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Factors Predicting Severity of Tinnitus: A Population-Based Assessment

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Abstract

The Blue Mountains Hearing Study (BMHS) has shown that tinnitus affects one in three older Australians with 16% of cases describing severe annoyance. Among persons describing severe symptoms, 52% have sought professional help. We aim to identify factors associated with the severity of tinnitus in 2,015 persons aged over 54 years. Comprehensive questionnaires about hearing were administered. Air- (250–8000 Hz) and bone-conduction (500–4000 Hz) audiometric thresholds of both ears, together with transient evoked and spontaneous otoacoustic emissions, were measured. Factors predicting severity of tinnitus were assessed in Cox proportional hazard models. After multivariate adjustment, factors significantly associated with severe tinnitus were hearing loss (relative risk [RR] 2.9), dizziness (RR 2.0), head injury (RR 2.0), sinus and middle ear infections (RR 1.9), and mastoiditis (RR 3.9). Associations with mild tinnitus included age (RR 0.8), hearing loss (RR 1.4) and history of dizziness (RR 1.5), meningitis (RR 2.2), and migraine (RR 1.5). Knowledge of these factors could contribute to improved tinnitus management.

Key Words: Blue Mountains Eye Study, Blue Mountains Hearing Study, mild tinnitus, otoacoustic emissions, pure-tone audiometry, severe tinnitus, tinnitus, tinnitus severity

Abbreviations: 95% CI = 95% confidence intervals; BMES = Blue Mountains Eye Study; BMHS = Blue Mountains Hearing Study; EHLS = Epidemiology of Hearing Loss Study; PTA = average of the pure-tone threshold hearing levels at 500, 1000, 2000, 4000 Hz; RR = relative risk; SOAE = spontaneous otoacoustic emissions; TEOAE = transient evoked otoacoustic emissions

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Sumario

El estudio auditivo de Blue Mountains (BMHS) ha mostrado que el acúfeno afecta a uno de cada tres australianos viejos, con un 16% de los casos reportando una molestia severa. Entre las personas que reportan signos severos, 52% han buscado ayuda profesional. Nuestra intención fue identificar los factores asociados con la severidad del acúfeno en 2.015 personas con edades por encima de los 54 años. Se administraron cuestionarios comprensivos sobre audición. Se midieron los umbrales audiométricos por conducción aérea (250-8000 Hz) y conducción ósea (500-4000 Hz) en ambos oídos, junto con emisiones otoacústicas espontáneas y evocadas por transientes. Los factores predictivos en la severidad del acúfeno fueron evaluados con los modelos de Cox de riesgo proporcional. Luego de ajustes multivariados, los factores significativamente asociados con la severidad del acúfeno fueron: pérdida auditiva (riesgo relativo [RR] 2.9), mareo (RR 2.0), lesión craneana (RR 2.0), infecciones sinusales y del oído medio (RR 1.9) y mastoiditis (RR 3.9). Las asociaciones con acúfeno leve incluyeron edad (RR 0.8), hipoacusia (RR 1.4) e historia de mareos (RR 1.5), meningitis (RR 2.2) y migraña (RR 1.5). El conocimiento de estos factores podría contribuir en mejorar el manejo del acúfeno.

Palabras Clave: Estudio Ocular de Blue Mountains, Estudio Auditivo de Blue Mountains, acúfeno leve, emisiones otoacústicas, audiometría tonal, acúfeno severo, acúfeno, severidad del acúfeno

Abreviaturas: 95% CI = intervalos de confianza del 95%; BMES = Estudio Ocular de Blue Mountains; BMHS = Estudio Auditivo de Blue Mountains; EHLS = Estudio de Epidemiología de la Hipoacusia; PTA = promedio de los umbrales auditivos tonales puros a 500, 1000, 2000 y 4000 Hz; RR = riesgo relativo; SOAE = emisiones otoacústicas espontáneas; TEOAE = emisiones otoacústicas evocadas por transientes

Tinnitus, the perception of ringing or buzzing in the ears or head, is a very common complaint that is reported to affect almost one in three Australian adults aged 55 years or older (Newall et al, 2001). Around 16% of those reporting tinnitus state that they are severely annoyed by their tinnitus (Newall et al, 2001). Of this group, more than half (52%) report having sought professional help. Tinnitus is potentially more severe when accompanied by hearing loss (Tyler, 1995; Holgers et al, 2000), depression (Halford and Anderson, 1991a; Budd and Pugh, 1996; van Veen et al, 1998; Erlandsson and Hallberg, 2000; Holgers et al, 2000; Folmer et al, 2001), sleep disturbance (Meikle et al, 1984; Folmer et al, 2001), concentration difficulties (Erlandsson and Hallberg, 2000), or psychological problems (Halford and Anderson, 1991b; Attias et al, 1995; Henry and Wilson, 1995; Rizzardo et al, 1998; Holgers et al, 1999; Erlandsson and Hallberg, 2000).

