ORIGINAL ARTICLE

Cigarette smoking, occupational exposure to noise, and self reported hearing difficulties

K T Palmer, M J Griffin, H E Syddall, D Coggon

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See end of article for
authors' affiliations

Correspondence to:
Dr K Palmer, MRC
Environmental
Epidemiology Unit,
Southampton General
Hospital, Southampton
SO16 6YD, UK;
ktp@mrc.soton.ac.uk

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Aims: To explore the interaction of smoking and occupational exposure to noise as risk factors for hearing difficulty in the general population.

Methods: A questionnaire was mailed to 21 201 adults of working age, selected at random from the age-sex registers of 34 British general practices, and to 993 members of the armed services, randomly selected from pay records. Questions were asked about smoking habits, years spent in a noisy occupation, difficulty in hearing conversation, and wearing of a hearing aid. Associations of hearing difficulty with smoking habit were examined by logistic regression and compared across strata of noise exposure, with adjustment for potential confounders.

Results: Around half of the respondents had ever smoked, and half of these still smoked. Among 10 418 who provided details on hearing, 348 were classed as having moderate and 311 as having severe hearing difficulty. Risk of hearing difficulty was 3–5-fold higher in those employed for >5 years in noisy work compared with those never employed in a noisy job. Within strata of noise exposure (including those who had never worked in a noisy job), ex- and current smokers had a higher risk of hearing difficulty than lifetime non-smokers. The additional risks were small compared with those of long term noise exposure, and the combination of effects was more consistent with an additive than a multiplicative interaction.

Conclusions: Smoking may adversely affect hearing, and workers should be encouraged to refrain from both smoking and exposure to noise. However, the extra risk to hearing incurred by smoking in high ambient noise levels is small relative to that from the noise itself, which should be the main target for preventive measures.

Sensorineural deafness is a common and important source of disability at older ages, often caused by noise at work. A recent survey suggested that some 153 000 men and 26 000 women in Britain aged 35–64 years are severely deaf because of workplace noise.¹ The hazard is well recognised and subject to various controls and checks, such as elimination of sources of noise, enclosure of noisy machinery, reduction of exposure times, use of ear defenders, and audiometry. Control of the hazard might be further improved if factors could be identified that modify susceptibility to noise and which place noise exposed workers at particular risk of deafness.

Cigarette smoking has attracted growing interest in this respect. Evidence on its relation to hearing loss has accrued from health screening programmes,^{2–3} occupational programmes of hearing conservation,^{4–9} and a few population based surveys.^{10–14} In general these have suggested that smokers have a greater risk of hearing loss than non-smokers,^{2–4 8–10 13} but there have been some contrary observations.^{5 6 11 12 14} Also, uncertainty has been expressed about the role of noise in some of these studies as a possible confounder or potentiator of the relation, and about other limitations such as small sample size and unrepresentativeness of study populations.¹⁵ In a few studies evidence has been found of a dose-response effect,^{3 9 13} but findings on this have not been entirely consistent.

A need remains, therefore, to confirm the association between cigarette smoking and hearing loss and to assess its relation to noise exposure. If smoking is harmful to hearing, it is important to establish whether its effect in combination with occupational noise exposure is additive or multiplicative. This issue is of importance in the counselling and job placement of noise exposed workers who smoke, but only

limited evidence exists about the combined effects of the two hazards.^{9 16}

In 1997–98 we conducted a large postal survey to obtain national estimates of exposure to vibration. Enquiries were also made about hearing difficulties, tinnitus, time spent working in noisy jobs, and smoking habits, and this provided an opportunity to examine the inter-relation of these factors more closely.

METHODS

Altogether, questionnaires were mailed to 21 201 men and women aged 16–64 years chosen at random from the age-sex registers of 163 GPs in 34 general practices across Britain and to 993 randomly selected members of the armed forces. The practices were chosen to give a broad geographical coverage and to ensure that industries with known exposure to vibration (a primary focus of inquiry) were represented in the sample, while members of the armed forces (who are cared for by military rather than civilian doctors) were sampled additionally. A single reminder was sent to non-responders about five weeks later. Details of the sampling methods, questionnaire, and validity of the measuring instruments have been published previously.^{1 17 18}

Among other things, enquiries were made about self reported hearing difficulties, tinnitus, and the wearing of a hearing aid; the total time spent working in noisy places where there was a need to shout to be heard (which roughly equates to noise exposures exceeding 85–90 dB(A)¹⁹); and smoking habits.

