model to include only statistically significant factors. Potential interactions with gender were evaluated. The final model was then reexamined substituting a pure tone average for hearing impairment, and again substituting individual hearing thresholds for hearing impairment. These alternative models were compared with the final model using the Hosmer-Lemeshow test.

RESULTS

Prevalence rates by sex and age group are shown in Table 1. The overall prevalence of tinnitus in this cohort was 10.6 percent (95% confidence interval [CI] 9.5-11.6). The prevalence of tinnitus was higher for men than for women (11.9% vs 9.4%, $p = .02$), and higher for those 55-84 years of age than for younger participants (14.4% vs 9.0%, $p < .001$). Increasing linear trends in prevalence by age group were statistically significant for men, women, and both sexes ($p < .05$). Of 345 participants with tinnitus, 91.9 percent rated their tinnitus as moderate (n = 274) or severe (n = 43); the remaining 28 participants reported mild tinnitus that caused difficulty falling asleep. The overall prevalence of tinnitus rated as severe was 1.3 percent. In a logistic regression model including only age and sex, the odds of having tinnitus increased with age (OR = 1.09 for each 5-year increase in age, 95%CI = 1.04, 1.16), and men were more likely to have tinnitus than were women (OR = 1.29, 95%CI = 1.03, 1.62).

Selected characteristics of this cohort, by tinnitus status, are shown in Table 2. In separate age- and sex-adjusted models we also evaluated the associations of these characteristics with tinnitus (Table 2). After adjusting for age and sex, most of the characteristics reflecting auditory function and possible injuries were significantly associated with having tinnitus. These included hearing impairment (OR = 3.60, 95%CI = 2.67, 4.84), history of ear infection (OR = 1.98, 95%CI = 1.40, 2.79 for men, but not significant for women), history

of ear surgery (OR = 3.72, 95%CI = 1.91, 7.23), history of head injury (OR = 1.94, 95%CI = 1.54, 2.45), history of otosclerosis (OR = 4.35, 95%CI = 1.61, 11.75), occupational noise exposure (ever: OR = 1.50, 95%CI = 1.19, 1.90; past year: OR = 2.00, 95%CI = 1.50, 2.67), possible middle ear effusion (OR = 1.41, 95%CI = 1.01, 1.98), and target shooting (ever: OR = 1.86, 95%CI = 1.37, 2.54; past year: OR = 1.72, 95%CI = 1.11, 2.66). In addition, for each additional loud hobby in which participants had engaged, the odds of having tinnitus increased (ever: OR = 1.15, 95%CI = 1.05, 1.27; past year: OR = 1.13, 95%CI = 1.03, 1.24). Hunting was not significantly associated with having tinnitus.

Depressive symptoms (OR = 2.04, 95%CI = 1.50, 2.76) and the use of anti-depressant medications (OR = 1.58, 95%CI = 1.17, 2.14) were significantly associated with having tinnitus, but the use of anti-anxiety medications was not.

Among the cardiovascular-related risk factors examined, the following were associated with having tinnitus after adjusting for age and sex: history of CVD (OR = 2.14, 95%CI = 1.32, 3.45), history of heavy drinking (OR = 1.34, 95%CI = 1.02, 1.76), obesity (OR = 1.41, 95%CI = 1.11, 1.81), peripheral vascular disease (OR = 2.59, 95%CI = 1.01, 6.65), higher numbers of packyears smoked (11-23 vs 0: OR = 1.57, 95%CI = 1.12, 2.21; 24+ vs 0: OR = 1.43, 95%CI = 1.02, 2.02), and being a current smoker (OR = 1.50, 95%CI = 1.12, 2.01 vs never smoker). A history of arthritis was also associated with having tinnitus (OR = 1.71, 95%CI = 1.32, 2.22). Having consumed alcohol in the past year was negatively associated with having tinnitus for women (OR = 0.54, 95%CI = 0.35, 0.83) but not men. Other cardiovascular-related factors that were not associated with having tinnitus included use of antihypertensive medication, diabetes, history of carotid artery surgery, hypertension, use of NSAID medication, regular exercise, and serum HDL and total cholesterol.

