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Occupation and the risk of bothersome tinnitus: results from a prospective cohort study (HUNT)

Bo Engdahl,[1] Norun Hjertager Krog,[1] Ellen Kvestad,[1] Howard J Hoffman,[2] Kristian Tambs[1,3]

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[1]Norwegian Institute of Public Health, Division of Mental Health, Oslo, Norway
[2]Epidemiology and Statistics Program, National Institute on Deafness and Other Communication Disorders (NIDCD), National Institutes of Health (NIH), Bethesda, Maryland, USA
[3]Departments of Psychiatry and Human Genetics, Virginia Commonwealth University, Richmond, Virginia, USA

Correspondence to
Dr Bo Engdahl;
bo.engdahl@fhi.no

ABSTRACT

Objectives: Estimates of occupation-specific tinnitus prevalence may help identify high-risk occupations where interventions are warranted. The authors studied the effect of occupation on prevalence of bothersome tinnitus and estimated the attributable fraction due to occupation. The authors also studied how much of the effect remained after adjusting for noise exposure, education income, hearing thresholds and other risk factors.

Design: A prospective cohort study.

Setting: A health survey of the Nord-Trøndelag county of Norway.

Participants: A sample of the general adult population (n=49 948).

Primary outcome measure: The primary outcome measure is bothersome tinnitus.

Results: Occupation had a marked effect on tinnitus prevalence. The effect of occupation on tinnitus was reduced in men by controlling for self-reported occupational noise exposure and in women by controlling for education and income. Adding hearing loss as a predictor increased the effect of occupation somewhat. In men, age-adjusted prevalence ratios of tinnitus ranged from 1.5 (workshop mechanics) to 2.1 (crane and hoist operators) in the 10 occupations with highest tinnitus prevalence. In women, the most important contribution to the tinnitus prevalence was from the large group of occupationally inactive persons, with a prevalence ratio of 1.5.

Conclusion: This study found a moderate association between occupation and bothersome tinnitus.

ARTICLE SUMMARY

Article focus

- We studied the effect of occupation on prevalence of bothersome tinnitus and estimated the attributable fraction due to occupation.
- We also studied if the effect remained after adjustment for noise exposure, education and income, other risk factors and hearing threshold.

Key messages

- There are very few epidemiological studies quantifying work-related tinnitus risk, and our large and representative sample gives precise estimates of occupational risk.
- This study shows moderate effects of occupation on bothersome tinnitus and presents prevalence estimates of 122 different occupations in 49 948 subjects.
- Noisy occupations were associated with an increased risk of bothersome tinnitus in men, but in women, occupations with the highest risk for tinnitus were not typically noisy ones, and the attributable fraction was determined mainly by the group of occupationally inactive.

Strengths and limitations of this study

- The major advantages of the present study are the prospective design and that the study population is representative of the general working population.
- The occupations are not classified by risk factors for tinnitus, but according to the tasks and duties undertaken in the job. Heterogeneity regarding exposure within occupational categories implies that occupation, as an explanatory variable, does not capture all effects of occupational exposures on tinnitus.

INTRODUCTION

Tinnitus, or the perception of sound without an external acoustic stimulus, is a common health complaint in the adult population. In addition to general irritation and annoyance with the sound, tinnitus can cause difficulties with sleep and concentration, reduced speech intelligibility and various psychosomatic, emotional and interpersonal problems.[1] The prevalence of chronic tinnitus in the adult population is estimated at 8%–15%, depending on the definition.[2 3] It is higher in men and increases with age up to a certain point, after which it declines.[3–5]

Tinnitus frequently occurs together with permanent hearing loss,[6 7] suggesting that tinnitus may be associated with cochlear damage. Tinnitus shares many of the same risk factors as hearing loss, including occupational noise, work-related diseases, exposure to toxins, non-occupational noise

exposure, drugs or medications, otological diseases, dizziness, head injury and socioeconomic and general health status.[4 7–11]

However, tinnitus is not always secondary to hearing loss and may occur in individuals with normal hearing. Some have suggested that tinnitus is an early sign of hearing loss, in particular noise-induced hearing loss,[12] although there are studies opposing this hypothesis.[13] Central nervous system mechanisms are believed to play an important role in the pathology of tinnitus.[14] Therefore, risk factors related to neural plasticity and sensitisation may be of importance. Stress seems to play a role: patients often report worsening of tinnitus with stress. Workers perceiving high job stress have an increased risk of tinnitus,[9 15] and tinnitus may be induced by stressful life events and trauma.[16] Work-related stress such as low degree of control, conflicting work demands, conflict between work and family life and lack of support from superiors may therefore be risk factors for tinnitus. Tinnitus has been associated with mental health and well-being,[17] factors that might themselves be work related, thus mediating the association between occupation and tinnitus. The direction of influence between tinnitus and many of these factors is, however, unclear, and there may even be bidirectional relationships.[18]

Although tinnitus has been associated with a few occupational risk factors such as noise exposure,[4 5 8 9 11] there are very few studies quantifying occupational-specific tinnitus risk.[4] Epidemiological studies of work-related tinnitus are needed in order to identify high-risk occupations with specific types of harmful exposure so that protective measures can be implemented.

Previous analyses of data from the Nord-Trøndelag Hearing Loss Study (NTHLS) showed effects of self-reported occupational and impulse noise exposure on tinnitus.[4] Analyses also revealed effects of education, income, general health status, recurrent ear infections, head injury and cigarette smoking. Frequent exposure to loud music and having played in a band were, in contrast, more frequent among subjects without tinnitus. Detailed information on occupation type was not included in the previous analyses. However, information from the nationwide occupation register has recently been used to study the effect of occupation-specific hearing loss.[19]

The primary aim of the present study was to determine the effect of occupation on bothersome tinnitus. Second, we estimated the fraction of tinnitus that can be attributed to occupation-associated risks. We also wanted to examine the extent to which differences in tinnitus between the various occupations remained after adjustment for self-reported occupational noise exposure, non-occupational noise exposure, other risk factors, education, income and hearing loss.