Some of these reports have explored factors associated with the severity of tinnitus. Holgers et al (2000) investigated predictive factors for incapacitating tinnitus (defined as the absence from work as a result of tinnitus), in 79 tinnitus patients recruited from Sahlgrenska University Hospital in Sweden. Associated factors included hearing loss, depression, and physical immobility. Folmer et al (2001) studied 160 patients attending a tinnitus clinic in an urban medical center and reported that the severity of chronic tinnitus was associated with severe sleep disturbance, anxiety, and depression. Halford and Anderson (1991a) in a study of 112 members from a tinnitus self-help group also reported that tinnitus was associated with depression and anxiety traits.

Most previous studies, some of which are outlined above, have studied specific populations drawn from tinnitus or hearing clinics. Although these studies are valuable, they often show associated conditions that may not

be found in a more general population of tinnitus sufferers.

To date, there have been few epidemiological hearing studies in large, older populations. Even fewer have objectively measured hearing functions that would allow the comprehensive assessment of factors associated with the severity of tinnitus. One of these few studies is the National Study of Hearing, conducted by the Medical Research Council's Institute of Hearing Research in the United Kingdom (UK) in 1978. The audiological data of 2,522 UK adults aged 17 years or older indicated that the odds of moderate or severe tinnitus increased with every 10-decibel increase in hearing level measured at 4000 Hz alone (Coles et al, 1990).

The recent Epidemiology of Hearing Loss Study (EHLS) was conducted on 3,737 members of a general population aged 48 to 92 years, residing in Wisconsin, USA (Nondahl et al, 2002). The study reported risk factors for tinnitus of at least moderate intensity, which was defined as tinnitus that caused difficulty in falling asleep. In the study, age, gender, hearing loss, cardiovascular disease, and history of head injury were identified as predictors for significant tinnitus (Nondahl et al, 2002).

While our study (the Blue Mountains Hearing Study [BMHS]) and the EHLS are aligned in many key methods as a result of collaboration between the investigators, there is one significant difference between the two populations; the Wisconsin study is based in a semirural farming area, whereas the BMHS is based in a fairly typical urban community. Noise-related hearing loss may therefore be a more important factor in the EHLS than in ours.

In this report, we aim to identify factors significantly associated with the annoyance levels of tinnitus, in a representative sample of 2,015 Australian adults, aged 55 years and older living in a defined population west of Sydney, Australia. This paper reports data from the BMHS conducted during 1997–99. Our data from detailed questionnaires and objective hearing examinations allows the comprehensive assessment of factors associated with the annoyance levels of tinnitus in a general urban population. As audiologists may be the first health professionals consulted by the tinnitus sufferer, it is important that they are informed about potential risk factors. This will result in appropriate referral for medical intervention and lifestyle changes, leading to overall improved tinnitus management.

METHODS

The Blue Mountains Hearing Study (BMHS) is a population-based survey of age-related hearing loss in an older Australian community, conducted during 1997–99, among members of the Blue Mountains Eye Study (BMES) cohort. This study initially assessed 3,654 persons aged 49 years or older, living in two suburban postcode areas west of Sydney, Australia, during 1992–94. It was conducted following a door-to-door census of all dwellings in 38 census districts within this region and achieved an 82.4% response. In 1997, all BMES participants were invited to attend five-year follow-up eye exams (BMES-2) as well as the hearing assessment (BMHS).

Of the original 3,654 participants, 575 (15.7%) died before the five-year follow-up eye examinations commenced, while 383 subjects (10.5%) moved from the study area. This left 2,696 subjects still living in the region and eligible to participate. Of these, 2,015 (74.7%) agreed to take part in hearing examinations while 681 (25.3%) did not participate. At the time of participating, the mean age of hearing study subjects was 69.8 years, and there were 1,156 women and 859 men. Participants were an average of two years younger at the baseline examination than those who did not participate, and an average of 10 years younger than those who had died. Compared with people who did not participate, participants were slightly more likely to be male, to live alone, and to rate their health slightly worse. These similar demographic characteristics exhibited no selection bias in our samples.

Compared with the Australian population aged 55+ years, participants were on average slightly older and more likely to be female. There were only minor differences in the proportion born outside Australia or having a non-English-speaking background and in the occupation distribution between participants and the overall Australian population . Our sample, therefore, appeared to be reasonably representative of general Australian populations. All participants gave written, informed consent, and the Study

was approved by the Western Sydney Area Health Service Human Ethics Committee.

The 2,015 respondents who agreed to participate in the BMHS were examined by experienced audiologists at the Blue Mountains Hospital during 1997–99. A detailed medical history was taken and included past history and treatment of risk factors for various ear, nose, and throat (ENT) conditions. The eye study questionnaire, administered by an interviewer at the BMES-2 eye examination, provided additional data on demographic and socioeconomic characteristics, cardiovascular disease risk factors, medications used, weight, past medical and family history, exercise, smoking, and caffeine and alcohol consumption.

The hearing examinations included pure-tone audiometry conducted in sound-treated facilities, using standard TDH-39 earphones and a Madsen OB822 audiometer (Madsen Electronics, Copenhagen, Denmark), which was calibrated regularly during the study to Australian Standards. Audiometric thresholds for air-conducted stimuli (right and left ears) were established for frequencies of 250, 500, 1000, 2000, 4000, 6000, and 8000 Hz, with 3000 Hz added if a 20 dB difference existed between 2000 and 4000 Hz thresholds. Bone-conduction thresholds, with masking applied when appropriate, were established for 500, 1000, 2000, and 4000 Hz whenever the air-conducted thresholds were above 15 dB HL. We defined hearing loss similarly to the EHLS, that is, the pure-tone average (PTA) of air-conducted thresholds at 500, 1000, 2000, and 4000 Hz worse than 25 dB HL, in the better ear .

