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Prevalence and 5-Year Incidence of Tinnitus among Older Adults: The Epidemiology of Hearing Loss Study

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Abstract

Tinnitus (ringing or buzzing in the ear or head) can range from barely noticeable to debilitating. Although a few studies have estimated the prevalence of this condition in adult populations, we know of no population-based estimates of incidence. As part of a population-based study of hearing loss in adults aged 48 to 92 years at baseline in Beaver Dam, Wisconsin, self-reported data on tinnitus were obtained at the baseline examination (1993–1995; N = 3753) and again 5 years later (1998–2000; N = 2800). A person was classified as having tinnitus if their tinnitus was at least moderate in severity or caused difficulty in falling asleep. The prevalence of tinnitus at baseline was 8.2 percent. The 5-year incidence of tinnitus among the 2513 participants at risk was 5.7 percent. Risk factors for prevalent and incident tinnitus were evaluated. The results suggest that tinnitus is a common problem for older adults and is associated with some modifiable risk factors.

Key Words: Hearing disorders, incidence, presbycusis, prevalence, tinnitus

Abbreviations: EHLS = Epidemiology of Hearing Loss Study; peak Ytm = peak compensated static acoustic admittance

Sumario

El *tinnitus* (tintineo o zumbido en el oído o en la cabeza) puede variar de ser apenas detectable hasta convertirse en debilitante. Aunque algunos estudios han estimado la prevalencia de esta condición en población adulta, no conocemos estimados de incidencia basados en un estudio poblacional. Como parte de un estudio poblacional de trastornos auditivos, realizado en Beaver Dam, Wisconsin, en adultos de edades entre los 46 y los 92 años de edad, se obtuvo en los estudios basales información de auto-reporte sobre *tinnitus* (1993–1995, N = 3753), y de nuevo 5 años después (1998–2000, N = 2800). Se consideró que una persona tenía *tinnitus*, si éste era al menos moderado en severidad o causaba dificultad para conciliar el sueño. La prevalencia del *tinnitus* a nivel basal fue de 6.2%. La incidencia de *tinnitus* a 5 años entre los 2513 participantes en riesgo fue de 6.7 por ciento. Se evaluaron los factores de riesgo para incidencia y prevalencia de *tinnitus*. Los resultados sugieren que el *tinnitus* es un problema común para adultos mayores y está asociado con algunos factores de riesgo modificables.

Palabras Clave: trastorno auditivo, incidencia, presbiacusia, prevalencia, *tinnitus* (acúfeno)

Abreviaturas: EHLS = Estudio de Epidemiología de Trastornos Auditivos; peak Ytm = pico de admitancia acústica compensada

Tinnitus is defined as a sound perceived in the ears or head unrelated to any external source. In its more severe forms, tinnitus can be accompanied by depression, concentration difficulties, insomnia, or headaches (Tyler and Baker, 1983; Scott et al, 1990). Tin-

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nitus can be a symptom of a variety of auditory disorders, but exact causal mechanisms are not well understood.

Population-based estimates of the prevalence of tinnitus within the United States are few. Results from the 1995 National Health Interview Survey (NCHS, 1998) applied to the 2000 census data (U.S. Department of Commerce, 2001) suggest that 6.0 percent of U.S. adults aged 45 years or more have tinnitus. Estimates from population-based studies in other countries range from 9.7 to 19 percent (Coles, 1984; Axelsson and Ringdahl, 1989; Davis, 1989; Quaranta et al, 1996), depending on the age of subjects and how tinnitus was defined. However, we know of no population-based estimates of the incidence of tinnitus. The purpose of this study was to provide population-based data on the prevalence and 5-year incidence of tinnitus and to document associated risk factors.