MATERIALS AND METHODS

Study population

The NTHLS is part of the Nord-Trøndelag Health Study (HUNT-2). The entire adult population of Nord-Trøndelag county in Norway was invited to participate in HUNT-2, which was conducted from January 1996 to February 1998. Screening included several types of examinations and two questionnaires (HUNT-2 Q1 and Q2). Seventeen of the 24 municipalities were offered and accepted hearing examination, consisting of pure-tone audiometry and the completion of two questionnaires (Hearing Q1 and Q2), as part of the screening program.

The subjects ranged in age from 20 to 101 years (median 48.0 years; mean (SD) 50.2 (17.0) years). The participation rate for all municipalities was 69% except one (Levanger), 65% among male subjects and 73% among female subjects. The corresponding rates for Levanger (where the HUNT-2 participants had to be re-invited to have their hearing examined) were 42%, 39% and 45% overall and for male subjects and female subjects, respectively. The participation rates varied with age, from about 40% for subjects younger than 30 years or older than 80 years to 82% for subjects from 60 to 69 years. The low participation rate among young people is likely due in part to the absence of students and young adults serving their (compulsory) military service who, while formally keeping their childhood home address, had moved to other parts of the country.

A total of 51 574 persons arrived for their hearing examination and provided written informed consent. Participants completed a questionnaire (Hearing Q1) on hearing-related information at the examination site. Audiometric data were missing for 774 persons (1.5%). Questionnaire data were missing or incomplete for 815 persons (1.6%). The sample is described in greater detail elsewhere.[20]

Information on occupation, education and income was obtained for all, but 37 subjects from the population register information from Statistics Norway. In total, the sample consisted of 49 948 subjects with complete data.

Measures

The Hearing Q1 included questions about bothersome tinnitus. Tinnitus was here defined by a 'yes' response to the single general question: 'Are you bothered by ringing in the ears?' Missing values and a 'no' response were considered equivalent to 'not bothered'. The Hearing Q2 included a slightly differently phrased question about the degree to which the respondent is bothered by tinnitus (response categories: not bothered, a little bothered and strongly bothered). In the present study, the question and data from Q1 were used. Previous analysis has shown a test–retest polychoric correlation for 27 792 persons tested twice on both Q1 and Q2, with the majority of time lags ranging from 3 to 6 months, of 0.65 (95% CI 0.63 to 0.66) indicating relatively high reliability for our tinnitus measure.[21]

Data on occupation were obtained using census records from 1970, 1980 and 1990. The most recent occupation information was used. For example, if a subject was not working in 1990, his or her occupation

status from 1980 was used. About 22% of the population (14% of male subjects and 30% of female subjects) had no registered occupation (ie, were occupationally inactive) during all the census registration years. Occupation was coded according to the Nordic Classification of Occupations[22] using a three-digit code. The digits represent the major class ('felt'), the sector ('område') and the occupation group. The codes consist of 13, 86 and 412 groups, respectively.[23] For supplementary analyses, the group of occupationally inactive was further distinguished into subclasses based on questions on working situation in the HUNT-2 Q1. The subgroups were (1) full-time household workers, (2) military service or student, (3) unemployed and (4) receiving social security or disability pension. These latter groups were not mutually exclusive, so that individuals could belong to more than one of these groups.

Education data were available for 1980, 1985, 1990, 1995 and 1998. We used the most recent education information. Education was classified into nine levels, from elementary school to tertiary studies leading to advanced professional degrees.

Income data from 1980, 1985, 1990, 1995 and 1998 were calculated as the mean income over the years available, corrected for an increase in the general population income during the period 1980–1998.

Self-reported noise exposure and other risk factors for hearing loss were obtained from the Hearing Q1. Occupational noise exposure was measured by questionnaire items on the duration of exposure to loud noise at work in general (scored 0–3) and from specific noise sources: staple gun/hammering, metal hammering/riveting, circular saw/machine planing, chain saw operation, tractor/construction machines, sledgehammer operation, blasting, machine room noise and other factory noise (scored as 'yes' or 'no'). Non-occupational risk factors were measured by questionnaire items about impulse noise (ie, explosions, shootings); playing in a band or going to discotheques, rock concerts or similar loud events; recurrent ear infections (in childhood or later); hospitalisation (ever) for a head injury (scored as 'no', 'perhaps or I don't know' and 'yes') and smoking cigarettes daily (scored as 'no', 'yes, for 0 to <5 years', 'yes, for ≥5 to <15 years', 'yes, for ≥15 years'). The items on the questionnaire are described in detail elsewhere.[4 24]

Air conduction hearing thresholds were obtained by pure-tone audiometry as described in an earlier publication.[20] The hearing scores were computed as pure-tone average on the worse ear for three independent mean values: (1) low-frequency hearing level (250 and 500 Hz), (2) medium-frequency hearing level (1000 and 2000 Hz) and (3) high-frequency hearing level (3000, 4000, 6000 and 8000 Hz).

Statistical methods

The effects of occupation on the prevalence of tinnitus were estimated using a log-binomial model with occupation group and age in 5-year groups as fixed factors. The analyses were stratified by sex and age groups (20–44, 45–64 and ≥65 years). The model, a generalised linear model in which the link function is the logarithm of the proportion under study and the distribution of the error is binomial, was estimated by maximum likelihood. The occupation groups 060–069 were aggregated into one occupation group 06 'pedagogical work' and used as a reference with a sufficient number of subjects for estimating prevalence ratios (PRs). Occupations with fewer than 40 subjects were collapsed into one group. Direct estimates of PRs by log-binomial regression have some advantages over ORs estimated with logistic regression analysis,[25] and the high prevalence of tinnitus in our sample makes PRs easier to interpret.

