

Cigarette smoking and occupational noise-induced hearing loss

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Background: Noise is the most common occupational hazard. Noise-induced hearing loss (NIHL) is a known occupational disease. The economic costs of NIHL have been estimated to be billions of dollars. Besides, cigarette smoking is a common habit worldwide. **Methods:** In a cross-sectional study, we surveyed the effect of smoking on NIHL in 504 workers in a large wagon manufacturing company exposed to noise >85 dBA. All required data were obtained using direct interview and questionnaires. To determine noise exposure level, we used industrial hygienist's reports of sound level measurements. A qualified audiologist assessed hearing status using standardized audiometric examination. **Results:** We concluded that the frequency of hearing loss in smokers was higher than non-smokers [based on Model 1: odds ratio (OR) = 9.35, 95% confidence interval (CI) = 5.74–15.22 and *P*-value < 0.001; and based on Model 2: OR = 9.06, 95% CI = 5.93–13.84 and *P*-value < 0.001]. Besides, these results were confirmed by logistic regression statistical method. **Conclusions:** It can be concluded that smoking may accelerate NIHL, but for confirming this opinion, further studies are warranted.

Keywords: hearing loss, noise, occupational exposure, smoking.

Introduction

Noise is the most frequent occupational hazard.^{1,2} About 30 million workers in the USA are exposed to unauthorized noise,³ and it is estimated that ~600 million workers are exposed to workplace noise all over the world.⁴ Long-term exposure to noise mainly damages hair cells of the organ of Corti in the inner ear,⁵ and eventually leads to noise-induced hearing loss (NIHL), which is usually characterized by bilateral sensorineural hearing loss. First part of the inner ear damaged, is a part of cochlea sensitive to sound frequencies 4000 Hz (between 3000 and 5000 Hz). This damage is gradually spread to adjacent areas sensitive to other frequencies, especially between 6000 and 8000 Hz.^{2,6,7} It should also be emphasized that individual sensitivity to NIHL is different, and the incidence of NIHL is dependent on various factors, such as sound pressure level and duration of exposure.⁸

According to National Institute on Occupational Safety and Health (NIOSH), 14% of workers are exposed to noise >90 dB, and in some industries (e.g. textile, petroleum, food and transportation) this estimate reaches up to 25% (pp. 259 in Niland¹; pp. 429, 893–95 in Rabinowitz and Rees²). It should be mentioned that NIHL can impose a large social and economic burden on the society. In addition, it can cause early removal of skillful and experienced workers from production cycle, which in turn can induce many psychosocial problems, e.g. isolation, depression and increased likelihood of accidents.^{9,10} On the other hand, treatment, rehabilitation and compensation costs for these workers may reach up to millions of dollars (pp. 121 in Johnson and Robinson⁷).¹¹

An important point is that NIHL is permanent and irreversible, but it is completely preventable.¹² Recently, some studies have propounded cigarette smoking as an important factor

that can increase the likelihood of NIHL. Also, cigarette smoking can cause cochlear damage.¹³

Smoking is common in all social classes, including workers, although there are some differences between various social classes.¹⁴

Hence, we decided to assess the interaction of smoking and noise on the hearing of workers in our country.

Methods

In a cross-sectional study, as a part of the periodic medical examinations in 2007, in a large wagon manufacturing factory in the capital of Iran, we assessed the simultaneous effect of smoking and noise on hearing. There were no other known occupational hazards affecting hearing, except for noise.