Difficulty in hearing was assessed by the question: "How well can you hear a person who is talking to you when he is sitting on your right [left] side in a quiet room?". This was modelled on an item from the MRC National Survey of

Main messages

- The data from this large community based survey support a growing body of evidence that smokers have more hearing difficulty than non-smokers, even after allowance for occupational exposure to noise.
- However, results indicate that noise has a greater effect on hearing than smoking does.
- The risk to hearing in noise exposed workers is not much greater in smokers than in non-smokers.

Hearing, in which the response category “moderate difficulty” corresponded to a measured mean hearing impairment of about 45 dB.²⁰ We classed subjects as severely affected if they wore a hearing aid or reported severe hearing difficulty in the worse affected ear; as being moderately affected if they reported moderate hearing difficulty in the worse ear; and as normal if they reported only slight hearing difficulty in the worse ear or no difficulty at all. (In those who only reported on hearing in one ear, the category was that for the ear on which information was given.) Tinnitus was identified by asking: “During the past 12 months have you had noises in your head or ears (such as ringing, buzzing or whistling) which lasted longer than five minutes?” It was defined as “persistent” if it was reported to occur most or all of the time. A smoker was defined as someone who had smoked at least once a day for a month or longer, and classed according to whether he or she still smoked regularly (current smoker) or did not (former smoker).

Information was also collected on age and sex as potential confounding factors, and on complaints of frequently feeling tired or stressed or suffering frequent headaches, as possible markers of lowered threshold for reporting symptoms in general. All statistical analyses were carried out in STATA, release 5.²¹ Associations of hearing impairment and tinnitus with smoking were examined by logistic regression, with adjustment for potential confounding. Separate analyses were conducted according to duration of employment in a noisy occupation. The findings were expressed as prevalence ratios (PRs) with associated 95% confidence intervals (CIs). These were derived from the corresponding odds ratios using a formula proposed by Zocchetti and colleagues.²²

RESULTS

Questionnaires were returned by 12 907 subjects (58% of those selected for study), with a higher response rate in older subjects and women. The occupational distribution of responders was generally similar to that in the preceding national census.²³ Further details on the response pattern have been published elsewhere.¹⁷

The respondents included 3184 current smokers, 3329 former smokers, and 6394 lifelong non-smokers. Non-smokers tended to be younger and reported working fewer years in a noisy occupation than ex- and current smokers.

Among 10 418 respondents who provided details on hearing, 9759 were classed as having slight or no hearing difficulty, 348 as having moderate hearing difficulty, and 311 as having severe hearing difficulty (including 165 who wore a hearing aid). Persistent tinnitus was reported by 527 subjects. As reported previously,¹ the prevalence of tinnitus was higher in those with hearing difficulties (about twice as common in age standardised comparisons), and both symptoms were more common at older ages. Subjects who felt frequently tired or stressed, or suffered frequent headaches, also reported such problems more often.

Policy implications

- Workers should be encouraged not to smoke and to avoid excessive exposure to noise.
- However, there is no strong need to limit the employment of smokers to a greater extent than non-smokers in jobs where ambient noise levels are significant.

Table 1 shows the association of hearing difficulties and tinnitus with smoking habit and years in noisy work, after adjustment for report of tiredness, stress, and headaches, and for age and sex. The baseline for comparison was subjects who were free of auditory problems, and all risks were estimated relative to those of non-smokers who had never worked in a noisy job.

The risks of moderate-to-severe hearing difficulty, severe hearing difficulty, and persistent tinnitus increased with years spent in noisy work for all categories of smoking habit, being some three to five fold higher in those employed for more than five years than in those never employed in noisy work.

Within strata of noise exposure, ex- and current smokers had a moderately higher risk of hearing difficulty than lifetime non-smokers in most comparisons. For example, the PR for moderate-to-severe hearing difficulty was 1.5 (95% CI 1.1 to 2.1) in current versus never-smokers without exposure to noise at work. By contrast, after allowance for age and duration of noisy employment, smoking status was only weakly related to tinnitus if at all.