Overall model fit was determined by the residual deviance, the lack of fit that remains after modelling with m predictors, as well as the McFadden pseudo R^2 defined as:

$$R_l^2 = 1 - \frac{\ln(L_m)}{\ln(L_0)}, \quad (1)$$

where L_m is the likelihood function of the model containing m predictors and L_0 is the likelihood function of the model containing only the intercept. As R_l^2 does not reach 1, a rule of thumb is that the model has an excellent fit with R_l^2 being between 0.2 and 0.4.[26]

The overall effect of occupation in the model was estimated by the partial R_l^2 (the difference in R_l^2 values between a model with and without occupation). Changes in the overall effect of occupation by controlling for hearing loss, self-reported noise exposure, other risk factors, education and income were measured by changes in partial R_l^2 after subsequently entering additional control variables in the model.

In order to estimate the portion of tinnitus cases in the population that can be attributed to an occupation, the occupation-specific adjusted attributable fraction (AF) was calculated by the following formula:[27]

$$\mathrm{pd}_i \frac{\mathrm{PR}_i - 1}{\mathrm{PR}_i}, \quad (2)$$

where PR_i is the adjusted prevalence ratio for the ith occupation relative to occupation group 063 and pd_i represents the proportion of cases in the ith occupation to the total population. The sum of the occupation-specific adjusted AF is thus:

$$1 - \sum_{i=0}^{k} \frac{\mathrm{pd}_i}{\mathrm{PR}_i}, \quad (3)$$

where k is the total number of occupations.

The 95% CIs of the occupation-specific AF where estimated by non-linear bootstrapping with the percentile method and 1000 replications. All statistical analyses

Table 1 Tinnitus prevalence

Age group	Men		Women	
	Sample size	Tinnitus prevalence (%)	Sample size	Tinnitus prevalence (%)
All	23 374	16.4	26 574	12.1
20–44 years	9359	10.6	10 920	8.4
45–64 years	8618	18.5	9246	12.0
>64 years	5397	23.0	6408	18.7

were performed using the computer program R, V.2.11.1.

RESULTS

The tinnitus prevalence is higher in men and increases by age (table 1).

The goodness of fit (viz., pseudo R^2) for models of tinnitus prevalence by age, occupation, self-reported noise exposure, other risk factors, education, income and hearing loss, entered step- and block-wise, are shown in tables 2 and 3 for men and women, respectively. Occupation contributed significantly to the prediction of tinnitus after adjusting for age in all age groups and for both sexes. Differences in pseudo R^2 values, ΔR_l^2, for each model showing specifically the additional effect of occupation compared with the same model without occupation, ranged from 0.9% to 2.5%. The effects of occupation as observed by ΔR_l^2 were higher in men than in women and highest in men older than 64 years. In all strata, the best-fit model was obtained with the complete set of predictors, with a significant increase in pseudo R^2 value for each step.

Controlling for self-reported occupational noise exposure reduced the effect of occupation only in men aged 45 years or older. The effect of occupation was still statistically significant. Additional control for leisure-related noise, recurrent ear infections, head injuries and smoking had little influence on the effect of occupation at all; this was also true when controlling for education and income. Controlling for hearing loss, however, increased the effect of occupation somewhat.

In women, the effect of occupation was not reduced by controlling for self-reported occupational noise exposure or by controlling for leisure-related noise, recurrent ear infections, head injuries and smoking. However, controlling for education and income considerably reduced the estimated effect of occupation, so that the effect was no longer statistically significant.

Tables 4 and 5 report the predicted age-adjusted prevalence estimates for tinnitus according to various occupational groups. The tables also show the AFs—the fraction of tinnitus cases in the population attributed to an occupation. The aggregated occupational group 'pedagogical work' was specified as a reference group. For men, the occupations with the highest PRs were crane and hoist operators and miners, with PRs of 2.1 and 1.9, respectively. For women, laboratory assistants had the highest PR, 1.9. The large group of subjects with no reported occupation had the highest AFs both in men and in women, although their PR was moderate, 1.2 and 1.5, respectively. The sum of all occupation-specific age-adjusted AFs was estimated to be 13.3% (95% CI 9.1% to 17.0%) and 21.4% (95% CI 13.9% to 24.9%) in men and women, respectively. In women, the overall AF was to a great extent determined by the contribution from the group not reporting an occupation.

In order to further investigate the nature of tinnitus prevalence in the group of occupationally inactive women, we restricted our sample to subjects younger than 65 years (N=5850). Significant effects after adjustment for age were estimated for receiving social security or disability pension (PR 2.0; 95% CI 1.6 to 2.5, N=567), for being unemployed (PR 1.6; 95% CI 1.2 to 2.0, N=503) and for being full-time household workers (PR 1.2; 95% CI 1.0 to 1.5, N=1713). There was no effect of being in the military service or a student (PR 0.9; 95% CI 0.7 to 1.1, N=936). The effect of receiving social security or disability pension was slightly reduced by controlling for noise exposure and other risk factors (PR 1.7; 95% CI 1.4 to 2.1) and further reduced by controlling for education and income (PR 1.4; 95% CI 1.2 to 1.8). Controlling for hearing loss resulted in a negligible additional change (PR 1.3; 95% CI 1.1 to 1.6).