Transient evoked and spontaneous otoacoustic emissions (TEOAE and SOAE respectively) were measured in both ears using an Otodynamics Echoport ILO288 Otoacoustic Emission Analyzer with version 4.2OB software. Measures of frequency-specific (at 1000, 2000, 3000, 4000, and 5000 Hz bandwidth) and overall TEOAE waveform reproducibility (WR%) data were obtained. The presence of any SOAE responses in either ear with an amplitude ≥10 dB SPL above the surrounding noise floor was also recorded. Although the presence of SOAE has been defined as a peak in the spectrum at least 3 dB above the noise floor (Bright 1997), we chose to use a highly conservative measure for the purposes of this study.

The BMHS questionnaire included a series of questions related to tinnitus (Appendix) and drawn from the American Tinnitus Association's survey in Portland, Oregon, USA. These questions addressed the severity, onset, and duration of tinnitus, and whether the participant's general practitioner or a hearing professional had been consulted. Tinnitus was identified using the question "Have you experienced *any* prolonged ringing, buzzing, or other sounds in your ears or head within the past year . . . that is, lasting for 5 minutes or longer?" which resulted in three possible data responses of "no," "yes," and "missing." Participants who responded affirmatively to this question were asked to rate their severity of tinnitus using the question "How annoying is your tinnitus?" This question produced possible responses of "extremely," "very," "mildly," "not at all," "unsure," and "missing." Missing responses accounted for 11 subjects (1.8% of those reporting tinnitus) who were excluded. As few subjects reported "extremely annoying tinnitus" (n = 25) and "very annoying tinnitus" (n = 71), these groups were combined and reclassified as "severe tinnitus" (n = 96). Subjects who described their tinnitus as "mildly annoying" were categorized as having "mild tinnitus" (n = 296). Those reporting tinnitus that was "not at all annoying" (n = 194) and "unsure" (n = 5) were combined with persons reporting "no tinnitus" (n = 1404). This group was renamed to "absent tinnitus" and was used as a reference category (n = 1603).

We are aware that other instruments have been used to quantify the severity of tinnitus including the Tinnitus Handicap Inventory (Kuk et al, 1990), the Tinnitus Severity Scale (Sweetow and Levy, 1990), the Subjective Tinnitus Severity Scale (Halford and Anderson, 1991b), and the Tinnitus Severity Questionnaire (Erlandsson et al, 1992). However, in our study, where a series of questionnaires and hearing examinations were tested on aging respondents, we were aware that additional lengthy instruments could potentially increase test effects, resulting in reduced accuracy of the data. We therefore used a single question to quantify the annoyance level of tinnitus. There is good precedent in other epidemiological studies for doing this (Coles et al, 1990; Nondahl et al, 2002), and we believe that our use of a single question provides an accurate estimate of a respondent's judgment of tinnitus severity, and was appropriate in this circumstance.

Potential predictors for reported tinnitus severity were obtained from the questionnaires and hearing examinations, as follow:

- **demographic** factors (age, gender, marital status, race, language spoken at home)
- **socioeconomic** factors (tertiary qualifications, employment status, Daniel occupational prestige score (Congalton, 1969), receipt of government pension, home ownership)
- **dependency factors** (living alone, reliance on community support services [Meals-on-Wheels, Home Care, or home nursing], reliance on family members or friends for cleaning, going out, shopping)
- reported **illnesses affecting hearing** (middle ear and sinus infections, ear surgery, skull fracture, and severe head or neck injuries)
- history of **medical conditions** (dizziness, angina, diabetes, stroke, hypertension, acute myocardial infarction, and high blood cholesterol)
- **reported active and passive smoking** (secondhand smoke)
- coffee, alcohol, and Zinc intake
- **body mass index** (a relationship between weight and height that is associated with body fat)
- **hearing loss** (dichotomous variable, as measured by PTA of air-conducted thresholds at 500, 1000, 2000, and 4000 Hz worse than 25 dB HL, in the better ear), and outer hair cell function (as measured by TEOAE wave reproducibility scores) and the presence of SOAEs
- **tinnitus characteristics** (duration, onset, and laterality)

Univariate analysis techniques were used to identify individual factors significantly associated with annoyance levels of tinnitus. These included χ^2 test for categorical variables and one-way analysis of variance for continuous variables. We used statistical models to assess associations between severe (or mild) tinnitus and factors of interest.

Logistic regression is frequently used to identify factors associated with a dichotomous outcome variable (in this case, severe tinnitus v. absent tinnitus and mild v. absent tinnitus). Nevertheless, logistic regression provides odds ratio as the measure of effect rather than relative risk, the latter being a more accurate measure of the risk. For outcomes with low prevalence, odds ratios derived from logistic regression are numerically similar to the relative risk and could be used as its estimate. However, when the prevalence of an outcome is high, odds ratios tend to overestimate the relative risk when greater than one and to underestimate their relative risk when less than one (Zhang and Yu, 1998). Thus, a factor's relative risk of, say, three can be interpreted to mean that at any point in time, subjects exposed to the risk factor are three times more likely than nonexposed subjects to have the outcome, but the odds ratios cannot be interpreted in the same manner.

