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ORIGINAL ARTICLE

Prevalence and Pattern of Noise-induced Hearing Loss in Tile and Ceramic Industry

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ABSTRACT

Noise-induced hearing loss is considered as one of the most common occupational problems. Audiometric pattern of NIHL is different in various workplaces. This study was designed to find the prevalence and pattern of hearing loss in tile and ceramic industry. This was a cross-sectional study conducted on 853 tile and ceramic workers in Yazd, Iran. Plants were selected by simple random sampling from all tile and ceramic plants in Yazd. Hearing thresholds were recorded at 500, 1000, 2000, 3000, 4000, 6000, and 8000Hz. Hearing loss at each frequency was defined as hearing threshold higher than15 dB-HL. Data were analyzed by SPSS (ver. 20) using Student's *t*-test, chi-square test, and ANOVA. The audiometric frequency mostly affected by noise in both ears was 6000 Hz, followed by 4000 Hz and 3000 Hz. Prevalence of unilateral notch in one of the frequencies (3000, 4000, or 6000 Hz) was 18.6% and bilateral notch was observed in 3.9% of the subjects. Mean (±SD) hearing threshold at high frequencies (3000, 4000, and 6000 Hz) in right and left ears was 17.23 (±0.48) and 16.81 (±0.48) dB-HL, respectively and the difference was not significant (P>0.05). Most of the subjects suffered from slight high-frequency hearing loss. NIHL was common in tile and ceramic workers, although most workers suffer from slight and mild hearing loss. Audiometric notch was not frequent in this industry.

KEYWORDS: *Noise, NIHL, Tile industry, Audiometric notch, Hearing loss*

INTRODUCTION

Noise is considered as the most frequent physical hazard in all industries [1-2]. About 28% of the workers were exposed to high levels of noise in the European Union [3]. National Institute for Occupational Safety and Health (NIOSH) reported that in the USA, about 5.7 million workers in manufacturing industries were exposed to hazardous noise [4].

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Noise-induced hearing loss (NIHL) is considered as one of the most common occupational problems among noise-exposed workers [1, 5]. It is the second most common form of acquired hearing loss after presbycusis [6-7]. In 2002, 10 million workers in the US suffered from this disorder [8]. NIHL was responsible for more than 60% of the occupational disorders reported to the Labour Inspection Authority in Norway [9].

Continuation of exposure to noise results in a shift in hearing thresholds at 3-6 KHz frequencies and even extension of the loss to lower

frequencies which may impair the subject's normal hearing [8, 10-11], so it may affect the worker's quality of life [5, 12]. Thus, NIHL can impose a large social and economic burden on the society due to such issues as exclusion of experienced workers from production cycle and high costs of rehabilitation and compensation [6-7].

NIHL is defined as a bilateral and symmetric hearing loss sometimes accompanied by an audiogram notch at 3, 4, or 6 kHz, i.e. hearing loss at 3 to 6 kHz compared with higher and lower frequencies [10, 13-14]; NIHL may exist without an audiometric notch [15].

The main mechanism of hearing loss due to noise is the damage of sensory hair cells in organ of Corti in the cochlea of the inner ear. These hair cells may be damaged by mechanical, metabolic and vascular mechanisms as well as production of oxygen radicals [9, 12]. Hair cells in the organ of Corti rest in a frequency-sensitive manner, so some parts are more sensitive than others to the effect of noise. The most sensitive frequencies (3000–6000 Hz) to the effect of noise are placed in the base of cochlea [16-17].

Audiometric pattern of NIHL is different in various situations; usually it is bilateral and symmetrical [18]; however, some asymmetry can be observed as well, especially due to the head position during work [19]. NIHL appears in the left ear in an earlier time and is more severe than right ear [20-21]. The pattern of hearing loss may depend on the frequency spectrum of noise, shape of the ear canal and some other factors.

Tile and ceramic industry are a large industry in Yazd, a central province of Iran, with more than 5000 workers working in different parts of this industry. This study was designed to find the prevalence and pattern of hearing loss in different parts of tile and ceramic industry.

MATERIALS AND METHODS

This was a cross-sectional study conducted on 853 subjects working in different parts of six tile and ceramic plants (excluding office workers) in Yazd, Iran. All plants used a similar technology for tile production, so their noise exposure was comparable. Plants were selected by simple random sampling from all tile and ceramic plants in Yazd, Iran. Sample size was calculated using the formula for cross-sectional studies studies ($n = \frac{z_{1-\frac{\alpha}{2}}^2 . P(1-P)}{d^2}$) considering α=0.05, power of 80% and P=0.05, and limited population of tile workers and the relative number of workers in each part of the factories. In each plant, subjects were selected by simple random sampling from different parts with exposure to noise higher than 80 dBA, including mixing and grinding (n=84), ball mill (n= 101), spray drying (n=89), forming (n=78), glaze-making (n=73), glazing (n=109), printing (n=72), firing (n=78), packing and loading (n=66), technical unit (n=68), and forklift driving (n= 35).