DISCUSSION

Our results showed that occupation has moderate but significant effects on the prevalence of bothersome tinnitus. The effect of occupation on tinnitus prevalence was smaller in women than in men, but the gender difference was not as marked as the previously reported effect of occupation on hearing loss in this sample.[19] Controlling for self-reported occupational noise exposure reduced the occupation effect in men but had no effect in women; this is likely a confirmation of previous reports that women are in general exposed to less occupational noise. However, additional control for education and income only affected the occupation effect in women.

Several occupations recognised to be associated with loud noise exposure were associated with an increased risk of tinnitus in men and contributed to the overall AF of tinnitus, that is, the fraction of tinnitus cases due to occupation. This is in agreement with previous findings

Table 2 Log-binomial regression models. Pseudo R^2 and differences in pseudo R^2 between models with and without occupation among men

	Model variables									
	Age	Age and occupation		Age, occupation and occupational noise exposure		Age, occupation and all risk factors†		Age, occupation, all risk factors†, income and education		Age, occupation, all risk factors†, income, education and hearing loss	
Age group	R_l^2 (%)	R_l^2 (%)	ΔR_l^2 (%)	R_l^2 (%)	ΔR_l^2 (%)	R_l^2 (%)	ΔR_l^2 (%)	R_l^2 (%)	ΔR_l^2 (%)	R_l^2 (%)	ΔR_l^2 (%)
All	2.4	3.4	1.06**	5.0	0.82**	6.7	0.76**	6.8	0.78**	8.3	1.16**
20–44 years	0.1	1.9	1.83*	3.9	1.82	6.3	1.74	6.6	1.73	10.1	1.80
45–64 years	0.5	2.5	2.04**	4.4	1.73**	6.8	1.76**	7.0	1.74**	11.7	1.97**
>64 years	0.1	2.5	2.49**	11.8	2.20**	12.6	2.21**	12.9	2.26**	14.6	2.48**

R_l^2, pseudo R^2 (McFadden, 1979); ΔR_l^2, partial pseudo R^2 is the difference in R_l^2 values between a model with and without occupation.
*p<0.05; **p<0.01, likelihood ratio test on 89 df.
†Self-reported occupational noise, leisure noise, recurrent ear infections, head injuries and smoking.

Table 3 Log-binomial regression models. Pseudo R^2 and differences in pseudo R^2 between models with and without occupation among women

	Model variables									
	Age	Age and occupation		Age, occupation and occupational noise exposure		Age, occupation and all risk factors†		Age, occupation, all risk factors†, income and education		Age, occupation, all risk factors†, income, education and hearing loss	
Age group	R_l^2 (%)	R_l^2 (%)	ΔR_l^2 (%)	R_l^2 (%)	ΔR_l^2 (%)	R_l^2 (%)	ΔR_l^2 (%)	R_l^2 (%)	ΔR_l^2 (%)	R_l^2 (%)	ΔR_l^2 (%)
All	2.3	2.8	0.59**	3.4	0.62**	5.1	0.59**	5.4	0.38	7.8	0.45**
20–44 years	0.0	1.3	1.31*	2.7	1.38**	4.6	1.20	5.4	1.01	7.4	0.97
45–64 years	0.3	1.4	1.15*	1.8	1.17*	3.9	1.19*	4.1	1.02	7.3	1.08**
>64 years	0.5	1.4	0.91*	2.2	0.99	3.7	1.04	4.1	0.77	7.0	0.85**

R_l^2, pseudo R^2 (McFadden, 1979); ΔR_l^2, partial pseudo R^2 is the difference in R_l^2 values between a model with and without occupation.
*p<0.05; **p<0.01, likelihood ratio test on 54 df.
†Self-reported occupational noise, leisure noise, recurrent ear infections, head injuries and smoking.