The combined effect on hearing difficulty of current smoking and long term noise exposure was generally less than multiplicative, and more consistent with an additive effect. Thus, among subjects with moderate-to-severe hearing difficulty, the risk difference between smokers and non-smokers was similar in every stratum of years employed in noise; and the same was true among subjects with severe hearing difficulty who had never worked in a noisy job or had been employed in it for up to five years. In those with severe hearing difficulty who had been employed for more than five years in a noisy job, the risk difference between smokers and non-smokers was greater, but the interaction was still less than multiplicative.

DISCUSSION

This population based survey tends to confirm that smoking is associated with hearing difficulty, and that this relation exists even in those who have never been exposed to occupational sources of noise. However, it indicates that any such effect is modest in comparison with long term employment in a noisy job, and that the combined effects of smoking and noise are additive rather than multiplicative.

A strength of our survey was the large, geographically dispersed, and well defined sampling base, which included over 22 000 randomly selected subjects across England, Wales, and Scotland. The distribution of occupations in respondents was nationally representative, being similar to that at the preceding national census.

Participation was incomplete (response rate 58%), but response bias would only explain the association of smoking with hearing difficulty if smokers with symptoms participated more readily than smokers without. This seems unlikely, and similar associations were found in those who responded to the questionnaire at the first invitation and those who required a reminder (data not presented), providing evidence against this pattern of bias.

Table 1 Associations between self reported hearing difficulties, tinnitus, smoking, and working in a noisy occupation

Hearing problem/smoking habits	Years worked in noisy job*							
	None				<1-5			
	No.	No. (%) +ve	PR (95% CI)	No.	No. (%) +ve	PR (95% CI)	No.	PR (95% CI)
Severe hearing difficulty†								
Never smoked	2698	45 (1.7)	1.0	551	18 (3.3)	2.2 (1.3 to 3.7)	293	4.6 (2.9 to 7.1)
Formerly smoked	1109	37 (3.3)	1.4 (0.9 to 2.1)	362	15 (4.1)	2.0 (1.1 to 3.5)	256	5.9 (3.9 to 8.7)
Currently smoking	915	23 (2.5)	1.3 (0.8 to 2.1)	338	15 (4.4)	2.4 (1.4 to 4.2)	208	5.8 (3.7 to 8.9)
Moderate/severe hearing difficulty†								
Never smoked	2736	83 (3.0)	1.0	573	40 (7.0)	2.4 (1.7 to 3.3)	341	5.0 (3.8 to 6.3)
Formerly smoked	1140	68 (6.0)	1.4 (1.0 to 1.8)	384	37 (9.6)	2.4 (1.7 to 3.4)	319	5.9 (4.7 to 7.4)
Currently smoking	943	51 (5.4)	1.5 (1.1 to 2.1)	367	44 (12.0)	3.3 (2.4 to 4.5)	248	5.7 (4.4 to 7.1)
Persistent tinnitus‡								
Never smoked	2752	99 (3.6)	1.0	574	41 (7.1)	1.9 (1.4 to 2.7)	312	3.0 (2.2 to 4.1)
Formerly smoked	1131	59 (5.2)	1.0 (0.7 to 1.4)	394	47 (11.9)	2.4 (1.7 to 3.3)	277	3.8 (2.8 to 5.0)
Currently smoking	929	37 (4.0)	0.9 (0.6 to 1.3)	355	32 (9.0)	2.1 (1.4 to 3.0)	223	3.6 (2.5 to 4.9)

*Years in a job where there was a need to shout to be heard.

†Severe = severe or can't hear at all in either ear, or wearing of a hearing aid; moderate = moderate difficulty in the worse affected ear (and no use of a hearing aid).

‡Persistent = most or all of the time in the past 12 months.

No. (%) +ve = number and % positive for the hearing outcome.