Exclusion criteria were age more than 50 yr (to exclude age-related hearing loss), conductive hearing loss, previous history of acoustic trauma, congenital hearing loss, and ototoxic drug consumption. The use of hearing conservation devices was completely irregular in all plants, so reliable information could not be collected about this issue. Those with exposure to ototoxic substances could not be excluded from the study.

The data about exposure to noise was extracted from previous measurements by industrial hygienists. In all plants, noise was continuous without significant fluctuation. There was no significant impact or impulse noise. Time-weighted average (TWA) for an eight-hour shift was considered as the noise exposure in different parts.

Audiometry was performed for the subjects using a diagnostic audiometer (AC40, Interacoustic, Denmark, head-phone: TDH 39). The subjects were tested after at least 16 h abstinence from occupational or non-occupational noise. The tests were performed in an acoustic booth meeting ANSI 2014 criteria [20]. Hearing thresholds were recorded at 500, 1000, 2000, 3000, 4000, 6000, and 8000Hz.

Hearing loss at each frequency was defined as hearing threshold higher than15 dB-HL. NIHL was defined as each of these conditions: a notch (i.e. 10 dB or more difference between the observed frequency and its previous and next frequencies) at 3000, 4000 or 6000Hz; or a higher than 15 dB hearing threshold averaged at 3000, 4000 and 6000 Hz [22]. Because subjects were all younger than 50 yr, the effect of age on hearing is minimal [23] and the hearing loss was only attributed to noise.

Data were analyzed by SPSS (ver. 20) (Chicago, IL, USA) using Student's t-test, chi-square test, and ANOVA. Level of significance was set at P<0.05.

An informed consent was obtained from each participant. This study was approved by the Ethics Committee of Shahid Sadoughi University of Medical Sciences.

RESULTS

Totally 853 tile and ceramic workers with exposure to noise higher than 80 dBA (8h-TWA) entered the study. Most workers were males (91.9%). Table 1 shows demographic data of the subjects.

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Table 1. Demographic data of the subjects

Variable	Mean ± SD	Median	SEM	Range
Age (yr)	32.95±7.15	32	0.24	18-50
Work history (yr)	5.95± 4.62	4	0.16	1-25

Table 2 shows the mean hearing thresholds (dB-HL) at different frequencies in each ear. There was not a significant difference between right and left ears regarding the level of hearing loss.

Table 2. Descriptive statistics of hearing thresholds in different hearing frequencies of each ear*

Frequency (Hz)		Mean	SD	SEM	Median	*P*-value
500	RE	10.65	4.79	0.20	10.0	>0.05
	LE	10.46	3.65	0.15	10.0	
1000	RE	10.96	5.62	0.23	10.0	>0.05
	LE	10.85	4.62	0.19	10.0	
2000	RE	13.69	42.82	1.81	10.0	0.02
	LE	11.72	5.98	0.25	10.0	
3000	RE	15.03	10.33	0.44	10.0	>0.05
	LE	15.09	9.28	0.39	10.0	
4000	RE	17.79	13.15	0.55	12.5	>0.05
	LE	17.01	11.15	0.47	10.0	
6000	RE	18.89	13.47	0.57	15.0	>0.05
	LE	18.33	12.51	0.53	15.0	
8000	RE	16.19	13.44	0.57	10.0	>0.05
	LE	16.01	12.50	0.53	10.0	

*RE: right ear, LE: left ear; SD: standard deviation; SEM: standard error of mean; S: significant; NS: not significant

The audiometric frequency mostly affected by noise in both ears was 6000 Hz, followed by 4000 Hz and 3000 Hz. Fig. 1 shows the prevalence of abnormal thresholds at each audiometric frequency of the right and left ears.