Table 4 Predicted age-adjusted PR and AFs of tinnitus among men*

Nordic Classification of Occupational Codes		PR (95% CI)	AF (%)† (95% CI)	Sample size (23 374)
872	Crane and hoist operators, etc	2.1 (1.4 to 3.1)	0.23 (0.05 to 0.42)	53
501	Miners (in underground mines, quarrymen, shot firers)	1.9 (1.5 to 2.5)	0.69 (0.36 to 1.03)	171
754	Sheet-metal workers	1.8 (1.2 to 2.8)	0.19 (0.01 to 0.38)	68
871	Stationary engine operators	1.8 (1.1 to 2.8)	0.15 (−0.01 to 0.33)	40
827	Dairy workers	1.7 (1.2 to 2.3)	0.35 (0.11 to 0.61)	125
A30	Military (senior officers)	1.7 (1.1 to 2.5)	0.19 (0.01 to 0.39)	58
881	Longshoremen and vehicle loaders	1.7 (1.1 to 2.6)	0.17 (−0.01 to 0.37)	64
912	Cooks	1.7 (1.0 to 2.9)	0.12 (−0.02 to 0.28)	55
909	Others in 90 public safety and protection work	1.6 (1.0 to 2.7)	0.11 (−0.02 to 0.26)	44
751	Workshop mechanics	1.5 (1.1 to 2.0)	0.33 (0.04 to 0.64)	183
757	Metal plate and steel structural workers	1.5 (1.1 to 2.0)	0.32 (0.04 to 0.62)	174
77	Wood work	1.5 (1.0 to 2.5)	0.12 (−0.04 to 0.29)	46
821	Millers	1.5 (0.9 to 2.5)	0.12 (−0.04 to 0.30)	51
331	Salesmen operating from an office	1.4 (1.0 to 1.9)	0.30 (−0.02 to 0.58)	182
836	Papermakers	1.4 (1.0 to 2.0)	0.21 (−0.01 to 0.44)	124
875	Material-handling equipment operators	1.4 (0.9 to 2.1)	0.15 (−0.04 to 0.36)	96
0X6	Personnel specialists	1.4 (0.8 to 2.3)	0.08 (−0.06 to 0.24)	50
876	Oilers and greasers, etc	1.4 (0.8 to 2.5)	0.06 (−0.07 to 0.22)	57
753	Machine and motor repairmen	1.3 (1.0 to 1.5)	0.71 (0.08 to 1.31)	695
761	Electricians and electrical fitters	1.3 (1.0 to 1.6)	0.39 (−0.08 to 0.83)	410
772	Sawmill and planing mill workers	1.3 (1.0 to 1.6)	0.36 (−0.06 to 0.72)	282
756	Welders and flame cutters	1.3 (1.0 to 1.7)	0.27 (−0.07 to 0.63)	256
A10	Military (corporals and privates)	1.3 (0.9 to 1.9)	0.21 (−0.07 to 0.51)	247
755	Plumbers and pipe fitters	1.3 (0.9 to 1.8)	0.20 (−0.10 to 0.47)	177
75	Iron and metal ware work	1.3 (0.9 to 1.9)	0.14 (−0.07 to 0.36)	106
7	Manufacturing and construction work	1.3 (0.9 to 2.0)	0.13 (−0.06 to 0.33)	86
769	Others in 76 electrical work	1.3 (0.9 to 2.1)	0.11 (−0.08 to 0.30)	82
765	Linemen and cable jointers	1.3 (0.8 to 1.9)	0.10 (−0.10 to 0.31)	87
759	Others in 75 iron and metal ware work	1.3 (0.7 to 2.2)	0.06 (−0.08 to 0.22)	56
X	Occupation not reported	1.2 (1.0 to 1.5)	1.88 (0.16 to 3.33)	3216
111	Directors, managers and working proprietors	1.2 (1.0 to 1.5)	0.46 (−0.10 to 0.98)	469
003	Other engineers, engineer technicians, industrial designers	1.2 (1.0 to 1.6)	0.43 (−0.07 to 0.91)	459
874	Operators of earth-moving and construction machinery	1.2 (1.0 to 1.6)	0.36 (−0.09 to 0.76)	383
826	Butchers, sausage makers, etc	1.2 (0.9 to 1.8)	0.15 (−0.10 to 0.42)	157
299	Others in 29 other clerical work	1.2 (0.9 to 1.7)	0.14 (−0.11 to 0.36)	149
853	Plastic product makers	1.2 (0.8 to 1.7)	0.13 (−0.13 to 0.40)	163
002	Chief engineers	1.2 (0.8 to 1.7)	0.11 (−0.16 to 0.35)	153
781	Building and furniture painters	1.2 (0.8 to 1.7)	0.10 (−0.14 to 0.37)	146
105	Senior administrators and executive officials, municipal administration	1.2 (0.8 to 1.7)	0.08 (−0.12 to 0.30)	99
113	Administration secretaries	1.2 (0.8 to 2.0)	0.07 (−0.08 to 0.23)	57
834	Mechanical pulp workers	1.2 (0.7 to 2.0)	0.06 (−0.09 to 0.23)	57
106	Other administrators and executive officials, municipal administration	1.2 (0.7 to 2.1)	0.05 (−0.09 to 0.22)	54
Y‡	Occupations with <40 subjects	1.1 (1.0 to 1.3)	1.48 (−0.31 to 3.04)	2519
774	Construction carpenters and workers	1.1 (0.9 to 1.4)	0.53 (−0.28 to 1.28)	911
882	Warehouse workers	1.1 (0.9 to 1.5)	0.16 (−0.22 to 0.53)	290
441	Forestry workers and loggers	1.1 (0.8 to 1.5)	0.12 (−0.24 to 0.49)	276
641	Bus drivers	1.1 (0.8 to 1.7)	0.08 (−0.15 to 0.32)	133
302	Working proprietors, retail trade	1.1 (0.8 to 1.6)	0.06 (−0.19 to 0.32)	131
0X2	Social workers	1.1 (0.7 to 1.8)	0.05 (−0.13 to 0.25)	92
822	Bakers and pastry cooks	1.1 (0.7 to 1.9)	0.05 (−0.12 to 0.22)	78
612	Able and ordinary seamen	1.1 (0.6 to 2.1)	0.03 (−0.11 to 0.17)	49