The baseline for all risk estimates was subjects who were free of auditory problems. All risks were estimated relative to those of non-smokers who had never worked in a noisy job. All PRs were adjusted for age, sex, and self report of frequent tiredness or stress and frequent headaches. The analysis excludes 50 subjects with severe hearing difficulty, 77 with moderate to severe hearing difficulty, and 49 with tinnitus who failed to provide information on years worked in a noisy job or frequency of tiredness, stress, and headaches.

In view of the relatively small number of working aged subjects reporting hearing loss, smoking status rather than pack-years of smoking was used as the index of exposure. This precluded examination of a dose-response relation, but subjects are less likely to have been misclassified using this metric of exposure. Major error arising from the question on hearing impairment also seems unlikely, as the validity of this item has previously been established.²⁰ However, our metric of exposure to noise (years worked in a noisy job where there was a need to shout to be heard) was crude to the extent that it did not fully reflect intensity of noise above a likely threshold of 85–90 dB(A). Among noise exposed workers, differences in intensity of noise exposure or degree of compliance with wearing of ear defenders may have existed by smoking status. This may have caused residual confounding after allowance for years of employment in noise, but cannot explain the increased risk in smokers who had never held a noisy job.

A number of other potential explanations for the association need to be considered. Smokers may have reported hearing difficulty more readily than non-smokers, perhaps as part of a general tendency to report somatic symptoms at a lower threshold; but the association persisted despite adjustment for markers of such a tendency (frequent complaints of headaches, tiredness, and stress).

Alternatively, assuming a genuine effect, smoking may act as a direct ototoxin;²⁴ may impair blood flow to the cochlea by inducing vasospasm, atherogenic narrowing, and thrombotic occlusion of the nutrient arteries;²⁵ or may alter blood viscosity,^{15–26} or generate carboxyhaemoglobin,^{27–28} exacerbating any problems of local hypoxia.

There have been only a few population based surveys of smoking and hearing loss previously. When 1662 elderly subjects from the Framingham study underwent audiometric screening, no association was found between hearing thresholds and current smoking status or number of cigarettes smoked.¹¹ And hearing thresholds in middle age did not deteriorate more rapidly during follow up among smokers than non-smokers from rural Denmark.¹⁴ But in the US Health Interview Survey,¹⁰ men who smoked two or more packs per day more often reported hearing problems than non-smokers; in a population based cross-sectional survey based in Beaver Dam, USA,¹³ a 25 dB hearing loss in the worse ear was 1.7 times more common in current smokers than lifetime non-smokers after adjustment for other factors; and in another study, which sampled non-smokers from the community, a moderately increased risk of hearing loss (OR 1.3) was found in association with exposure to environmental tobacco smoke.²⁹

Surveys set within programmes of health screening and hearing conservation have produced some of the most convincing evidence that smoking is detrimental to hearing. For example, in Japan, where labour law mandates periodic audiometry for all employees irrespective of noise exposure, two large surveys found worse hearing among smokers than non-smokers in non-noisy white collar occupations, and a dose-response effect among current smokers which was much clearer for high frequency hearing loss than for low frequency loss.^{3–9} Mizoue and colleagues⁹ have suggested that inner ear cells responsible for high frequency hearing are more vulnerable to ischaemic damage, as they are located at the end of nutrient arteries, and that the inconsistency of findings across studies may reflect failure to distinguish the different potential patterns of hearing loss.

The combined effects of noise and smoking have only occasionally been explored. In keeping with our findings, Mizoue *et al* reported an additive effect, based on periodic health data from 4624 Japanese steel company workers.⁹ But

by contrast, Prince *et al* found that the combined effect of these risk factors was more than that from simple additivity.¹⁶

Workers should be encouraged as a matter of good public health policy to avoid the hazards of both noise and smoking. But our results suggest that from the viewpoint of hearing there is no strong imperative to limit the employment of smokers to a greater extent than non-smokers where ambient noise levels are significant. Counselling may be appropriate in these circumstances, but our data indicate only a small additional risk from smoking and underscore the importance of noise as the primary target for preventive measures in hearing conservation programmes.

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Authors' affiliations

K T Palmer, H E Syddall, D Coggon, MRC Environmental Epidemiology Unit, Community Clinical Sciences, University of Southampton, UK
M J Griffin, Institute of Sound and Vibration Research, University of Southampton, UK

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