Original Article

Hearing loss among Fasa sugar factory workers', Fars Provincre, Iran (2016)

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Abstract

Background: Hearing loss induced by noise is one of the well-known and main health problems of occupational exposures. As a result, the current study sought to examine the association between age, working experience, and smoking status and hearing loss among sugar factory workers.

Materials and Methods: This cross-sectional study was conducted in 2016 among 270 workers of a sugar factory in Fasa, Iran. Workplace noise was measured based on ISO 9612 by using Casella-Cel (model 450) sound level meter. Pure-tone audiometry test was performed by audiometry device (AC 40). Data were analyzed by SPSS software using independent two-sample t-test to compare the mean scores of hearing threshold in different age and work experience groups.

Results: Out of 270 workers at the factory, 155 were exposed to noise exceeding 85 dB. Based on sound pressure level measurements, the major noise producing parts of the factory were steam boiler, furnace, turbine, drying, and welding sections. The results showed that the average hearing threshold at 4000 Hz in both ears was higher than other frequencies. This was followed by the hearing thresholds at frequencies of 8000 and 2000, 500, 1000 and 250 Hz, in that order. Noise had the strongest effect in the mentioned frequencies ($P < 0.05$).

Conclusions: The results indicated that smokers and older people were at higher risk of hearing loss compared to non-smokers and younger workers. Thus, it is suggested that policy makers minimize hearing loss among workers by taking noise controlling measures in departments that are exposed to excessive noise, training workers, conducting regular periodic hearing tests, and establishing a regular work-rest cycle.

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Introduction

Noise is the most common occupational and environmental hazard and is regarded as a common harmful agents in the workplace (1-5). Hearing loss induced by noise is one of the oldest and main causes of occupational disease. It mainly occurs due to prolonged exposure to noise above 85 dB at the workplace (6, 7).

Despite using control devices to reduce workplace noise, it remains one of the most common harmful job-related factors (8). The effect of noise on human health can be divided into two main groups: effect on the auditory system (temporary or permanent loss of hearing) and non-auditory impacts (physiological effects such as increased blood pressure, effect on workers' safety, effect on performance and mental effect) (9).

Biologically, noise may cause hearing loss through damaging cochlear hair cells and

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changing metabolic mechanisms, caused by vasoconstriction-induced hypoxia (10). There is evidence that incidents occur more frequently if workers are exposed to excessive noise in the workplace (11). In addition to the noise level, other factors that can trigger noise effects include: age, sex, eyes and skin color, audio frequency range, persistence of sound, and sound duration (12). However, the important point in job-related diseases is that these diseases are preventable through identification, evaluation, and control of hazards. Preventing such diseases will create an ideal living environment.

Ahmed HO et al. assessed hearing loss among workers in one of the industries in Saudi Arabia. They concluded that the prevalence of hearing loss in high (4000 and 8000 Hz) and low (500-1000 and 2000 Hz) freuqnecies were 47.9% and 32.4%, respectively (13).

Sugar industry plays a significant role in the economy of Iran. It is thus important to maintain the healthy status of its workforces in order to achieve sustainable development. On the other hand, to date, no documented study has made attempts to measure the relationship between demographic features and hearing loss among workers of this factory. As a result, the current study sought to examine the association between age, working experience, and smoking status and hearing loss in sugar factory workers.

Material and Methods

This cross-sectional study was conducted in 2016 among 270 wokers of Fasa sugar factory, Fasa, Iran. Workplace noise was measured based on ISO 9612 (14-16) by using Casella-Cel (model 450) sound level meter, low response speed and A-weighted network were applied for sound level meter at field measurements.

Among 270 people who worked in this factory, 155 people were exposed to sound levels that exceeded 85 dB. Based on the exclusion criteria, 33 people were excluded from the research, leaving us with a target sample of 122 workers.