Although the prevalence of severe tinnitus was not high (4.9%), mild tinnitus was highly prevalent (14.9%), and thus logistic regression was not used in this study. We used the Cox proportional hazard model, assuming a constant risk period, as suggested by Breslow (1974). Similar to the logistic regression, this model is used to assess factors associated with a dichotomous outcome. The difference between them is that the Cox model takes account of time until the outcome. However, if the time is treated as a constant, conditional hazard ratios (a mirror image of odds ratios in logistic regression) that were estimated using the Cox model could be used to estimate relative risk (RR) for cross-sectional data (Lee, 1994), such as in the BMHS.

Significant factors associated with annoyance levels of tinnitus were then individually identified using univariate analyses. These factors were subsequently used in developing multivariate adjusted Cox models for predicting mild and severe tinnitus. All analyses were performed using SPSS statistical software for Windows version 11.0 (SPSS In, 2002).

RESULTS

Of the 2,015 participants, 602 (29.9%) reported tinnitus symptoms, 1,404 reported no tinnitus symptoms, and there were 9 with missing responses. Of those reporting tinnitus, 96 rated their tinnitus as severe, 296 as mild, and 199 as not annoying, while 11 persons did not report the annoyance levels of tinnitus. The groups reporting no tinnitus symptoms (n = 1404) or not being annoyed by its presence (n = 199) were combined and recategorized as

Table 1. Descriptive Statistics of Participants Reporting Different Degrees of Tinnitus Severity, n (%), Unless Stated Otherwise

	Severity of Tinnitus			
Factor	Absent tinnitus	Mild	Severe	P-value
Age, Mean (SD, n)	70.1 (8.7, 1603)	68.6 (7.8, 296)	70.5 (8.4, 96)	0.02[1]
Female gender	894 (57.3)	167 (57.4)	59 (62.8)	0.43[2]
Hearing loss	583 (37.4)	124 (42.6)	59 (62.8)	<0.001
Dizziness	498 (34.1)	124 (47.0)	52 (61.9)	<0.001
Severe head injury	369 (24.2)	87 (30.6)	39 (41.9)	<0.001
Sinus infection	411 (27.2)	105 (37.8)	46 (50.0)	<0.001
Middle ear infection	151 (10.1)	48 (16.7)	17 (18.7)	<0.001
Mastoiditis	18 (1.2)	9 (3.2)	3 (3.3)	0.02
Meningitis	15 (1.0)	8 (2.8)	2 (2.2)	0.03
Migraine	361 (23.1)	95 (32.6)	35 (37.2)	<0.001

[1]The p-value for the analysis of variance comparing mean ages among the three levels of tinnitus annoyance.
[2]The p-value for λ^2 comparisons of the proportion of women at each of the three levels of tinnitus annoyance. Note that gender is a potential confounder.

absent tinnitus. After excluding missing responses, this left the following categories of tinnitus with increasing severity: absent tinnitus (n = 1603), mild tinnitus (n = 296), and severe tinnitus (n = 96).

All potential predictors as outlined were individually tested for an association with annoyance levels of tinnitus using χ^2 test and one-way analysis of variance. The significant factors and potential confounder (a factor that distorts an association between the exposure and outcome, as a result of its effects on both variables, in this case, age and gender), together with their descriptive statistics, are shown in Table 1. All other factors were not significant. The nonsignificant auditory factors among them included the presence of SOAEs and the following measures for both ears with better and worse PTA:

- the overall TEOAEs WR% between adjacent responses
- the TEOAEs WR% in the 1000, 2000, 3000, 4000, and 5000 Hz bands

On average, subjects reporting severe tinnitus were older than those with mild or absent tinnitus, and those with mild tinnitus were younger than those with absent tinnitus (p = 0.02). No significant gender effects were found (p = 0.43). Increasing tinnitus severity was significantly associated with hearing loss, reported history of dizziness, severe head injury, sinus and middle ear infections, mastoiditis, meningitis, and migraine. These trends were all significant ($p < 0.05$).

The best predictive Cox proportional hazard models for mild and severe tinnitus are shown in Table 2. These models consisted of the combination of factors that best explained variations of the outcomes. Risks of mild and severe tinnitus, relative to the absent tinnitus group, were expressed as relative risks with 95% confidence intervals (CI).

After multivariate adjustment in the model, the presence of hearing loss almost tripled the likelihood of severe tinnitus (RR 2.9, 95% CI 1.6 to 5.2). A number of medical history parameters were also associated with severe tinnitus including dizziness (RR 2.0, 95% CI 1.2 to 3.4), severe head injury (RR 2.0, 95% CI 1.1 to 3.3), sinus and middle ear infections (RR 1.9, 95% CI 1.1 to 3.2 and RR 1.9, 95% CI 1.0 to 3.6, respectively), and mastoiditis (RR 3.9, 95% CI 1.2 to 13.0), compared with subjects without these symptoms. Age and gender were treated as potential confounders due to their associations with age-related hearing loss and were included in the model regardless of their significance.