Factors associated with tinnitus in these models were then evaluated in a multivariable model. Results from the final, most parsimonious model, are shown in Table 3. Most of the factors remaining in this model were classified under the auditory function/injury category. These included occupational noise exposure (past year: OR = 1.90, 95%CI = 1.38, 2.63), hearing impairment (OR = 3.20, 95%CI = 2.33, 4.38), history of ear infection (for men, OR = 1.75, 95%CI = 1.20, 2.57; but not women, OR = 0.90, 95%CI = 0.62, 1.31), history of head injury (OR = 1.84, 95%CI = 1.40, 2.40) and target shooting (ever: OR = 1.56, 95%CI = 1.09, 2.24). Other factors that remained positively associated with having tinnitus in the multivariable model were depressive symptoms (OR = 1.82, 95%CI = 1.33, 2.51), history of arthritis (OR = 1.46, 95%CI = 1.08, 1.96), and current use of NSAID medications (OR = 1.33, 95%CI = 1.02, 1.75). For women, consuming alcohol in the past year was inversely associated with having tinnitus (OR = 0.56, 95%CI = 0.35, 0.90). There was no linear association between age and tinnitus in this fully-adjusted model, nor was there a significant interaction between age and gender. The interactions between gender and history of ear infection ($p = .01$) and gender and alcohol consumption ($p = .03$) were both statistically significant.

The model in Table 3 was repeated with a pure-tone average (PTA) of hearing thresholds at 500, 1000, 2000 and 4000 Hz (worse ear) replacing the hearing impairment classification, and the results were very similar. In that model, participants were 17% more likely to have tinnitus with every 5 dB increase in PTA (OR = 1.17, 95%CI = 1.13, 1.22; complete model results not shown). Similarly, when individual thresholds (at 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz, worse ear) were substituted for the hearing impairment classification, the 3000 Hz threshold (OR = 1.06 for every 5 dB increase in threshold, 95%CI = 1.01,1.11) and 6000 Hz threshold (OR = 1.09 for every 5 dB increase in threshold, 95%CI = 1.04,1.14) were significantly associated with having tinnitus (complete model results not shown). Based on the Hosmer & Lemeshow test (Hosmer & Lemeshow, 1989), all three models

(using the hearing impairment classification, the PTA, and the individual thresholds) fit the data well; however, the best fitting model used the hearing impairment classification shown in Table 3.

Among those with occupational noise exposure in the past year, 53.4% indicated that they ever wore hearing protection at that job. Among those who had regularly participated in target shooting in the past year, 84.7% indicated that they ever wore hearing protection while doing so. After adjusting for age and sex, the use of hearing protection was not significantly associated with tinnitus for either occupational noise exposure (OR = 1.45, 95%CI = 0.82, 2.59) or target shooting (OR = 5.62, 95%CI = 0.72, 43.66).

DISCUSSION

Prevalence

The prevalence of tinnitus in this cohort of adults was 10.6 percent. Prevalence was slightly higher in men than in women, and higher in those 55-84 years of age than in younger participants. Comparisons with other large epidemiologic studies of tinnitus prevalence are shown in Table 4.

Tinnitus is commonly thought to increase in prevalence with age, but this may not be the case through the entire lifespan. In this cohort, the prevalence of tinnitus among women was lower for ages 65-84 than for ages 55-64 (12.6% verses 14.6%). No such difference was noted for men. In the parent population (Nondahl et al, 2002), the prevalence of tinnitus was lower for both men and women beginning in the 8th decade of life. A lower prevalence of tinnitus beginning sometime in the 8th decade has also been reported by the National Health Examination Survey of 1960-1962 (Leske, 1981), the 1987 National Health Interview Survey (Brown, 1990), the National Center for Health Statistics (1998), and studies from Australia (Sindhusake et al, 2003a) and Great Britain (Davis, 1989). Axelsson and Ringdahl (1989) reported this pattern beginning in the 7th decade in men but not women.

Reasons for a lower prevalence of tinnitus in later life are unclear. It may be that older adults find the relative contribution of tinnitus to their overall health burden less important as they age, so their ability to successfully cope with tinnitus actually improves and they are less likely to report tinnitus. Theoretically, selective mortality could also play a part: a similar causal pathway between tinnitus and cardiovascular disease (or some other disease) may result in earlier deaths among some of those with tinnitus so that tinnitus prevalence decreases with age. Longitudinal data are needed to understand the impact of aging on the development of tinnitus.