METHOD

The Epidemiology of Hearing Loss Study (EHLS) is a population-based study of hearing loss in adults 48 to 92 years of age (Cruickshanks et al, 1998). During 1987 to 1988, residents of the city or township of Beaver Dam, Wisconsin, who were 43 to 84 years of age (N = 5924) were identified through a private census and invited to participate in a study of age-related ocular disorders (The Beaver Dam Eye Study, 1988–1990, N = 4926) (Klein et al, 1991). All who participated in the baseline eye examination and were alive as of March 1, 1993 were eligible to participate in the hearing study (EHLS, N = 4541). Of those eligible, 3753 (82.6%) participated, 42.3 percent of whom were male. The mean age was 65.8 years.

A 5-year follow-up examination was conducted from 1998 to 2000. Of 3407 alive and eligible, 2800 participated (82.2%), 41.4 percent of whom were male. The mean age at follow-up was 69.3 years.

The following procedures were used with both the baseline and 5-year follow-up examinations. The study was approved by the Human Subjects Committee of the University of Wisconsin-Madison. Informed consent was obtained from each participant at the beginning of the examinations. A questionnaire about medical history (including tinnitus) and occupational and leisure time noise exposure was administered as an interview.

Tinnitus questions were the following: (1) "In the past year have you had buzzing, ringing, or noise in your ears?" (No/Yes/Unknown); (2) "How severe is this noise in its worst form?" (Mild/Moderate/Severe/Unknown); and (3) "Does this noise cause you to have problems getting to sleep?" (No/Yes/Unknown). A person was classified as having significant tinnitus if he/she reported having "buzzing, ringing, or noise" in the ears in the past year of at least moderate severity, tinnitus that caused difficulty in falling asleep, or both. Only cases of significant tinnitus were analyzed in an effort to focus on more clinically significant symptoms that were comparable with other definitions in the literature (Coles, 1984; Axelsson and Ringdahl, 1989; Quaranta et al, 1996). Tinnitus described as mild and not causing difficulty in falling asleep was not counted as significant tinnitus. When a person indicated experiencing tinnitus, did not indicate that it caused problems getting to sleep, and answered "unknown" to the severity question, his or her tinnitus was classified as mild and was not counted as significant tinnitus (n = 11 at baseline, n = 6 at follow-up).

Audiologic tests included otoscopy (Nondahl et al, 1996), screening tympanometry (Nondahl et al, 1996; Wiley et al, 1996), and pure-tone air- and bone-conduction audiometry (Cruickshanks et al, 1998). Tinnitus matching was not part of the study protocol owing to time constraints. All audiometric and tympanometric equipment complied with American National Standards Institute standards (ANSI, 1987, 1989). Pure-tone audiometric testing at 0.25 to 8 kHz was performed in accordance with recommended American Speech-Language-Hearing Association procedures (ASHA, 1978). Bone-conduction testing was conducted at 0.5 and 4 kHz at baseline and at 0.5, 2, and 4 kHz at the 5-year follow-up. Audiometers were calibrated every 6 months.

Potential risk factors from the baseline examination explored in logistic regression models for both prevalent and 5-year incident tinnitus were age, gender, hearing loss (pure-tone average of hearing thresholds at 0.5, 1, 2, and 4 kHz > 25 dB HL in the worse ear), conductive hearing loss (15 dB air–bone gap in either ear), and possible middle ear effusion (peak compensated static acoustic admittance [peak Ytm] of 0.0 acoustic millimhos (mmhos) on the tympanogram, or a peak Ytm of 0.1 to 0.2 mmhos and at least one of the following: peak Ytm in the opposite ear > 0.8 mmhos, head cold in the past week, sinus infection or problems in the past week, ear infection on the day of the examination, earache or pain in the past year, ear pressure in past year, feeling of fullness in the ear

in the past year, or discharge from the ear in the past year).

Current aspirin use (at least twice a week for more than 3 months) was also explored. Other medications were not evaluated for the following reasons: (1) the prevalence of multiple medication use, making the isolation of individual medication effects problematic, and (2) the absence of information on dose and duration of use.