Significant factors associated with mild tinnitus included age, the presence of hear-

Table 2. Factors Significantly Associated with the Severity of Tinnitus, Reported as Sex-, Age-, and Hearing Loss-Adjusted Relative Risk with 95% Confidence Intervals

	Severity of Tinnitus			
Factor	Mild		Severe	
Age (10 years)	**0.8**	**(0.6 to 0.9)**	1.0	(0.7 to 1.4)[1]
Female gender	0.9	(0.7 to 1.2)	1.1	(0.7 to 2.0)
Hearing loss	**1.4**	**(1.0 to 1.9)**	**2.9**	**(1.6 to 5.2)[2]**
Dizziness	**1.5**	**(1.2 to 2.0)**	**2.0**	**(1.2 to 3.4)**
Head injury			**2.0**	**(1.1 to 3.3)**
Sinus infection			**1.9**	**(1.1 to 3.2)**
Middle ear infection			**1.9**	**(1.0 to 3.6)**
Mastoiditis			**3.9**	**(1.2 to 13.0)**
Meningitis	**2.2 (1.0 to 4.8)**			
Migraine	**1.5 (1.1 to 2.0)**			

Note: The interpretation of the risk of severe (or mild) tinnitus in respondents reporting dizziness, head injury, sinus and middle ear infections, mastoiditis, meningitis, or migraine is similar to that of respondents with hearing loss. Risks of severe and mild tinnitus relative to the risk of absent tinnitus symptoms. All significant factors are bold.

[1]After adjusting for other variables in the model, the risk of severe tinnitus does not significantly increase for every 10-year increase in age.

[2]The risk of severe tinnitus in participants with hearing loss is increased by a factor of 2.9 after adjusting for effects of the other variables in the model.

ing loss, reported history of dizziness, meningitis, and migraine, after adjusting for other variables in the best predictive model (Table 2). Persons with hearing loss were 1.4 times as likely to report mild tinnitus compared with those without hearing loss (RR 1.4, 95% CI 1.0 to 1.9). Dizziness increased the likelihood that participants would report mild tinnitus (RR 1.5, 95% CI 1.2 to 2.0), as did migraine (RR 1.5, 95% CI 1.1 to 2.0) and meningitis (RR 2.2, 95% CI 1.0 to 4.8). The risk of mild tinnitus was significantly associated with decreasing age (RR 0.8, 95% CI 0.6 to 0.9).

DISCUSSION

This study has demonstrated that hearing loss, reported history of sinus and middle ear infections, history of dizziness, head injury, and mastoiditis were significantly associated with an increase in the risk of severe tinnitus. Hearing loss, history of dizziness, meningitis, and migraine were significantly associated with the increased risk of mild tinnitus. It was also found that the risk of mild tinnitus significantly decreased with age. It is clear from these findings that factors such as hearing loss, dizziness, ear diseases, and so on play a significant role in determining the annoyance level of tinnitus.

The association of tinnitus severity and hearing loss is not new. In fact, a number of studies have previously reported this link (Leske, 1981; Axelsson and Ringdahl, 1989; Coles et al, 1990; Holgers et al, 2000; Sueta et al, 2001; Nondahl et al, 2002). The EHLS (Nondahl et al, 2002) revealed an odds ratio of 3.9 (95% CI 2.9 to 5.3) for tinnitus in subjects with hearing loss. This was slightly higher than the relative risk ratio estimated in our study (RR 2.9, 95% CI 1.6 to 5.2). Our lower risk estimate may be due, in part, to different definitions of tinnitus severity. The EHLS used tinnitus of at least moderate annoyance that causes difficulty in falling asleep, while we used tinnitus causing high to extreme annoyance. The EHLS definition was likely to include more tinnitus cases classified as severe than in our study. In addition, the higher odds ratio in the EHLS is consistent with the knowledge that the odds ratio tends to overestimate the relative risk when greater than one (Zhang and Yu, 1998). Our results nevertheless confirm that whatever the origin or degree of hearing loss, its significance in relation to the level of tinnitus annoyance cannot be underrated. Clinicians should, as a result, be dili-

gent in offering effective forms of rehabilitation for hearing-impaired tinnitus sufferers.

Coles et al (1990) reported an increase in odds of moderate or severe tinnitus with every 10-decibel increase in hearing level measured at 4000 Hz (better ear), in UK adults, as part of the population-based National Study of Hearing. The findings indicated three-fold increase in the odds for 20–39 dB HL, eight-fold increase for 40–49 dB HL, and 27-fold increase for 80+ dB HL, when compared with hearing threshold <10 dB HL. It is interesting that this was not confirmed by our findings. We repeated their analysis by selecting a group of subjects reporting mild or severe tinnitus, then assessing an association between mild or severe tinnitus and increasing hearing level (also measured at 4000 Hz in the better ear) without adjusting for any variable, as done in the UK study. We, however, did not find a significant increase in the risk of severe tinnitus for increasing hearing level. Compared with hearing threshold <10 dB HL, the risks for 10–19, 20–29, 30–39, 40–49, 50–59, 60–69, and 70–79 dB HL were less than one fold (RR 0.9, 0.5, 0.8, 0.9, 0.9, 0.7, and 0.9 respectively) while that for 80+ dB HL was more than one fold (RR 1.3). None of these ratios, however, came close to significance.