In this study, noisy workplaces were selected based on sound level measurements; these measurements were performed annually, and saved as 'noise monitoring records'. The last four records were used and five parts of the factory with significant noise exposure (>85 dBA) in all four records were selected as noisy workplaces. The respective lowest and highest noise levels at different stations of these five parts were 88 and 96 dBA. The turnover of workers in the noisy parts was so fast that it was impossible to estimate the exact level of exposure to noise for each worker, but the turnover of workers between noisy and non-noisy parts was slow and exposure duration could be calculated almost exactly. Our study population (*N* = 307) consisted male smoker workers of these noisy parts exposed to noise levels >85 dBA. There were no women workers exposed to such high noise levels (most of the women were office workers). All workers were from a similar social class. After filling a questionnaire, based on direct interview by an occupational medicine specialist, all workers with a history of ototoxic drug use, diabetes mellitus, hyperlipidaemia, hypothyroidism, severe or frequent ear infection, chronic middle-ear pathology or major ear operations, head injury, exposure to non-occupational noise (such as amplified music, participation in war, hunting, etc.), noise exposure in previous job(s), unilateral or conductive hearing loss or any kind of hearing loss with a known aetiology except for noise exposure and also ex-smokers

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(those who have given up smoking) were excluded ($n=55$). Thus, 252 male smokers who worked in noisy workplaces and participated in periodic medical examinations composed the target population. Also, there were 453 male non-smoker workers in these noisy parts. Based on our study design the proportion of case group to the control group was 1:1, so 252 non-smoker male workers, who worked in the same parts, were randomly selected as the control group (among whom 83 workers were excluded by applying the exclusion criteria). Inclusion and exclusion criteria, and the data collection method for this group were the same as the smokers group. Thus the only difference between the two groups was cigarette smoking.

All workers voluntarily participated in this study following a written informed consent which was obtained in Persian.

Smoking was ascertained based on the following questions: 'Have you ever smoked?' and 'Do you smoke?' Duration of smoking, working in noisy workplaces and age were recorded in years. Smoking was assessed by pack-years (packs of cigarette smoked each day \times years of smoking) as well. A qualified audiologist assessed hearing threshold using standardized audiometric procedures assuring of ≤ 14 h noise avoidance. The tests were performed in an acoustic chamber meeting the ANSI S3.1-1991 standards with a diagnostic audiometer (Model AD 229e, interacoustic Denmark Co. Ltd).

The pure-tone hearing thresholds at 500, 1000, 2000, 3000, 4000 and 6000 Hz were measured for air and bone conduction, in both ears.

The hearing loss was defined based on two models—Model 1: the hearing threshold differences of >30 dB between 4000 and 1000 Hz in both ears; and Model 2: hearing threshold level of >25 dB at 4000 Hz in the better ear—as the indicators of hearing loss.

The collected data were analysed using SPSS for Windows software, Version 14.5. Data were analysed using the t -test (for quantitative variables), Chi-square test (for qualitative variables) and logistic regression.

Results

The mean age of total 504 workers was 42.25 years (± 6.56), and mean exposure time to noise was 18.14 years (± 6.50), and average hearing loss at 4000 Hz was 25.46 dB (± 17.88). According to the Models 1 and 2, mentioned above, 29.6 and 39.5% of workers suffered from hearing loss.

In this study the mean age of non-smokers and smokers was 41.63 ± 6.97 and 42.86 ± 6.07 years, respectively ($P=0.035$), and the mean exposure duration to noise in non-smokers and smokers was 17.51 ± 6.62 and 18.77 ± 6.33 years, respectively ($P=0.03$). The respective average hearing thresholds at 4000 Hz in non-smokers and smokers in the better ear were 15.83 and 35.09 dBA, which was statistically significant ($P<0.001$).

We found a statistically significant difference in hearing loss between the groups (smokers and non-smokers); according to Models 1 and 2, the respective odds ratios (ORs) were 9.35 [95% confidence interval (CI) = 5.74–15.22], and 9.06 (95% CI = 5.93–13.84).

Hearing loss and average hearing threshold have been compared in two age groups (≤ 40 and >40 years) (table 1).

In order to more exactly assess the relationship between hearing loss and smoking, and eliminate the confounding effect of age and duration of exposure to noise, we used logistic regression analysis. In this analysis (after eliminating confounding variables) there was still a statistically significant relationship between NIHL and smoking. This analysis showed that hearing loss OR increases in accordance with increased pack-years of smoking (table 2).