Other factors explored were smoking status (never, past, current), alcohol consumption (grams of ethanol per week), history of heavy drinking (≥ 4 drinks per day), history of cardiovascular disease (myocardial infarction, stroke, or angina), diabetes status, total serum cholesterol, hypertension (systolic ≥ 140 mm Hg or diastolic ≥ 90 mm Hg or taking blood pressure medication), years of education, and occupational group (managerial/professional, technical/sales, service, farming/forestry/fishing, production/craftsman/repair, operator/fabricator/laborer). History of occupational noise exposure, another factor explored, was considered to be present if the participant (1) had a full-time job that required speaking in a loud voice in order to be heard by another person 2 feet away; (2) had been a farmer and had driven a tractor, at least half the time without a cab; or (3) had 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; had used grenades, mortars, or shoulder-held grenade launchers; or had used a weapons system requiring more than one person for operation research (Popelka et al, 2000). The associations of history of target shooting (at least once a month, on average, for a year), history of hunting (fired gun in past year), history of head injury (skull fracture, concussion, broken nose, loss of consciousness due to a head injury, whiplash or other serious neck injury), and history of otosclerosis with the prevalence and incidence of tinnitus were also evaluated.

Statistical analyses were completed with SAS software (SAS Institute Inc., 1999, Gary NC). T-tests were used to compare means, t-tests of least squares means were used to compare age-adjusted means, the chi-square test for general association was used to compare percentages by participation status (except for otosclerosis, for which Fisher's exact test was used), and the Cochran-Mantel-Haenszel test for general association was used to compare age-adjusted percentages.

RESULTS

Prevalence

Using the definition of significant tinnitus detailed in the Method section, the overall prevalence of significant tinnitus at baseline was 8.2 percent (95% confidence interval [CI] 7.4–9.1). Of 308 subjects with tinnitus, 92.5 percent had rated their tinnitus as moderate (n = 229) or severe (n = 56); the remaining 23 subjects reported mild tinnitus that caused difficulty falling asleep. The prevalence of tinnitus rated as severe was 1.5 percent. Prevalence rates by gender and age group are shown in Table 1 for the 3737 participants for whom tinnitus data were available. There was no statistically significant difference in prevalence of tinnitus by gender and no statistically significant age group trend.

Selected characteristics of this population, by tinnitus status, are shown in Table 2. On the basis of these unadjusted results, participants with significant tinnitus were more likely to have occupational noise exposure, hearing loss, history of head injury, history of cardiovascular disease, and conductive hearing loss than participants without tinnitus.

Potential risk factors were examined with age- and gender-adjusted logistic regression models (results not shown) to identify factors to explore further in multiple logistic regression models. Results from the final, most parsimo-

Table 1 Prevalence of Tinnitus by Sex and Age Group

Age Group (yr)	*Number at Risk**	*Prevalence (%)*	*95% CI*
Men	1582	8.8	7.4–10.2
48–59	589	7.8	5.6–10.0
60–69	500	10.4	7.7–13.1
70–79	372	9.1	6.2–12.1
80–92	121	5.8	2.4–11.6
Women	2155	7.8	6.7– 9.0
48–59	707	6.8	4.9– 8.6
60–69	602	9.8	7.4–12.2
70–79	564	8.3	6.1–10.6
80–92	282	5.3	2.7– 7.9
Both sexes	3737	8.2	7.4– 9.1
48–59	1296	7.3	5.8– 8.7
60–69	1102	10.1	8.3–11.9
70–79	936	8.7	6.9–10.5
80–92	403	5.5	3.2– 7.7

*Sixteen participants did not provide sufficient information for tinnitus classification and are excluded from this table.