This discrepancy is probably due to differences in population characteristics and definitions of tinnitus and its severity in the two studies. First, the population in the UK study was much younger. Second, the definition of tinnitus in the UK study was more specific (ringing or buzzing sound in the head or ear[s] that lasts ≥5 minutes and does not occur after a loud noise) than ours (ringing or buzzing sound in the head or ear[s] that lasts ≥5 minutes). Finally, annoyance levels of tinnitus in our study were rated as not at all, mild, very, and extreme, but they were rated as none, slight, moderate, and severe in the UK study.

Apart from the above reasons, this incidence may be explained using the neurophysiological model proposed by Hazell and Jastreboff (1990; Jastreboff et al, 1996). The model specifies that damage to the auditory pathways is a trigger for tinnitus generation; however, it is the processing of the signal (nonauditory factor), particularly at the cortical level, that determines the severity of tinnitus. Hence, decreasing hearing level is not directly associated with increasing severe tinnitus.

Our study found that age was inversely associated with mild and severe tinnitus. However, only the association with mild tinnitus was significant (Table 2). It may be that older people find it easier to accept tinnitus as a part of the aging process than their younger counterparts and, as a result, are less likely to describe tinnitus as annoying.

After adjusting for other variables, gender was not significantly associated with either severe or mild tinnitus in the current study. This was consistent with the findings of Quaranta et al (1996). The EHLS, however, found that females were at greater risk of having severe tinnitus than were males (odds ratio = 1.4, 95% CI 1.1 to 1.8) after adjusting for the effects of age, hearing loss, cardiovascular disease, and head injury (Nondahl et al, 2002). Differences in definitions of tinnitus severity may again have affected the outcomes.

Our study identified dizziness as one of the factors associated with both mild and severe tinnitus. This was supported by a recent Japanese study (Sueta et al, 2001) that found a significant association between dizziness and tinnitus severity. This may reflect increased anxiety and stress levels caused by dizziness resulting in the exacerbation of tinnitus. Clinicians should therefore refer any tinnitus patients suffering dizziness to medical practitioners for treatment.

Severe tinnitus has been previously associated with head injury in clinic patients (Vernon and Press, 1994; Folmer and Griest, 2003) and in a general population of older adults (Nondahl et al, 2002). Folmer and Griest (2003) reported that patients with tinnitus onset associated with head or neck trauma were more likely to have higher Tinnitus Severity Index scores than patients whose tinnitus onset was not associated with trauma. The EHLS reported that the odds of severe tinnitus in subjects with history of head injury were 1.6 (95% CI 1.2 to 2.0). This was supported by the risk estimated in the BMHS of 2.0 (95% CI 1.1 to 2.3) after adjusting for other factors.

Our study has also shown that treatable diseases such as sinus and middle ear infections and mastoiditis all increased the risk of severe tinnitus while meningitis and migraine were associated with an increase

in the risk of mild tinnitus. The EHLS has reported an increase in the odds of tinnitus incidence by a factor of 8.85 in subjects with otosclerosis, in a five-year follow-up study (Nondahl et al, 2002). It is interesting that no other large studies have identified ear or ear-related diseases as risk factors for tinnitus severity. The identification of past middle ear or sinus infections, mastoiditis, and meningitis as a relatively frequent precursor of tinnitus is potentially important as its recognition could lead to recommendations for more aggressive nonsteroidal anti-inflammatory drug (NSAID) and antibiotic management, particularly for sinus infection, which may often go untreated for long periods.

In conclusion, our findings have shown that hearing loss, age, head injury, dizziness, meningitis, sinus and middle ear infections, mastoiditis, and migraine play a significant role in determining the annoyance level of tinnitus. The knowledge of these modifiable factors is important for audiologists who could encourage their patients to pursue medical treatment leading to the alleviation of their tinnitus. It is therefore important for audiologists to be alerted to these factors that may be revealed as part of the audiological evaluation. All these could contribute to improved tinnitus management. It will be important, however, for these findings to be confirmed by other studies before any general recommendations can be made. The longitudinal evaluation of our cohort, currently underway, may provide further evidence.

REFERENCES

Attias J, Shemesh Z, Bleich A, Solomon Z, Bar-Or G, Alster J, Sohmer H. (1995) Psychological profile of help-seeking and non-help-seeking tinnitus patients. *Scand Audiol* 24:13–18.

Axelsson A, Ringdahl A. (1989) Tinnitus—a study of its prevalence and characteristics. *Br J Audiol* 23:53–62.

Breslow N. (1974) Covariance analysis of censored survival data. *Biometrics* 30:89–99.

Bright KE. (1997) Spontaneous OAE. In: Robinette MS, Glattke TJ, ed. *OAE: Clinical Applications*. Thieme, 46–62.

Budd RJ, Pugh R. (1996) Tinnitus coping style and its relationship to tinnitus severity and emotional distress. *J Psychosom Res* 41:327–335.

Coles R, Davis A, Smith P. (1990) Tinnitus: its epidemiology and management. In: Jensen JH, ed. *Proceedings of the Fourteenth Danavox Symposium*. Copenhagen: Danavox Jubilee Foundation, 377–402.