The evidence for a gender difference in the prevalence of tinnitus is equivocal. In the present study, prevalence was slightly higher for men than for women (11.9% vs 9.4%). This was also true in the parent population (8.8% vs 7.8%; Nondahl et al, 2002). However, confounding factors can cloud this relation. In the present study, men remained at higher risk of having tinnitus than women after adjusting for age (OR = 1.29, p = .025); however, once the model was adjusted for other factors there was no association between sex and having tinnitus (OR = 0.85, p = .25). In the parent study the relation reversed after adjusting for age, hearing impairment, cardiovascular disease and history of head injury, with women more likely to report tinnitus than men (OR = 1.38 for women compared to men; Nondahl et al, 2002). Some studies have found men 40 to 59 years of age (Axelsson and Ringdahl, 1989) or men of all ages (NCHS, 1998) to have a higher prevalence of tinnitus than comparably aged women; however, these findings were not adjusted for other factors. Other studies, (Leske, 1981; Cooper, 1994) found women to have a higher prevalence of tinnitus, but also did not adjust for other factors. Sindhusake et al found no gender difference, either

unadjusted (2003a) or adjusted (2003b). It appears likely that gender patterns may be at least partially attributable to differences in exposures between men and women rather than sex-based biological differences in susceptibility.

Risk Factors

We found that many factors were associated with tinnitus in logistic regression models adjusting for age and sex, suggesting that tinnitus is a heterogeneous disorder with several potentially modifiable risk factors. In a combined multivariable model, five of nine factors associated with having tinnitus pertained to auditory function and possible injuries to the auditory system.

One of those factors was hearing impairment. In the present study, hearing impairment was the factor most strongly associated with having tinnitus (OR = 3.20). Other cross-sectional studies have found similar results (Nondahl et al, 2002; Sindhusake et al, 2003b). Two studies relying on self-reported hearing impairment data also reported this association (Axelsson and Ringdahl, 1989; Brown, 1990). Although cochlear dysfunction may be the common factor, Nuttall and colleagues (2004) suggest that the auditory nerve can be viewed as a “final common path” over which tinnitus-invoking information is conveyed to the centers of perception.

Noise exposure, which may cause cochlear damage and result in hearing impairment, also was associated with tinnitus. Two measures of noise exposure, occupational noise exposure in the past year, and having a history of target shooting, remained significantly associated with tinnitus in the final model. Although regulations promoting the use of hearing protection during occupational noise exposure have no doubt helped to reduce the risk of occupationally-related noise-induced hearing impairment, about half of participants in this study never wore hearing protection at their loud occupation. Else (1973) has demonstrated that hearing protection must be worn for a very high proportion of the exposure time in order to provide adequate protection, so one might surmise that inconsistent use of hearing protection during occupational noise exposure or target shooting could leave participants at higher risk for subsequent hearing impairment, and perhaps, tinnitus.

Having a history of head injury has been consistently associated with prevalence and incidence of tinnitus in the Epidemiology of Hearing Loss Study (Nondahl et al, 2002; Nondahl et al, 2010). Reducing the risk of head injury by preventive measures such as proper use of helmets on bicycles, motorcycles, and other recreational vehicles; safe driving habits; and reducing the risk of falls could have the added benefit of reducing the risk of developing tinnitus.

A history of ear infection was associated with having tinnitus in men (OR = 1.75) but not women (OR = 0.90). In the Blue Mountains Hearing Study, a history of ear infection was associated with tinnitus overall (Relative Risk = 1.35); gender-specific results were not reported (Sindhusake et al, 2003b). It is well known that chronic ear infections (infections that persist or keep recurring) can lead to increased sensorineural hearing impairment, although there is currently no consensus about how the hearing impairment develops (Paparella MM, 1970; da Costa et al, 2009). While acute ear infections are more common than chronic ear infections, a chronic infection may show less severe symptoms and may remain unnoticed or untreated for a long time. In the present study no distinction was made in regards to the type of ear infection reported, so for some participants it may have included chronic infection(s). It is possible that the same underlying processes that lead to cochlear damage from chronic ear infections may also increase the probability of developing tinnitus. It is unclear why the relation between history of ear infection and tinnitus was demonstrable

in men but not women, but may reflect gender differences in severity or treatment of infections.