Table 2 Characteristics of Participants at Baseline

Characteristic	Percentage with Characteristic		
	No Tinnitus (n = 3429)	Tinnitus (n = 308)	All (n = 3737)*
12 or more years of education	76.0	72.4	75.7
Occupational noise exposure†	54.1	61.4	54.7
Hypertension	51.1	47.1	50.8
Hearing loss†‡	43.8	67.7	45.8
Male gender	42.1	45.1	42.3
History of hunting	38.0	41.9	38.4
History of head injury†	29.3	41.6	30.3
Regular aspirin use	28.0	31.3	28.3
History of heavy drinking	16.3	20.7	16.7
Current smoker	14.5	16.8	14.7
History of cardiovascular disease†	14.0	19.9	14.5
Diabetes	10.0	9.6	10.0
Possible middle ear effusion	9.3	12.3	9.6
History of target shooting	8.4	11.4	8.6
Conductive hearing loss†‡	7.6	13.0	8.1
Otosclerosis	0.2	0.7	0.3
Mean age (yr)	65.8	65.6	65.8
Mean total cholesterol (mmol/L)	6.17	6.17	6.17
Ethanol consumption (g/wk)	43.9	43.9	43.9

*Sixteen participants did not provide sufficient information for tinnitus classification and are excluded from this table;
†Differences by tinnitus status were statistically significant (chi-square test for association, $p < .05$).
‡Denominator for "hearing loss" and "conductive hearing loss" excludes 182 participants who were interviewed at baseline but not examined.

nious model are shown in Table 3. For every 5-year increase in age, there was a 14 percent decrease in risk of having tinnitus. Females were 35 percent more likely to have tinnitus than were males. Similarly, hearing loss, cardiovascular disease, and history of head injury were positively associated with having tinnitus.

5-Year Incidence

The participation status at the 5-year follow-up examination of the 3737 participants with baseline tinnitus data is shown in Table 4. There were 3429 baseline participants at risk for developing incident tinnitus (2983 with no baseline tinnitus and 446 with mild tinnitus not causing difficulty falling asleep); 2558 (74.6%) of these participated in the follow-up examination.

Table 3 Risk Factors for Prevalence of Tinnitus from Final Multiple Logistic Regression Model

Risk Factor	Odds Ratio	95% CI
Age (unit = 5 yr)	0.84	0.78–0.90
Female sex	1.38	1.06–1.80
Hearing loss	3.90	2.89–5.27
Cardiovascular disease	1.45	1.05–2.00
History of head injury	1.56	1.21–2.02

Comparisons between those who participated in the 5-year follow-up study and those who did not, among those without tinnitus at baseline, are presented in Table 5. In general, participants in the follow-up study were younger, had more education, and were in better health than nonparticipants. Most of the statistically significant differences by participation status remained after adjusting for age.

The 5-year incidence of tinnitus was 5.7 percent (95% CI 4.8–6.6). Incidence rates by gender and age group are shown in Table 6. There was no statistically significant difference in the incidence of tinnitus by gender and no statistically significant age group trend.

Selected characteristics of participants in the 5-year follow-up study, by tinnitus status, are shown in Table 7. On the basis of these unadjusted results, participants who developed significant tinnitus were more likely to have 12 or more years of education, hearing loss, history of head injury, conductive hearing loss, higher total cholesterol, and lower ethanol consumption than participants who did not.

Table 4 5-Year Follow-up Participation by Baseline Tinnitus Status

Baseline Tinnitus Status*	Status at Follow-up: Participants n	Participants %	Nonparticipants n	Nonparticipants %	Deceased† n	Deceased† %
None	2208	74.0	471	15.8	304	10.2
Mild	350	78.5	37	8.3	59	13.2
Moderate/severe	236	76.6	34	11.0	38	12.3

*Sixteen participants did not provide sufficient information for tinnitus classification at baseline and are excluded from this table.
†Includes those who died before and after the follow-up examination began.

Potential risk factors for the 5-year incidence of tinnitus were examined in the same manner as prevalence. Results from the final, most parsimonious model are shown in Table 8. Those who had a hearing loss at the baseline examination had an 83 percent higher risk of developing tinnitus than those who did not have a hearing loss. For every 0.26 mmol/L increase in total cholesterol at baseline, there was a 4.2 percent higher risk of developing tinnitus. Similarly, history of head injury and history of otosclerosis were positively associated with incidence of tinnitus; age and gender were not associated.