Congalton A. (1969) *Status and Prestige in Australia*. Melbourne: FW Cheshire.

Cruickshanks KJ, Wiley TL, Tweed TS, Klein BE, Klein R, Mares-Perlman JA, Nondahl DM. (1998) Prevalence of hearing loss in older adults in Beaver Dam, Wisconsin: the Epidemiology of Hearing Loss Study. *Am J Epidemiol* 148:879–886.

Erlandsson SI, Hallberg LR. (2000) Prediction of quality of life in patients with tinnitus. *Br J Audiol* 34:11–20.

Erlandsson SI, Hallberg LR, Axelsson A. (1992) Psychological and audiological correlates of perceived tinnitus severity. *Audiology* 31:168–179.

Folmer RL, Griest SE. (2003) Chronic tinnitus resulting from head or neck injuries. *Laryngoscope* 113:821–827.

Folmer RL, Griest SE, Martin WH. (2001) Chronic tinnitus as phantom auditory pain. *Otolaryngol Head Neck Surg* 124:394–400.

Halford JB, Anderson SD. (1991a) Anxiety and depression in tinnitus sufferers. *J Psychosom Res* 35:383–390.

Halford JB, Anderson SD. (1991b) Tinnitus severity measured by a subjective scale, audiometry and clinical judgement. *J Laryngol Otol* 105:89–93.

Hazell JW, Jastreboff PJ. (1990) Tinnitus. I: Auditory mechanisms: a model for tinnitus and hearing impairment. *J Otolaryngol* 19:1–5.

Henry JL, Wilson PH. (1995) Coping with tinnitus: two studies of psychological and audiological characteristics of patients with high and low tinnitus-related distress. *Int Tinnitus J* 1:85–92.

Holgers KM, Erlandsson SI, Barrenas ML. (2000) Predictive factors for the severity of tinnitus. *Audiology* 39:284–291.

Holgers KM, Zoger S, Svedlund J, Erlandsson SI. (1999) Psychiatric profile of tinnitus patients referred to an audiological clinic. *Proceedings of the Sixth International Tinnitus Seminar*. Cambridge: British Society of Audiology, 283–285.

Jastreboff PJ, Gray WC, Gold SL. (1996) Neurophysiological approach to tinnitus patients. *Am J Otol* 17:236–240.

Kuk FK, Tyler RS, Russell D, Jordan H. (1990) The psychometric properties of a tinnitus handicap questionnaire. *Ear Hear* 11:434–445.

Lee J. (1994) Odds ratio or relative risk for cross-sectional data? *Int J Epidemiol* 23:201–203.

Leske MC. (1981) Prevalence estimates of communicative disorders in the U.S.: language, hearing and vestibular disorders. *ASHA* 23:229–237.

Meikle MB, Vernon J, Johnson RM. (1984) The perceived severity of tinnitus. Some observations concerning a large population of tinnitus clinic patients. *Otolaryngol Head Neck Surg* 92:689–696.

Newall P, Mitchell P, Sindhusake D, Golding M, Wigney D, Hartley D, Smith D, Birtles G. (2001) Tinnitus in older people: it is a widespread problem. *Hear J* 54:14–18.

Nondahl DM, Cruickshanks KJ, Wiley TL, Klein R, Klein BE, Tweed TS. (2002) Prevalence and 5-year incidence of tinnitus among older adults: the epidemiology of hearing loss study. *J Am Acad Audiol* 13:323–331.

Quaranta A, Assennato G, Sallustio V. (1996) Epidemiology of hearing problems among adults in Italy. *Scand Audiol* 25(suppl. 42):7–11.

Rizzardo R, Savastano M, Maron MB, Mangialaio M, Salvadori L. (1998) Psychological distress in patients with tinnitus. *J Otolaryngol* 27:21–25.

Sindhusake D, Mitchell P, Newall P, Golding M, Rochtchina E, Rubin G. (2003) Prevalence and characteristics of tinnitus in older adults: the Blue Mountains Hearing Study. *Int J Audiol* 42:289–294.

SPSS Inc. (2002) SPSS Version 11.0 for Windows. SPSS Inc.

Sueta T, Shiraishi K, Fukuyo K. (2001) Multivariate analysis using quantitative methods to evaluate the subjective loudness of tinnitus. *Nippon Jibiinkoka Gakkai Kaiho* 104:694–702.

Sweetow RW, Levy MC. (1990) Tinnitus severity scaling for diagnostic/therapeutic usage. *Hear Instrum* 41:20–21, 46.

Tyler RS. (1995) Tinnitus in the profoundly hearing-impaired and the effects of cochlear implants. *Ann Otol Rhinol Laryngol Suppl* 165:25–30.

Van Veen ED, Jacobs JB, Bensing JM. (1998) Assessment of distress associated with tinnitus. *J Laryngol Otol* 112:258–263.

Vernon JA, Press L. (1994) Characteristics of tinnitus induced by head injury. *Arch Otolaryngol Head Neck Surg* 120:547–551.

Zhang J, Yu KF. (1998) What's the relative risk? A method of correcting the odds ratio in cohort studies of common outcomes. *JAMA* 280:1690–1691.