For collecting demographic data, a questionnaire was designed to gather information about participants' age, employment history, and smoking history. The questionnaire was also intended to probe into the participants' status in terms of the exclusion criteria including the history of systemic diseases (e.g. diabetes, thyroid disorders, ear-related diseases, presence of inflammation in the middle ear, and the tear of ear-drum on otoscopic inspection), history of consumption of ototoxic drug, severe or recurrent ear infections, exposure to noise at a second/previous job/condition (being to the front line or in artillery units) or hobbies (e.g. hunting), severe head trauma, previous experience of working in a noisy environment (e.g. apart from the factory), meningitis, and previous exposure to sudden explosion of noise. All the people who worked for at least six months in the factory completed the questionnaire. At first, different stages of the study were explained to the workers and informed consent was received from them. Then, separate interviews were conducted by the participants.

Pure-tone audiometry test was performed by audiometry device (model AC 40, Interacoustics, USA). In this test, hearing threshold was measured and recorded according to air conduction in both ears at frequencies of 250, 500 , 1000, 2000, 4000 , 8,000 Hz (17, 18).

Noise-induced permanent hearing loss was calculated in each of the four main frequencies (4000, 2000, 1000, and 500 Hz) after removing the effect of age, based on the following formula:

$$NHIL = \frac{(T_{L_{500HZ}}) + (T_{L_{1000HZ}}) + (T_{L_{2000HZ}}) + (T_{L_{4000HZ}})}{4}$$

T_L: Hearing threshold in a particular frequency
NHIL: Noise-induced hearing loss (dB)

If the value of the permanent hearing loss was available, monaural impairment in each ear was determined based on the following procedure:

$$MI = (NIHL - 25) \times 1.5$$

MI: Monaural impairment

Total monaural impairment in both ear was determined based on the following equation:

$$MI_t = \frac{(MI_b \times 5) + (MI_P \times 1)}{6}$$

MI_t: Monaural impairment, total
MI_b: Monaural impairment, better
MI_p: Monaural impairment, poor

Participants' hearing status was classified into the following categories: Normal hearing (≤ 25 dB), mild hearing loss (26-40 dB), moderate hearing loss (41-60 dB), severe hearing loss (61-80 dB),very severe hearing loss (≥ 81 dB) (19).

Different parts of the factory were measured by Casella-Cell and noisy parts of the factory with the sound more or equal to 85 dB were determined. In order to study the relationship between hearing threshold, age, and work experience of the workers, studied people were classified into two age groups (less than or equal to 30 years and more than 30 years) (20). They were also categorized into two groups based on their work experience (less than 10 years and more than 10 years) (21).

Data were analyzed using SPSS software (version 22.0, IBM Corporation, Armonk, NY, USA). Independent two-sample t-test was used to compare the means of hearing threshold in the two age and work experience groups. The significance level was set at 95%.

Results

Out of 270 workers at the factory, 155 were exposed to noise exceeding 85 dB. Thirty-three of them were excluded based on the exclusion criteria, leaving us with 122 participants. Major noisy parts of the factory included boilers, steam ovens, turbines, drying, and welding. The results of these measurements showed that the lowest and the highest sound levels recorded in the factory were 87.7 and 98.7 dB, respectively.

The mean ± standard deviation for participants' age and work experience were 47.12 ± 7.74 years, and 15.65 ± 5.76 years, respectively.

In total, 84.65% of the workers had normal hearing (both of their ears had normal hearing, when the hearing threshold was less or equal to 25 dB). Furthermore, the right ear of 34% the people had normal hearing and the left ear of 24% of them had normal hearing. Additionally, 15.43% of the participants were suffering from various degrees of hearing loss. About 8.86% had mild hearing loss. Moreover, the right ear of 42.37% of the workers and the left ear of 52.63% of them had mild hearing loss. Also, 4.36% had moderate hearing loss. The right ear of 16% of the participants and the left ear of 15% of the workers had moderate hearing loss. A total of 1.65% suffered from severe hearing loss. Also, the right ear of 7.23% of the people and the left ear of 7.82% of the them had severe hearing loss. Finally, 0.74% had very severe hearing loss. Considering each ear, the right ear of 0.56% and the left ear of 0.63% of the workers had very severe hearing loss.