DISCUSSION

Prevalence

Tinnitus is a relatively common condition among older adults. The overall prevalence of significant tinnitus was 8.2 percent (95% CI 7.4–9.1). Results from the 1995 National Health Interview Survey, a continuing nationwide survey of the U.S. civilian noninstitutionalized population (NCHS, 1998), applied to 2000 census data (U.S. Department of Commerce, 2001), suggest that 6.0 percent of adults aged 45 years or

Table 5 Baseline Characteristics of Participants at Risk for Incident Tinnitus, by 5-Year Follow-up Participation Status*

Characteristic	Percentage with Characteristic: Did Not Participate in 5-Year Follow-up (n = 871)	Percentage with Characteristic: Participated in 5-Year Follow-up (n = 2558)	p Value: Unadjusted	p Value: Age-adjusted
12 or more years of education	62.7	80.6	<.001	<.001
Occupational noise exposure	53.7	54.2	.80	.07
Hypertension	61.3	48.0	<.001	.005
Hearing loss†	63.5	37.7	<.001	<.001
Male gender	45.6	40.9	.016	<.001
History of hunting	39.3	37.6	.37	.002
History of head injury	24.9	30.8	.001	.054
Regular aspirin use	33.1	26.4	<.001	.27
History of heavy drinking	19.2	15.4	.014	<.001
Current smoker	18.0	13.4	.002	<.001
History of cardiovascular disease	24.0	11.0	<.001	<.001
Diabetes	16.	28.2	<.001	<.001
Possible middle ear effusion	11.3	8.7	.036	.93
History of target shooting	8.1	8.5	.70	.12
Conductive hearing loss†	9.4	7.1	.040	.54
Otosclerosis	0.0	0.3	.21	.048
Mean age (yr)	70.9	64.0	<.001	—
Mean total cholesterol (mmol/L)	6.06	6.21	.004	.001
Ethanol consumption (g/wk)	39.1	45.4	.16	.59

*Sixteen participants did not provide sufficient information for tinnitus classification at baseline and are excluded from this table.
†Denominator for "hearing loss" and "conductive hearing loss" excludes 171 participants who were interviewed at baseline but not examined.

Table 6 5-Year Incidence of Tinnitus by Gender and Baseline Age Group*

Age Group (yr)	Number at Risk	Incidence (%)	95% CI
Men	1032	6.5	5.0– 8.0
48–59	448	6.5	4.2– 8.8
60–69	341	6.2	3.6– 8.7
70–79	208	7.7	4.1–11.3
80–92	35	2.9	0.1–14.9
Women	1481	5.2	4.1– 6.3
48–59	575	5.9	4.0– 7.8
60–69	430	4.4	2.5– 6.4
70–79	358	5.3	3.0– 7.6
80–92	118	4.2	1.4– 9.6
Both sexes	2513	5.7	4.8– 6.6
48–59	1023	6.2	4.7– 7.6
60–69	771	5.2	3.6– 6.8
70–79	566	6.2	4.2– 8.2
80–92	153	3.9	1.5– 8.3

*Among the 2558 people participating in both the baseline and follow-up examinations who were at risk for incident tinnitus, 45 provided insufficient data for tinnitus classification at the follow-up examination, leaving the 2513 participants shown in this table.

more had "tinnitus or ringing in the ears." We know of no other comparable studies from the United States. The National Health Examination Survey of 1960 to 1962 (Leske, 1981) and the Health and Nutrition Examination Survey of 1971 to 1975 (Cooper, 1994) asked about tinnitus symptoms over "the past few years" and so resulted in prevalence estimates (32% and 14.9%, respectively) over a much longer period than the present study. The Framingham cohort, selected to be free of cardiovascular disease at baseline, reported that 16.8 percent of those at least 60 years of age had "ringing or buzzing in [their] ears now" (Gates et al, 1990).