APPENDIX

Tinnitus-related questions

Tinnitus

1. Have you experienced any prolonged ringing or buzzing in your ears or head within the past year, that is, lasting for 5 minutes or longer?

none . . . . . ☐ 1 *go to 4-1*
occasional . . . . . ☐ 2
often . . . . . ☐ 3
unsure . . . . . ☐ 8
missing . . . . . ☐ 9

2. We call this **tinnitus**. When did you first notice the tinnitus?

less than 1 year ago . . . . . ☐ 1
1 to 5 years . . . . . ☐ 2
5 to 10 years . . . . . ☐ 3
more than 10 years ago . . . . . ☐ 4
missing . . . . . ☐ 9

3. Was the onset of the tinnitus gradual or sudden?

gradual . . . . . ☐ 1
sudden . . . . . ☐ 2
don't know . . . . . ☐ 8
missing . . . . . ☐ 9

4. Where do you hear your tinnitus?

right ear . . . . . ☐ 1
left ear . . . . . ☐ 2
both ears . . . . . ☐ 3
both ears. . . . . R>L . . . . . ☐ 4
both ears. . . . . L>R . . . . . ☐ 5
in the head . . . . . ☐ 6
unsure . . . . . ☐ 8
missing . . . . . ☐ 9

5. When you hear tinnitus, which word best describes the sound you usually hear?

crackling (static) . . . . . ☐ 1
ringing . . . . . ☐ 2
buzzing . . . . . ☐ 3
pulsating . . . . . ☐ 4
roaring . . . . . ☐ 5
other . . . . . ☐ 6
unsure . . . . . ☐ 8
missing . . . . . ☐ 9

6. Is your tinnitus present:

all the time . . . . . ☐ 1
part of the time . . . . . ☐ 2
only occasionally . . . . . ☐ 3
unsure . . . . . ☐ 8
missing . . . . . ☐ 9

7. Do you hear your tinnitus:

during the day when it is quiet . . . . . ☐ 1
during the day above other noises . . . . . ☐ 2
only at night . . . . . ☐ 3
unsure . . . . . ☐ 8
missing . . . . . ☐ 9

8. Does the tinnitus keep you awake at night?

very often . . . . . ☐ 1
often . . . . . ☐ 2
occasionally . . . . . ☐ 3
never . . . . . ☐ 4
unsure . . . . . ☐ 8
missing . . . . . ☐ 9

9. How annoying is your tinnitus?

extremely annoying . . . . . ☐ 1
very annoying . . . . . ☐ 2
mildly annoying . . . . . ☐ 3
not annoying at all . . . . . ☐ 4
unsure . . . . . ☐ 8
missing . . . . . ☐ 9

10. Does your tinnitus get you down at times?

very often . . . . . ☐ 1
often . . . . . ☐ 2
occasionally . . . . . ☐ 3
never . . . . . ☐ 4
unsure . . . . . ☐ 8
missing . . . . . ☐ 9

11. What treatment have you tried for your tinnitus? *multiple responses accepted*

none . . . . . ☐ 1 *go to 3-13*
medications . . . . . ☐ 2
hearing aids . . . . . ☐ 3
tinnitus masker . . . . . ☐ 4
acupuncture . . . . . ☐ 5
relaxation therapy . . . . . ☐ 6
music therapy . . . . . ☐ 7
tinnitus retraining Rx . . . . . ☐ 8
missing . . . . . ☐ 9

12. Which of those treatments was most helpful? *multiple responses accepted*

none . . . . . ☐ 1
medications . . . . . ☐ 2
hearing aids . . . . . ☐ 3
tinnitus masker . . . . . ☐ 4
acupuncture . . . . . ☐ 5
relaxation therapy . . . . . ☐ 6
music therapy . . . . . ☐ 7
tinnitus retraining Rx . . . . . ☐ 8
missing . . . . . ☐ 9

13. Other details of tinnitus

_____
_____
_____
_____
_____

14. Have you sought help or spoken to any professional about your tinnitus?

yes . . . . . ☐ 1
no . . . . . ☐ 2 *go to 4-1*
don't know . . . . . ☐ 8
missing . . . . . ☐ 9

15. Which of the following have you contacted? *multiple responses accepted*

family doctor . . . . . ☐ 1
ENT doctor . . . . . ☐ 2
audiologist . . . . . ☐ 3
hearing service/ hearing aid provider . . . . . ☐ 4
self-help group (e.g., BHA, ATA, SHHH) . . . . . ☐ 5
unsure . . . . . ☐ 8
missing . . . . . ☐ 9

16. Have you received *treatment or support services for your tinnitus* from any of the following in the past 5 years? *multiple responses accepted*

family doctor . . . . . ☐ 1
ENT doctor . . . . . ☐ 2
audiologist . . . . . ☐ 3
hearing service/ hearing aid provider . . . . . ☐ 4
self-help group (e.g., BHA, ATA, SHHH) . . . . . ☐ 5
unsure . . . . . ☐ 8
missing . . . . . ☐ 9

17. What is the name of professionals or services you have visited because of tinnitus?

Name 1 _____ How long ago? ____ years

Name 1 _____ How long ago? ____ years