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

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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.

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 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. 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/rivetting, 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.  Air conduction hearing thresholds were obtained by pure-tone audiometry as described in an earlier publication. 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, 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:

$$R^2 = 1 - \frac{\ln(L_m)}{\ln(L_0)}$$

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 $R^2$ does not reach 1, a rule of thumb is that the model has an excellent fit with $R^2$ being between 0.2 and 0.4.

The overall effect of occupation in the model was estimated by the partial $R^2$ (the difference in $R^2$ 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 $R^2$ 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:

$$AF = \frac{pd_i \cdot PR_i - 1}{PR_i},$$

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

$$1 - \sum_{i=63}^{k} pd_i \cdot \frac{PR_i - 1}{PR_i},$$

where $k$ is the total number of occupations. The 95% CIs of the occupation-specific AF were estimated by non-linear bootstrapping with the percentile method and 1000 replications. All statistical analyses
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 $R^2$ of tinnitus after adjusting for age in all age groups and

| Age group    | Sample size | Tinnitus prevalence (%) |
|--------------|-------------|-------------------------|
| All          | 23374       | 16.4                    |
| 20–44 years  | 9359        | 10.6                    |
| 45–64 years  | 8618        | 18.5                    |
| >64 years    | 5397        | 23.0                    |

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. Controlling for self-reported occupational noise exposure reduced the estimated effect of occupation 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

| Age group  | Model variables          | 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 |
|------------|--------------------------|-----------------------------------------------|--------------------------------------|---------------------------------------------------------|---------------------------------------------------------------------|
| All        | Age $R^2$ (%) Age and occupation $R^2$ (%) | $\Delta R^2$ (%) | $\Delta R^2$ (%) | $\Delta R^2$ (%) | $\Delta R^2$ (%) | $\Delta R^2$ (%) | $\Delta R^2$ (%) |
|            | 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** |

$R^2$, pseudo $R^2$ (McFadden, 1979); $\Delta R^2$, partial pseudo $R^2$ is the difference in $R^2$ 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

| Age group  | Model variables          | 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 |
|------------|--------------------------|-----------------------------------------------|--------------------------------------|---------------------------------------------------------|---------------------------------------------------------------------|
| All        | Age $R^2$ (%) Age and occupation $R^2$ (%) | $\Delta R^2$ (%) | $\Delta R^2$ (%) | $\Delta R^2$ (%) | $\Delta R^2$ (%) | $\Delta R^2$ (%) | $\Delta R^2$ (%) |
|            | 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** |

$R^2$, pseudo $R^2$ (McFadden, 1979); $\Delta R^2$, partial pseudo $R^2$ is the difference in $R^2$ 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 |
|--------------------------------------------|-------------|------------------|-------------|
| 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, shotfirers) | 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 Miller                                 | 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          |
| 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, engine 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 < 0.40 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                 |
| 911 Housekeepers (public service)          | 1.5 (1.2 to 1.8) | 1.42 (0.59 to 2.30) | 842                  |
| 914 Housekeepers, maids (private service)  | 1.5 (1.0 to 2.2) | 0.29 (–0.01 to 0.63) | 212                  |
| 299 Clerks (public health insurance)       | 1.4 (0.8 to 2.4) | 0.11 (–0.09 to 0.35) | 102                  |
| 0X3 Librarians, archivists and scientific  | 1.4 (0.7 to 2.8) | 0.06 (–0.08 to 0.23) | 47                   |
| 003 Other engineers, engineer technicians, | 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                   |
| 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                   |
| 912 Cooks                                  | 1.2 (0.9 to 1.8) | 0.20 (–0.15 to 0.57) | 247                  |
| 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) | 0.00 (–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       | 0.3 (0.1 to 1.0) | −0.20 (−0.31 to 0.00) | 119 |
| institutions                                 |             |                  |                     |
| 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 loss¹⁹—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.¹⁴

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.39 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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**Competing interests**

None.

**Patient consent**

Obtained.

**Ethics approval**

The study was approved by the Norwegian Regional Committee of Medical Ethics and by the Norwegian Data Inspectorate.

**Contributors**

The following authors have contributed to the paper: BE: Design, analysis and interpretation of data, writing. NHK: Preparing data, drafting the manuscript, critical revision of manuscript. EK: Preparing data, drafting the manuscript, critical revision of manuscript. HJH: Obtaining funding, data acquisition, drafting the manuscript, critical revision of manuscript. KT: Conception and design, obtaining funding, data acquisition, drafting the manuscript, critical revision of manuscript.

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**Data sharing statements**

There is no additional data available.

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