Prevalence estimates from population-based studies in other countries range from 9.7 to 19 percent. In the United Kingdom, Coles (1984) found that 16 to 19 percent of adults aged 17 years or more had spontaneous tinnitus of over 5 minutes duration. A few years later, Davis (1989) found 9.7 percent of adults sampled in Great Britain to have prolonged spontaneous tinnitus. A Swedish study found 14.2 percent of adults to suffer from tinnitus "often" or "always" (Axelsson and Ringdahl, 1989). A more recent study within five Italian cities found that 14.5 percent of adults sampled experienced prolonged spontaneous tinnitus (Quaranta et al, 1996).

Slight differences in definitions of tinnitus, along with differences in population characteristics, may explain why the current prevalence

Table 7 Characteristics of Participants at 5-Year Follow-up, by Incidence Status

Characteristic	Percentage with Characteristic		
	No Tinnitus (n = 2369)	Incident Tinnitus (n = 144)	All (n = 2513)
12 or more years of education*	80.7	87.5	81.1
Occupational noise exposure	54.1	56.9	54.2
Hypertension	47.9	50.0	48.0
Hearing loss*†	36.5	48.9	37.2
Male gender	40.7	46.5	41.1
History of hunting	37.2	43.8	37.6
History of head injury*	30.2	41.0	30.8
Regular aspirin use	26.6	22.5	26.4
History of heavy drinking	15.3	16.2	15.3
Current smoker	13.3	14.1	13.4
History of cardiovascular disease	10.6	14.9	10.8
Diabetes	7.9	9.2	8.0
Possible middle ear effusion	8.5	7.9	8.5
History of target shooting	8.4	9.7	8.5
Conductive hearing loss†	7.0	8.8	7.1
Otosclerosis	0.2	1.4	0.3
Mean age (yr)	63.9	63.4	63.8
Mean total cholesterol (mmol/L)‡	6.2	6.39	6.21
Ethanol consumption (g/wk)‡	46.2	33.9	45.5

*Differences by tinnitus status were statistically significant (chi-square test for association, $p < .05$).

†Denominator for "hearing loss" and "conductive hearing loss" excludes 142 participants who were interviewed but not examined at baseline or follow-up.

‡Differences by tinnitus status were statistically significant (t-test, $p < .05$).

Table 8 Risk Factors for 5-Year Incidence of Tinnitus from Final Multiple Logistic Regression Model

*Risk Factor**	*Odds Ratio*	*95% CI*
Hearing loss	1.83	1.21 –2.75
Total cholesterol (unit = 0.26 mmol/L)	1.042	1.004–1.080
History of head injury	1.55	1.08 – 2.22
Otosclerosis	8.85	1.42 –55.14

*Also retained in the final model were age (p = .10) and gender (p = .76).

estimate of 8.2 percent is somewhat lower than the prevalences found by these other studies. Unlike most medical conditions for which objective tests can be used to standardize case definitions across studies, there is no objective test for tinnitus. It is therefore not possible to establish validated self-report assessment tools. Differentiating between an occasional perceived noise and prolonged or persistent noises adds to the difficulty of the task. Consensus among researchers and clinicians about the best questions and definitions to use to permit valid comparisons across populations or clinic groups is needed.

Severe tinnitus was experienced by 1.5 percent of the Beaver Dam cohort. Other reported population-based prevalence estimates for severe tinnitus range from 1.0 to 2.4 percent (Coles, 1984; Axelsson and Ringdahl, 1989; Davis, 1989).

Beginning with those 60 to 69 years of age (see Table 1), age was inversely associated with having tinnitus in the present study. This is consistent with results from the final multiple logistic regression model (see Table 3). Reasons for this inverse pattern 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. Another possibility is that there are lifelong differences between the age groups, apart from age, that account for the differences in prevalence (a "cohort effect"). Selective mortality may also play a part: a similar causal pathway between tinnitus and cardiovascular disease may result in earlier deaths among some of those with tinnitus so that tinnitus prevalence decreases with age. Idler (1993) and Wiley and colleagues (2000) discuss these issues at length. One previous study reported a negative association between prevalence of tinnitus and age for participants over the age of 70 (Davis, 1989); another reported a decreased prevalence of tinnitus beginning at age 75 (NCHS, 1998). Conversely, a few studies have reported a positive association between age and prevalence of tinnitus (Leske, 1981; Axelsson and Ringdahl, 1989; Quaranta et al, 1996).