Table 1 Comparing hearing threshold in smokers and non-smokers in two age groups

	Age ≤ 40 years				Age >40 years			
	Smokers (n = 71)	Non-smokers (n = 101)	P-value	Odds ratio (95% CI)	Smokers (n = 181)	Non-smokers (n = 151)	P-value	Odds ratio (95% CI)
Hearing loss according to model 1 ^a (%)	17 (23.94)	3 (23.94)	<0.001	10.28 (2.88–36.67)	108 (59.66)	21 (13.90)	<0.001	9.15 (5.29–15.84)
Hearing loss according to model 2 ^b (%)	23 (32.39)	6 (5.94)	<0.001	7.58 (2.86–19.87)	136 (75.13)	34 (22.51)	<0.001	10.40 (6.24–17.30)
Average hearing threshold at 4 KHz (SD)	23.52 (14.67)	12.12 (9.65)	<0.001	–	39.64 (16.97)	18.31 (12.21)	<0.001	–

SD: standard deviation

a: Hearing threshold difference between 1000 and 4000 Hz more than 30 dB

b: Hearing threshold at 4000 Hz more than 25 dB in better ear

Table 2 Relationship between hearing loss^a and age, duration of exposure and cigarette smoking by logistic regression

Variable	β	SE ^b	P-value	OR (95% CI)
Constant	-2.271	0.335	<0.001	
Age (year)				
≤40 (n = 172)				1.00
>40 (n = 332)	1.176	0.287	<0.001	3.24 (1.84–5.69)
Time of exposure to noise (year)				
≤19 (n = 246)				1.00
>19 (n = 258)	0.699	0.252	0.006	3.01 (1.22–3.29)
Smoking (pack/year)				
Non-smokers (n = 252)				1.00
<20 (n = 162)	1.467	0.365	< 0.001	4.33 (2.12–8.87)
≥20 (n = 90)	3.306	0.367	< 0.001	27.28 (13.30–55.95)

SE: standard error

a: Hearing threshold at 4000 Hz more than 25 dB in better ear

Discussion

In our study, among employers exposed to noise levels >85 dBA, smoking increases the likelihood of hearing loss, and this increase is statistically significant.

And it can be mentioned that among smokers exposed to noise levels >85 dBA, high-frequency hearing loss OR will significantly be increased by increasing pack-years of smoking.

According to the results, mean age and exposure duration in smokers are more than non-smokers, but this difference is not significant.

It has been shown that cigarette smoking, through increasing the blood viscosity and decreasing oxygenation can impair cochlear circulation.¹³

Of the few studies about the relationship between smoking and NIHL, most of them in different parts of the world have shown this relationship (though with different significances), and are consistent with our study.^{15–23}

In contrast, there are some studies which were not able to show a relationship between smoking and NIHL.^{24,25}

It can be concluded that smoking may accelerate NIHL, but for confirming this opinion, more studies are required. If prospective studies confirm this idea, giving up smoking or modification in smoking habit may delay the appearance of hearing loss, especially in workers exposed to workplace noise. Therefore it can be recommended that in smoker workers exposed to noise exceeding 85 dBA, the periods of audiometric evaluation should be decreased (e.g. from annually to semiannually), in order to early recognition of hearing loss. Also, smoker workers should be participated in educational courses for smoking cessation in a periodic manner.

Finally, it can be mentioned that further research is required to confirm our findings and identify the definite mechanisms.

Conflicts of interest: None declared.

Key points

- Smoking is one of the most common habits in all social classes, including workers.
- Based on recent studies, cigarette smoking is an important factor that can increase the likelihood of NIHL.
- Smoking may accelerate NIHL and accordingly it can be recommended that smoker workers exposed to noise >85 dBA, should be followed carefully.
- It is also recommended that they should attend educational courses on smoking cessation periodically, especially in noisy workplaces.

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