Continued

Table 4 Continued

Nordic Classification of Occupational Codes		PR (95% CI)	AF (%)† (95% CI)	Sample size (23 374)
119	Others in 11, administration of private enterprises and organisations.	1.1 (0.6 to 1.9)	0.02 (−0.13 to 0.18)	61
404	Managers and supervisors (farms)	1.1 (0.6 to 1.8)	0.02 (−0.14 to 0.20)	84
031	Other physicians	1.1 (0.6 to 2.0)	0.01 (−0.12 to 0.15)	49
793	Cement finishers, excavators, etc	1.0 (0.8 to 1.3)	0.04 (−0.48 to 0.58)	509
104	Other administration governmental servants—local state administration	1.0 (0.6 to 1.7)	0.01 (−0.15 to 0.20)	80
0X1	Auditors	1.0 (0.6 to 1.8)	0.01 (−0.14 to 0.17)	64
06	Pedagogical work	1.0 (ref)	0.00 (ref)	1095
764	Installers, fitters, repairmen (radio, TV, phone, telegraph)	1.0 (0.6 to 1.6)	0.00 (−0.20 to 0.21)	123
0X9	Others in technical, physical science, humanistic, artistic work	1.0 (0.5 to 2.1)	−0.01 (−0.12 to 0.14)	48
311	Salesmen of insurance	1.0 (0.5 to 1.9)	−0.01 (−0.13 to 0.12)	45
911	Housekeepers, etc (not private or public service)	1.0 (0.5 to 1.8)	−0.01 (−0.14 to 0.13)	51
931	Janitors, vergers, etc	1.0 (0.7 to 1.2)	−0.07 (−0.49 to 0.32)	333
644	Lorry and van drivers	1.0 (0.8 to 1.2)	−0.10 (−0.75 to 0.55)	782
024	Silviculturists and forestry consultants	0.9 (0.5 to 1.7)	−0.02 (−0.16 to 0.12)	61
681	Postmen	0.9 (0.5 to 1.6)	−0.03 (−0.18 to 0.14)	74
76	Electrical work	0.9 (0.4 to 1.8)	−0.03 (−0.14 to 0.10)	48
671	Local postmasters, postal assistance	0.9 (0.6 to 1.5)	−0.03 (−0.22 to 0.17)	117
A20	Non-commissioned officers and subalterns	0.9 (0.6 to 1.4)	−0.04 (−0.30 to 0.22)	164
643	Taxi drivers	0.9 (0.5 to 1.5)	−0.04 (−0.19 to 0.11)	70
791	Masons, bricklayers and plasterers	0.9 (0.5 to 1.4)	−0.05 (−0.24 to 0.14)	101
333	Shop assistants	0.9 (0.6 to 1.2)	−0.17 (−0.53 to 0.22)	373
663	Railway supervisors	0.8 (0.4 to 1.6)	−0.04 (−0.17 to 0.09)	43
851	Concrete product makers, etc	0.8 (0.5 to 1.5)	−0.05 (−0.20 to 0.11)	80
201	Accountants and book keepers	0.8 (0.5 to 1.3)	−0.08 (−0.28 to 0.11)	119
903	Policemen and detectives	0.8 (0.5 to 1.3)	−0.10 (−0.29 to 0.10)	126
777	Wood working machine setters and operators	0.8 (0.5 to 1.2)	−0.13 (−0.36 to 0.09)	159
332	Shop managers	0.8 (0.6 to 1.1)	−0.20 (−0.49 to 0.09)	236
412	Livestock workers (general)	0.8 (0.6 to 1.1)	−0.23 (−0.59 to 0.13)	436
411	Farm helpers (general)	0.8 (0.6 to 1.0)	−0.35 (−0.76 to 0.06)	429
401	General farmers, livestock farmers (working on own behalf)	0.8 (0.7 to 1.0)	−2.20 (−4.33 to −0.42)	2763
095	Editors and journalists, etc	0.7 (0.3 to 1.6)	−0.06 (−0.17 to 0.06)	44
297	Real estate managers, store-room keepers, etc	0.7 (0.4 to 1.4)	−0.07 (−0.21 to 0.08)	64
103	Leading administrators and executive officials—local state administration	0.7 (0.3 to 1.4)	−0.09 (−0.22 to 0.04)	57
403	Gardeners, horticultural farmers and fruit growers	0.6 (0.2 to 1.5)	−0.08 (−0.17 to 0.02)	43
021	Veterinarians	0.5 (0.2 to 1.5)	−0.08 (−0.17 to 0.02)	40
432	Fish hatchers	0.5 (0.2 to 1.4)	−0.09 (−0.19 to 0.02)	61
023	Agronomists and horticulturists, agricultural consultants	0.5 (0.2 to 1.1)	−0.15 (−0.28 to 0.00)	69
292	Clerks (bank)	0.4 (0.2 to 1.2)	−0.13 (−0.23 to 0.00)	67
699	Others in 69 other transport and communication work	0.3 (0.1 to 1.0)	−0.15 (−0.22 to 0.00)	40

Occupational groups are sorted by prevalence ratio.
*In relation to the reference occupation group 06 'pedagogical work'.
†AF estimated by bootstrap with 1000 replications.
‡Occupations with <40 are collapsed into one group.
AF, attributable fraction; PR, prevalence ratio.