After adjusting for other factors, females were at greater risk of having significant tinnitus than were males (see Table 3). This is consistent with the findings of Leske (1981) and Cooper (1994), who found the prevalence of tinnitus to be higher among females than among males. Other studies have found males 40 to 59 years of age (Axelsson and Ringdahl, 1989) or males of all ages (NCHS, 1998) to have a higher prevalence of tinnitus than comparably aged females. Quaranta and colleagues (1996) found no gender difference in tinnitus prevalence.

Tinnitus has been previously associated with hearing loss (Leske, 1981; Axelsson and Ringdahl, 1989), head injury (Vernon and Press, 1994), and cardiovascular disorders (Schleuning, 1991). According to Schleuning (1991), after otologic disorders, cardiovascular disorders are the second most common cause of tinnitus.

5-Year Incidence

The 5-year incidence of significant tinnitus was 5.7 percent. We know of no other studies that have reported on the incidence of tinnitus. Unlike with the prevalence results, there was no age or gender association with incidence of tinnitus, suggesting that, within this limited age range, tinnitus is not the result of "aging" but of discrete events and exposures.

Hearing loss at baseline and history of head injury at baseline were significant risk factors for developing significant tinnitus over 5 years (see Table 8), just as they were for the prevalence analyses. In addition, having higher concentrations of total serum cholesterol or a history of otosclerosis resulted in increased risk of developing tinnitus. Only seven participants at risk for incident tinnitus had a history of otosclerosis, two of whom reported significant tinnitus at the follow-up examination. The small number of participants reporting otosclerosis resulted in a wide confidence interval for its odds ratio.

The observed associations between, first, history of cardiovascular disease and the prevalence of significant tinnitus and, second, total cholesterol and the 5-year incidence of significant tinnitus provide additional evidence that cardiovascular disorders may be a contributing factor to some forms of tinnitus. Objective tin-

nitus, a rare form in which the sound can be heard by the examiner as well as the patient, can sometimes be traced to arteriovenous malformations, glomus tumors, abnormally high placement of the jugular bulb, carotid stenosis, or hypertension. Subjective tinnitus, heard only by the patient, has occasionally been linked to hypertension, increased cardiovascular output, or extensive arteriosclerosis (Schleuning, 1991). Additional research is needed to clarify the role of cardiovascular health and the development of tinnitus.

There is some inherent variability in the assessment of tinnitus. For example, the same tinnitus symptoms may be considered to be of moderate severity by one person but mild or severe by another person. In addition, one's awareness of tinnitus may vary over time. Among 233 participants with significant tinnitus at the baseline examination, 105 (45.1%) reported improvement at the follow-up examination. Among these 105 participants, 45 (42.9%) reported no tinnitus at follow-up, and 60 (57.1%) reported mild tinnitus. For some of these participants, the tinnitus may have genuinely diminished. Others may have successfully adjusted to it so that it did not bother them as much as it did 5 years previously.

The tinnitus status of participants with mild tinnitus at baseline was more variable 5 years later than that of participants with moderate/severe tinnitus at baseline. Only 139 of 341 (40.8%) participants with mild tinnitus were unchanged 5 years later, compared with 128 of 233 (54.9%) participants with moderate/severe tinnitus. In addition, participants were more likely to report changing from mild tinnitus to no tinnitus (n = 135 of 341; 39.6%) than from mild tinnitus to moderate/severe tinnitus (n = 67 of 341; 19.6%). The increased variability among mild cases supports not including mild cases that do not cause difficulty falling asleep in the current study's definition of significant tinnitus.

This study is one of very few population-based studies to report on the prevalence of tinnitus and may be the first to report incidence data on this well-known but little understood symptom. Most important, analyses suggest that tinnitus may be associated with some modifiable risk factors.

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