Three factors related to cardiovascular disease and its risk factors were associated with having tinnitus in the final multivariable model. The first was alcohol consumption. Alcohol consumption in the past year was negatively associated with having tinnitus among women, but not men. Light to moderate daily alcohol consumption has been shown to be associated with cardiovascular benefits, primarily through improvements in insulin sensitivity and high-density lipoprotein cholesterol (O'Keefe, Bybee, and Lavie, 2007), and therefore may also help to preserve microvascular health in the cochlea. One or two drinks per day has been shown to be associated with a reduction in all-cause mortality, as well as the risk of myocardial infarction, stroke, congestive heart failure and diabetes. However, consumption of more than two drinks per day is associated with numerous negative health effects (O'Keefe, Bybee, and Lavie, 2007). Earlier cross-sectional work from the Epidemiology of Hearing Loss Study demonstrated a protective effect of moderate alcohol consumption on hearing impairment (Popelka et al, 2000). Given that tinnitus is more common among those with hearing impairment, it seems plausible that moderate alcohol consumption could be associated with a lower prevalence of tinnitus as well. Why this would be demonstrated in women but not men in the present study is unclear, although gender variations in drinking patterns could play a part.

Arthritis, a disorder associated with inflammation, was also associated with tinnitus. There is considerable evidence that those with rheumatoid arthritis are at greater risk of developing vascular disease (Sattar et al, 2003; Szekanecz and Koch, 2008). Neural and microvascular damage from systemic inflammation may contribute to the development of tinnitus. However, with self-report data it is difficult to reliably determine whether the reported arthritis is rheumatoid (an autoimmune condition accompanied by chronic, systemic inflammation), osteoarthritis (a non-autoimmune degenerative condition often accompanied by milder inflammation), or some other type of arthritis. While it is possible that medications (especially salicylates) used for arthritis could exacerbate tinnitus, in this study we found that arthritis was independently associated with tinnitus even after adjusting for NSAID use. In an earlier cross-sectional study, data from the Supplement on Aging from the 1984 Health Interview Survey (Brown, 1990) showed those reporting "arthritis or rheumatism" had a 48% higher odds of reporting tinnitus. Sindhusake et al (2003b) also found an association between arthritis and tinnitus when adjusting for age and sex, but not after adjusting for additional factors.

The third CVD-related factor associated with tinnitus was the use of NSAID medications. In this study, more than half of participants used NSAID medications, including aspirin products. Salicylates can cause tinnitus in higher doses, although this effect is usually temporary and reversible. While our finding could reflect a direct association with NSAID medication use and tinnitus, it could also be indicative of an association between tinnitus and some of the inflammatory processes or other conditions for which the NSAIDS were taken.

Finally, depressive symptoms were associated with having tinnitus in the current study. The relationship between depression and tinnitus is likely complex. Sullivan et al (1992) suggested that depression may promote the transformation of tinnitus, a generally tolerable sensation, into an intolerable and disabling one, although Robinson et al (2004) refute this hypothesis.

Erlandsson and Hallberg (2000) point out that tinnitus of sudden onset can be a traumatic experience that leads to depression. Other researchers have suggested that a vicious circle

can form between tinnitus severity, insomnia, anxiety and depression, with one or more of these symptoms exacerbating the others (Folmer et al, 2001).

As with any definition, the definition of tinnitus used in this study may have led to some misclassification of tinnitus status. Those classified as tinnitus cases in the current study only represent a segment of participants who have developed tinnitus at one time or another. In addition, the cross-sectional nature of this study does not permit conclusions regarding causality.

This study demonstrates that the prevalence of tinnitus in this middle-aged cohort is high. More importantly, it adds to a small but important set of literature regarding factors that may be associated with this common, and often disturbing, symptom. Longitudinal studies are needed to confirm these results but they suggest that modifiable factors may be associated with tinnitus.

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Abbreviations

CES-D	Center for Epidemiologic Studies Depression Scale
CI	Confidence Interval
CVD	cardiovascular disease
NSAID	non-steroidal anti-inflammatory medication
OR	Odds ratio

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Table 1

Prevalence of Tinnitus by Sex and Age Group, Along with 95% Confidence Interval (CI)

Age Group (yr)	Number at Risk	Prevalence (%)[1] (95% CI)
Men	1483	11.9 (10.3, 13.6)
21-34	73	9.6 (4.1, 17.6)
35-44	414	10.6 (7.7, 13.6)
45-54	566	11.1 (8.5, 13.7)
55-64	324	13.9 (10.1, 17.7)
65-84	106	17.0 (9.8, 24.1)
Women	1784	9.4 (8.1, 10.8)
21-34	106	10.4 (4.6, 16.2)
35-44	516	7.2 (4.9, 9.4)
45-54	659	7.4 (5.4, 9.4)
55-64	384	14.6 (11.1, 18.1)
65-84	119	12.6 (6.7, 18.6)
Both sexes	3267	10.6 (9.5, 11.6)
21-34	179	10.1 (5.7, 14.5)
35-44	930	8.7 (6.9, 10.5)
45-54	1225	9.1 (7.5, 10.8)
55-64	708	14.3 (11.7, 16.9)
65-84	225	14.7 (10.1, 19.3)

[1] Linear trends in prevalence by age group were statistically significant for men, women, and both sexes (Mantel-Haenszel Chi-Square test, $p < .05$).