The results of this study showed that by increasing the age of workers, the average hearing threshold also increased meaningfully, so that 25% of people under 30 years had abnormal hearing, while 55% of workers over 30 years had abnormal hearing (P = 0.001).

On the other hand, work experience seemed to be an important factor in occupational hearing loss. Accordingly, 32% of the workers with work experience of less than 10 years had abnormal hearing status, while 66% of the workers with work experience of more than 10 years had abnormal hearing. The difference between these two groups was statistically significant (P < 0.0001, Table 1).

Table 1: The association between age and experience on hearing loss in sugar factory workers (n = 122)

Variable	Normal hearing status (≤ 25 dB, %)	Abnormal Hearing status (> 25 dB, %)
30 ≥ year	75	25
30 < year	45	55
10 ≥ years of experience	68	32
10 < years of experience	34	66

The results of the study show that at 4000 Hz, the average hearing threshold in both ears was higher than other frequencies. This was followed by the hearing thresholds at frequencies of 8000 and 2000, 500, 1000 and 250 Hz, in that order (Table 2). The differences between hearing thresholds at various frequencies were statistically significant ($P < 0.05$). In other words, noise had the strongest effect on the mentioned frequencies.

Table 2: Mean hearing threshold at various frequencies in the right and left ear in sugar factory workers (n = 122)

Frequency (Hz)	Left ear (mean ± SD)	Right ear (mean ± SD)
250	19.62 ± 5.35	18.48 ± 4.87
500	21.12 ± 5.75	19.50 ± 3.36
1000	16.37 ± 7.35	13.92 ± 8.34
2000	11.43 ± 6.38	20.84 ± 6.14
4000	22.85 ± 4.12	22.33 ± 5.22
8000	21.94 ± 5.74	20.95 ± 6.24

SD: Standard deviation

The mean ages in the smoking and non-smoking groups were 47.0 ± 7.4 years and 46.9 ± 8.2 years, respectively. Additionally, the average work experiences were 15.5 ± 5.6 years for the smoking group and 15.6 ± 5.8 for non-smokers. In general, 79.5% of smokers had normal hearing and 20.5% suffered from various degrees of hearing loss. More specifically, 13.8% of them had mild, 5.71% had moderate, and 1% had severe hearing loss.

Overall, 83.3% of non-smoking workers had normal hearing and 16.8% suffered from various degrees of hearing loss; that is, 10.9% had mild hearing loss (4% had moderate hearing loss, and 1.8% had severe hearing loss (Table 3).

Mean hearing threshold in non-smoking workers was significantly higher than that of smoking workers ($P < 0.001$). Moreover, 62.3% of the smoking workers and 59% of non-smoking workers had abnormal hearing status.

Table 3: Hearing status in sugar factory workers based on smoking status in 2016 (n = 122)

Hearing status \ Status	Smoking workers			Non-smoking workers		
	Right ear (%)	Left ear (%)	Both ears (%)	Right ear (%)	Left ear (%)	Both ears (%)
Normal hearing	31.24	40.00	79.51	45.36	8.72	83.33
Mild hearing loss	42.37	40.00	13.73	23.45	45.71	10.82
Moderate hearing loss	15.46	13.47	5.76	17.46	21.00	4.00
Severe hearing loss	9.38	4.53	1.00	13.73	18.44	1.85
Very severe hearing loss	1.55	2.00	0	0	6.13	0

Discussion

Noise-induced hearing loss is a major occupational hazard. Occupational exposure to noise threatens the health of many workers. In fact, it is the most threatening factor for the auditory system at the workplace (22).