Table 5 Predicted age-adjusted PR and AFs of tinnitus among women*

Nordic Classification of Occupational Codes		PR (95% CI)	AF (%)† (95% CI)	Sample size (26 574)
013	Laboratory assistants	1.9 (1.1 to 3.3)	0.18 (0.01 to 0.41)	73
294	Clerks (public health insurance)	1.6 (0.9 to 3.0)	0.12 (−0.05 to 0.32)	68
681	Postmen	1.6 (0.8 to 3.4)	0.07 (−0.05 to 0.23)	41
X	Occupation not reported	1.5 (1.3 to 1.8)	11.30 (6.96 to 15.62)	7946
915	Housekeepers (public service)	1.5 (1.2 to 1.8)	1.42 (0.59 to 2.30)	842
049	Others in 04 nursing care	1.5 (1.1 to 2.0)	0.52 (0.11 to 0.96)	355
921	Headwaiters, waiters	1.5 (1.1 to 2.1)	0.43 (0.05 to 0.83)	295
914	Housekeepers, maids (private service)	1.5 (1.0 to 2.2)	0.29 (−0.01 to 0.63)	212
911	Housekeepers, etc (not private or public service)	1.5 (1.0 to 2.2)	0.20 (−0.07 to 0.50)	129
861	Packers, labellers and related workers	1.5 (0.9 to 2.4)	0.18 (−0.06 to 0.44)	111
853	Plastic product makers	1.4 (0.8 to 2.4)	0.11 (−0.09 to 0.35)	102
0X3	Librarians, archivists and scientific personnel in museums	1.4 (0.7 to 2.8)	0.06 (−0.08 to 0.23)	47
003	Other engineers, engineer technicians, industrial designers, draughtsman	1.4 (0.6 to 3.3)	0.04 (−0.07 to 0.18)	48
932	Char workers and cleaners	1.3 (1.1 to 1.6)	2.03 (0.64 to 3.43)	1888
913	Kitchen assistants	1.3 (0.9 to 1.7)	0.32 (−0.15 to 0.80)	404
716	Sewers and embroiderers (textile products, leather garments)	1.3 (0.7 to 2.2)	0.09 (−0.11 to 0.29)	94
825	Canning and other preservation workers	1.3 (0.7 to 2.5)	0.06 (−0.09 to 0.25)	80
104	Other administration governmental servants—local state administration	1.3 (0.7 to 2.6)	0.06 (−0.09 to 0.23)	58
822	Bakers and pastry cooks	1.3 (0.6 to 2.6)	0.04 (−0.10 to 0.18)	45
Y‡	Occupations with <40 subjects	1.2 (1.0 to 1.5)	0.82 (−0.15 to 1.87)	1449
045	Other practical nurses	1.2 (0.9 to 1.5)	0.60 (−0.15 to 1.35)	1063
411	Farm helpers (general)	1.2 (0.9 to 1.5)	0.53 (−0.23 to 1.29)	843
912	Cooks	1.2 (0.9 to 1.8)	0.20 (−0.15 to 0.57)	247
919	Others in 91 public safety and protection work	1.2 (0.8 to 1.8)	0.17 (−0.17 to 0.53)	310
671	Local postmasters, postal assistance	1.2 (0.8 to 1.9)	0.12 (−0.17 to 0.40)	203
941	Barbers, hairdressers and beauticians	1.2 (0.8 to 1.9)	0.10 (−0.16 to 0.37)	186
292	Clerks (bank)	1.2 (0.7 to 1.9)	0.09 (−0.15 to 0.37)	202
413	Nursery workers and gardeners	1.2 (0.7 to 2.1)	0.08 (−0.14 to 0.30)	106
046	Dental assistance	1.2 (0.7 to 2.2)	0.07 (−0.10 to 0.26)	93
675	Telegraph dispatchers	1.2 (0.6 to 2.4)	0.05 (−0.10 to 0.22)	62
059	Others in 05 other professional health and medical work	1.2 (0.5 to 2.7)	0.02 (−0.09 to 0.17)	53
333	Shop assistants	1.1 (0.9 to 1.4)	0.59 (−0.73 to 1.91)	2042
401	General farmers, livestock farmers (working on own behalf)	1.1 (0.8 to 1.4)	0.24 (−0.47 to 1.05)	905
04	Nursing care	1.1 (0.7 to 1.8)	0.04 (−0.18 to 0.30)	120
211	Secretaries and stenographers	1.1 (0.6 to 1.8)	0.02 (−0.20 to 0.29)	161
302	Working proprietors, retail trade	1.1 (0.6 to 1.9)	0.02 (−0.16 to 0.23)	94
043	Practical nurses in psychiatric institutions	1.1 (0.5 to 2.4)	0.02 (−0.12 to 0.18)	67
111	Directors, managers, and working proprietors	1.1 (0.5 to 2.6)	0.02 (−0.10 to 0.14)	42
412	Livestock workers (general)	1.0 (0.8 to 1.4)	0.05 (−0.51 to 0.60)	439
299	Others in 29 other clerical work	1.0 (0.8 to 1.3)	0.03 (−1.05 to 1.11)	1636
673	Telephone switchboard operators (public service)	1.0 (0.5 to 2.2)	0.01 (−0.12 to 0.16)	47
951	Laundry and dry-cleaning workers	1.0 (0.5 to 1.9)	0.00 (−0.17 to 0.19)	81
06	Pedagogical work	1.0 (ref)	0.00 (ref)	1299
0X2	Social workers	1.0 (0.6 to 1.5)	−0.01 (−0.29 to 0.29)	263
922	Other waiting personnel	1.0 (0.6 to 1.7)	−0.01 (−0.22 to 0.21)	136
201	Accountants and book-keepers	0.9 (0.5 to 1.8)	−0.02 (−0.20 to 0.19)	121
674	Telephone switchboard operators (private exchange)	0.9 (0.3 to 2.3)	−0.02 (−0.11 to 0.11)	48
41	Farm work and livestock work	0.9 (0.4 to 2.0)	−0.02 (−0.16 to 0.14)	56

Continued

Table 5 Continued

Nordic Classification of Occupational Codes		PR (95% CI)	AF (%)† (95% CI)	Sample size (26 574)
332	Shop managers	0.9 (0.4 to 1.7)	−0.04 (−0.19 to 0.14)	89
041	Professional nurses	0.9 (0.7 to 1.3)	−0.13 (−0.69 to 0.46)	745
052	Physio- and occupational therapists	0.8 (0.4 to 1.5)	−0.07 (−0.26 to 0.15)	134
203	Other cashiers	0.8 (0.5 to 1.4)	−0.09 (−0.31 to 0.15)	176
916	Concierge (hotels)	0.7 (0.2 to 2.0)	−0.05 (−0.13 to 0.07)	51
047	Nursemaids in hospitals and other institutions	0.3 (0.1 to 1.0)	−0.20 (−0.31 to 0.00)	119
769	Others in 76 electrical work	0.2 (0.0 to 1.6)	−0.10 (−0.14 to 0.00)	48

Occupational groups are sorted by prevalence ratio.
*In relation to the reference occupation group 06 'pedagogical work'.
†AF estimated by bootstrap with 1000 replications.
‡Occupations with <40 are collapsed into one group.
AF, attributable fraction; PR, prevalence ratio.

in regard to the effects of occupation on hearing loss based on this same study sample.[19]

In women, occupations with the highest risk for tinnitus were not typically noisy ones, and the AF was determined mainly by the group of occupationally inactive. This is different from the analysis of occupation effects on hearing loss[19]—there was no increased risk of hearing loss in occupationally inactive women.