Table 2

Participant Characteristics by Tinnitus Status and Associated Odds of Having Tinnitus (Odds Ratio and 95% Confidence Interval)

Characteristic	Percent with Characteristic		Odds Ratio (95% CI)[3]
	No Tinnitus (n=2922)[2]	Tinnitus (n=345)[2]	
Auditory function/injuries			
Hearing impairment[1]	12.0	32.7	3.60 (2.67, 4.84)
History of ear infection			
Men[1]	51.4	66.3	1.98 (1.40, 2.79)
Women	61.8	61.0	1.04 (0.74, 1.45)
History of ear surgery[1]	1.0	3.8	3.72 (1.91, 7.23)
History of head injury[1]	27.0	42.2	1.94 (1.54, 2.45)
History of otosclerosis[1]	0.4	1.8	4.35 (1.61, 11.75)
Hunting (ever)[1]	37.5	43.9	1.18 (0.90, 1.55)
Hunting (past year)[1]	14.6	18.7	1.27 (0.92, 1.74)
Occupational noise exposure (ever)[1]	42.7	54.5	1.50 (1.19, 1.90)
Occupational noise exposure (past year)[1]	12.4	21.2	2.00 (1.50, 2.67)
Possible middle ear effusion[1]	11.3	15.8	1.41 (1.01, 1.98)
Target shooting (ever)[1]	11.1	19.6	1.86 (1.37, 2.54)
Target shooting (past year)[1]	4.7	8.2	1.72 (1.11, 2.66)
Symptoms of anxiety/depression			
Anti-anxiety medications	3.6	4.3	1.15 (0.63, 2.08)
Anti-depressant medications[1]	15.3	21.3	1.58 (1.17, 2.14)
CES-D score ≥ 16[1]	13.2	24.6	2.16 (1.61, 2.88)
CVD and its risk factors			
Alcohol consumption (any in past year)			
Men	89.9	88.6	0.91 (0.55, 1.50)
Women[1]	89.6	81.4	0.54 (0.35, 0.83)
Antihypertensive medication[1]	25.1	31.3	1.19 (0.90, 1.59)
Diabetes	6.1	7.9	1.12 (0.73, 1.72)
History of arthritis[1]	23.0	35.4	1.71 (1.32, 2.22)
History of carotid artery surgery	0.2	0.3	1.03 (0.12, 8.65)
History of CVD[1]	2.9	7.0	2.14 (1.32, 3.45)
History of heavy drinking[1]	17.9	24.3	1.34 (1.02, 1.76)
Hypertension	38.1	41.2	0.94 (0.73, 1.22)
NSAID medications[1]	58.9	65.3	1.27 (0.98, 1.63)
Obesity[1]	43.6	53.7	1.41 (1.11, 1.81)

Characteristic	Percent with Characteristic		Odds Ratio (95% CI)[3]
	No Tinnitus (n=2922)[2]	Tinnitus (n=345)[2]	
Peripheral vascular disease[1]	0.6	1.8	2.59 (1.01, 6.65)
Regular exercise[1]	62.7	56.6	0.80 (0.64, 1.01)
CVD and its risk factors (continued)			
Smoking (ever)[1]	45.6	52.3	1.24 (0.99, 1.56)
Smoking (packyears)[1]			
0	56.4	48.4	1.00 (reference)
> 0 and < 3	10.2	8.3	0.97 (0.64, 1.48)
3-10	11.7	13.0	1.26 (0.88, 1.79)
11-23	10.7	15.0	1.57 (1.12, 2.21)
24+	11.1	15.3	1.43 (1.02, 2.02)
Smoking (years since stopped)			
Never smoked	54.8	47.9	1.00 (reference)
Stopped 30 + yrs ago	5.3	5.3	0.86 (0.50, 1.46)
Stopped 20-29 yrs ago	7.4	9.1	1.25 (0.83, 1.90)
Stopped 10-19 yrs ago	7.5	6.8	1.00 (0.63, 1.58)
Stopped 1-9 yrs ago	7.7	8.2	1.23 (0.80, 1.89)
Current smoker	17.3	22.7	1.50 (1.12, 2.01)
Other			
Education (years)			
0-11	2.4	2.0	0.85 (0.38, 1.92)
12	27.7	28.6	1.16 (0.87, 1.55)
13-15	33.1	38.2	1.36 (1.04, 1.78)
16+	36.9	31.2	1.00 (reference)
	Means		
Age (years)[1]	49.0	50.8	1.09 (1.04, 1.16) per 5 yrs
# of loud hobbies (ever)[1]	1.6	1.9	1.15 (1.05, 1.27)
# of loud hobbies (past year)[1]	1.1	1.2	1.13 (1.03, 1.24)
Serum hdl cholesterol (mg/dL)	50.2	48.7	0.97 (0.93, 1.01) per 5 mg/dL
Serum total cholesterol (mg/dL)	203.5	202.8	0.99 (0.96, 1.02) per 10 mg/dL