The prevalence of hearing loss is different in various industries. This can be attributed to variations in the sound pressure level to which workers are exposed. Additionally, differences among workers' use of personal protective equipment may be influential in the hearing loss experienced by them. The majority of studies have indicated a positive relationship between sound pressure level and hearing loss (22, 23).

Hearing loss in the left ear (mild, severe, or very severe) is more and also the average hearing threshold in the left ear (21.12 ± 16.17) is greater than that of the right ear (20.00 ± 14.27). This can partly confirm some research findings and existing theories that claim the left ear is more sensitive than the right one (12, 23).

The findings of the present study also imply that hearing loss is significantly associated with age and work experience. Similar results were obtained in another study (24). Studies have shown that noise exposure for more than 10 years considerably increases the risk of NIHL (25, 26). Previous studies have also revealed that the average hearing thresholds in people aged over 30 years is more than those under 30 years (27, 28). Different studies have confirmed the relationship between noise exposure and hearing loss and have reported a relationship between hearing loss, work experience, and sound pressure levels in human and animals (29, 30).

Findings of various studies show that hearing loss begins with high frequency (or treble) noises; thus, hearing loss is more severe in the frequency of 4000 Hz than the frequencies of 1000 and 2000 Hz (31).

We found that in the frequencies of 500, 1000, and 4000 Hz, the average hearing loss in the left ear was more profound than that in the right ear. This indicates that the left ear is more sensitive than the right one (32). However, in the frequency of 2000 Hz, hearing loss is more severe in the right ear than the left one.

We also showed the average hearing threshold in both ears at 4000 Hz was higher than that in other frequencies. This was followed by the frequencies of 8000 and 2000, 500, 1000, and 250 Hz, in that order.

In recent years, several contradictory findings have been observed in studies focusing on workers and/or general population regarding the effects of smoking on hearing. Many studies have shown that smokers are at higher risk of hearing loss than non-smokers (33, 34). Although studies have reported a positive relationship between smoking and hearing loss, the joint effects of smoking and exposure to workplace noise on hearing has not been thoroughly investigated. This subject needs further investigation to confirm the relationship between smoking and hearing loss and also to obtain the type of association (i.e. multiplicative effect, etc.) between smoking and exposure to noise on hearing loss (35, 36). Studies indicate a joint effect mechanism between smoking and exposure to workplace noise on the risk of hearing loss.

We also found that smokers who work in noisy environments were more prone to noise-induced hearing loss caused by environment noise, compared to nonsmokers.

Ferrite et al. (37) and Mirmohammadi et al. (26) studied the simultaneous effect of smoking, noise, and age on hearing loss. They revealed a significant positive relationship between smoking and hearing loss, which is in line with the findings of the current study ($P < 0.0001$). In contrast, Ghotbi et al. (17) and Aghili et al. (38) did not detect any significant relationship between smoking and hearig loss.

It is therefore recommended that such individuals quit smoking. It is also suggested that smokers receive more attention in hearing protection programs. Given the abovementioned findings, the implementation of comprehensive and complete safeguards and controls for the studied society is required. Stakeholders should also take necessary measures for exposure control and workplace noise control to decrease the process of hearing loss in workers.

Conclusion

Sound pressure level exceeded the standards established by the country in various sectors of the factory. The findings also demonstrated that noise, age, and working experience significantly influence hearing loss. It is therefore necessary to take some measures to reduce noise and design hearing protection plans to control hearing loss among workers.

There were various noisy spots in the factory based on the sound pressure levels. Therefore, the following measures should be taken to prevent hearing loss among workers: (1) job rotation among workers, (2) executing hearing conservation programs practically and accurately, (3) providing regular training for workers to teach them how to use hearing conservation equipment properly and informing them about the negative effects of exposure to excessive noise and procedures to prevent it, (4) conducting periodical hearing tests among workers in order to identify the at risk individuals and study the trend of hearing loss, (5) taking noise controlling measures in departments that are exposed to excessive noise, and (6) offering rest periods to workers depending on sound pressure level to which they are exposed and the department in which they work.

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