Only a few previous studies have reported occupation-specific tinnitus prevalence. The odds for tinnitus according to different occupational groups were reported based on the 1994–1995 US National Health Interview Survey Disability Supplement data set.[4] This study showed a marginal elevation in tinnitus prevalence in skilled and unskilled workers compared with professionals (OR 1.18; 95% CI 1.00 to 1.39). This study also found a reduced prevalence in the two occupational groups of managerial or administrative (OR 0.82; 95% CI 0.68 to 0.99) and technical or sales (OR 0.83; 95% CI 0.70 to 0.98).

Some studies evaluating the effect of self-reported occupational noise exposure found results comparable to the present study. In a British general population sample of 12 907 subjects,[9] age-adjusted PRs for working in noisy environment for >10 years was estimated to be 2.6 (95% CI 2.0 to 3.4) in men and 1.9 (95% CI 1.0 to 3.7) in women in comparison with those with no occupational exposure to noise. The overall tinnitus prevalence of the sample was 6% in men and 3% in women. Previous British data also showed tinnitus to be about twice as common in those with a history of occupational exposure to noise.[28]

In an earlier analysis of tinnitus in the NTHLS, being exposed to loud noise at work for >15 hours per week resulted in an OR of 1.7 (95% CI 1.5 to 1.9) in men and 1.6 (95% CI 1.4 to 1.9) in women compared with those who had not been exposed to loud noise at work.[4]

Among 2015 older Australians, the RR of tinnitus was 1.4 (95% CI 1.1 to 1.7) for participants exposed to 'tolerable noise' and 1.5 (95% CI 1.11 to 2.1) for those exposed to high levels of occupational noise ('unable to hear speech') compared with unexposed participants.[7] Among 3753 older adults in Beaver Dam, Wisconsin, no association was found between major occupation, history of occupational noise exposure or hunting history, with the likelihood of having tinnitus (prevalence) or developing tinnitus (incidence).[5]

We found adding hearing loss as a predictor did not decrease the effect of occupation; when controlling for some other risk factors, a small increase in occupational effect was found. Thus, hearing loss does not seem to mediate, but rather suppress, the effect of occupation on tinnitus. This points to the importance of occupational risk factors not related to hearing loss, such as work demands, level of control, social support and other psychosocial factors.

The negative effect for women of being occupationally non-active is partly in agreement with results from a study of self-reported hearing problems in a Swedish working and non-working population.[11] A higher prevalence of frequent or constant tinnitus was found among non-workers (15%) than workers (11%). While we found this effect mainly among women, the previous study reported higher effects for men (25% and 15% for non-workers and workers, respectively) than for women (10% and 8%). These numbers were not age-adjusted, however, and the age distribution of workers was quite different from non-workers.

Receiving social security or disability pension was associated with the highest risk of tinnitus in the group of occupationally non-active women. It may be that reduced functional ability or poor general health decreases the ability to cope with tinnitus, although the causal direction is not clear, as tinnitus may well be a part of the disability in the first place. Also, the increased risk of tinnitus may be related to psychosocial factors, such as loss of social status and self-esteem, social support, personal economy and lifestyle factors such as physical inactivity. Regardless of the underlying cause, the elevated occurrence of tinnitus among unemployed women is hardly a real occupational effect, so the true fraction of tinnitus attributable to type of occupation is

much lower than the 21.4% estimated by including unemployed women.

Strengths and limitations

The major advantages of the present study are the prospective design and that the study population is representative of the general working population. A substantial selection bias is unlikely since occupational data were complete for all participants, and the participation rate in this population survey was relatively high (69% for the vast majority of the county).

A recent survey of sufferers from tinnitus showed that they report excessive noise in the work environment as the single most important factor for developing tinnitus.[29] Thus, there might be a serious problem with recall bias that tends to exaggerate an association when both the exposure and the outcome are self-reported. In the present study, occupation data were obtained from highly valid prospective registry data, thus, we consider recall bias on this factor not to be a problem.

Test–retest of the question 'are you bothered by tinnitus?' indicated a relatively high reliability. Tinnitus is a personal, subjective experience that cannot be measured objectively and is thus per definition described by self report. The clinical validity of the measure is unknown as we have no data on the correlation between being bothered by tinnitus and seeking medical help. Subjective need for treatment has been reported in as many as 2/3 of the subjects who found them self-suffering from tinnitus often or always.[30] The prevalence of suffering from tinnitus in that study was reported to be 14%, which is very similar to the prevalence of bothered by tinnitus in our study. But probably only a few per cent of the subjects with bothersome tinnitus have actually been seeking help for this condition, a number that will depend on factors such as whether treatments are determined to be effective and if they are known or available to the broader public.

A weakness of the study is the lack of information about the duration of employment and exposure. However, the estimated average tinnitus prevalence for each occupation group applies to workers whose age is equal to the sample mean. Accordingly, we have essentially adjusted for exposure duration.

The Nordic Classification of Occupations does not classify occupations on the basis of noise exposure levels or other risk factors for tinnitus, but according to the tasks and duties undertaken in the job. Heterogeneity regarding noise and other exposure within occupational categories implies that occupation, as an explanatory variable, does not capture all effects of occupational exposures on tinnitus. Our results showed that adding information on self-reported occupational noise exposure improved the prediction of tinnitus somewhat.

Selection for good hearing function in some occupations could in principle bias the results, but we think it unlikely that this type of selection had a major effect on our results.

CONCLUSIONS

This study found a moderate association between occupation and tinnitus. Estimates of occupation-specific tinnitus prevalence may help identify high-risk occupations in which interventions are needed.

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