[1]Differences by tinnitus status were statistically significant (chi-square test, Fisher's Exact Test or t-test, $p < .05$).

[2]Data for some characteristics exclude 431 participants who provided partial data but were not examined.

[3]Adjusted for age and gender, except for gender-stratified models which were adjusted for age, and age model which was adjusted for gender.

Table 3

Risk Factors Associated with Tinnitus from Final Logistic Regression Model

Risk Factor[1]	Odds Ratio	95% CI
Auditory function/injuries		
Hearing impairment	3.20	(2.33, 4.38)
History of ear infection		
Men	1.75	(1.20, 2.57)
Women	0.90	(0.62, 1.31)
History of head injury	1.84	(1.40, 2.40)
Occupational noise exposure (past year)	1.90	(1.38, 2.63)
Target shooting (ever)	1.56	(1.09, 2.24)
Symptoms of anxiety/depression		
CES-D score ≥ 16	1.82	(1.33, 2.51)
CVD and its risk factors		
Alcohol consumption (any in past year)		
Men	1.33	(0.70, 2.51)
Women	0.56	(0.35, 0.90)
History of arthritis	1.46	(1.08, 1.96)
NSAID medications	1.33	(1.02, 1.75)

[1]Model was also adjusted for age (p = .67).

Table 4

Selected large epidemiologic studies of tinnitus prevalence

Authors	Country	Study Years	n	Ages (yrs)	Definition of tinnitus	Prevalence (%)
Leske (1981)	USA	1960-62	6672	18-79	"At any time over the past few years, have you ever noticed ringing (tinnitus) in your ears or have you been bothered by other funny noises?"	32.4
Axelsson & Ringdahl (1989)	Sweden	Not reported	2378	20-80	Suffering from tinnitus "often" or "always"	14.2
Davis (1989)	UK	1980-86	35,330	17+	Prolonged spontaneous tinnitus: tinnitus that lasts for more than 5 minutes at a time and that occurs not only after loud sounds.	9.7
Ries (1994) Hoffman & Reed (2004)	USA	1990-91	59,343	18+	Bothered by ringing in the ears or other funny noises in the head in the past 12 months	8.4
Quaranta et al (1996)	Italy	Sometime between 1989-96	2170	18-80	Prolonged spontaneous tinnitus: tinnitus that lasts for more than 5 minutes at a time and that occurs not only after loud sounds.	14.5
Nondahl et al. (2002)	USA	1993-95	3737	48-92	"Buzzing, ringing, or noise in your ears" in the past year that was at least moderate in severity or that caused difficulty in falling asleep.	8.2
Adams & Marano (1995) Benson & Marano (1998) Hoffman & Reed (2004)	USA	1994-95	99,435	18+	"Now having a ringing, roaring or buzzing in the ears that has lasted for at least three months."	4.4
Hoffman & Reed (2004)	Norway	1996-98	47,410	20-101	"Bothered by ringing in the ears."	15.1
Sindhusake et al. (2003a)	Australia	1997-99	2015	55-99	"Have you experienced any prolonged ringing, buzzing or other sounds in your ears or head within the past year … that is, lasting for five minutes or longer?"	30.3
Nondahl et al (current study)	USA	2005-07	3267	21-84	"Buzzing, ringing, or noise in your ears" in the past year that was at least moderate in severity or that caused difficulty in falling asleep.	10.6
Hasson et al (2009)	Sweden	2008	11,441	16-64	"Have you during the most recent time experienced sound in any of the ears, without there being an external source (so-called tinnitus) lasting more than five minutes?"	26 (employed) 30 (not employed)