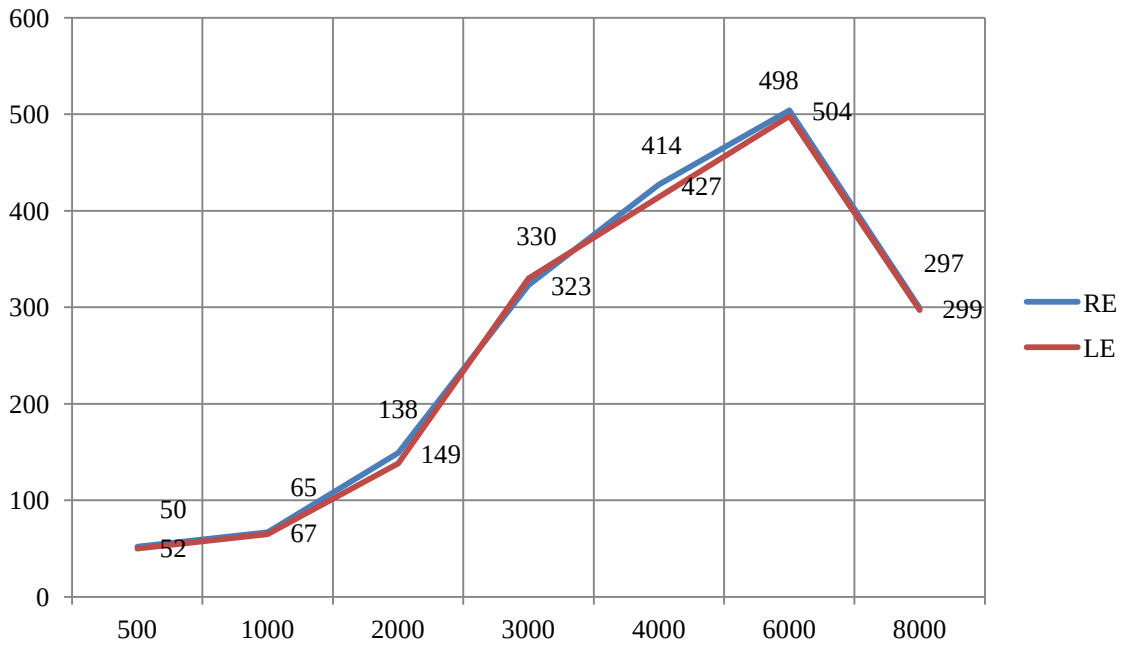

***Fig*. 1.** Prevalence of abnormal hearing threshold in each frequency of either ear

Prevalence of unilateral notch in one of the frequencies (3000, 4000, or 6000 Hz) was 18.6% and bilateral notch was observed in 3.9% of the subjects. Prevalence of notch at each hearing frequency of the ears is compared in *Fig*. 2.

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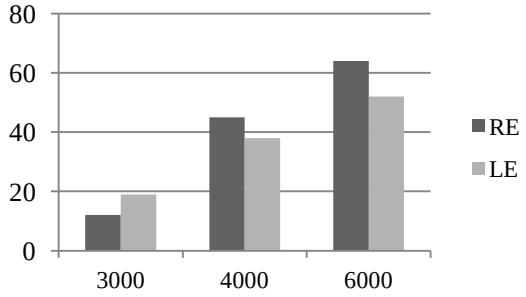

***Fig*. 2.** Frequency of hearing loss in different frequencies in each ear (Y-axis: number; X axis: audiometric frequency in Hz)

Mean (±SD) hearing threshold at high frequencies (3000, 4000, and 6000 Hz) in right and left ears was 17.23 (±0.48) and 16.81 (±0.48) dB-HL, respectively and the difference was not significant (P>0.05). Most of the subjects suffered from slight high-frequency hearing loss. Table 3 shows the prevalence of hearing loss (averaged at high frequencies) in each ear regarding the severity of the loss.

Severity	RE		LE		*P*-value
	number	percent	number	percent	
Slight	242	28.4	258	30.2	>0.05
Mild	62	7.3	64	7.5	>0.05
Moderate	24	2.8	27	3.2	>0.05
Moderately severe	22	2.6	13	1.5	>0.05
Severe	6	0.7	3	0.4	>0.05
Profound	0	0.0	0	0.0	>0.05
Total	356	41.8	365	42.8	>0.05

* RE: right ear, LE: left ear

Totally, 473 subjects (55.45%) had normal audiometry, and 149 subjects (17.40%) showed unilateral or bilateral hearing loss averaged at 3000, 4000, and 6000 Hz, and the remainder (27.15%) had slight hearing loss. Prevalence of hearing loss was significantly different in various parts of the tile industry. Hearing loss was most frequent in firing, grinding and mixing and ball-mill units.

DISCUSSION

In this study, pattern of NIHL was evaluated in tile and ceramic industry. We showed a relatively high prevalence for NIHL (more than 44%), although most cases suffered from slight and mild impairment. This prevalence was much lower than the prevalence of NIHL in miners [24] and almost similar to the prevalence of NIHL in student musicians [25] and electro production workers [26]. The difference in the prevalence can be due to different levels of noise in different workplaces and even the definition of NIHL.

In the current study, 6000 Hz was the frequency mostly affected by noise followed by 4000 and 3000 Hz consistent with the previous study [27]. Although presbycusis is the most common cause of sensorineural hearing loss, we did not consider age as a causal factor in this study, because all the participants were younger than 50 yr old and presbycusis mostly is prominent after 50 yr [23]. The prevalence of audiometric notch as a characteristic feature of NIHL was not so high in this industry, and again notch was most commonly observed at 6000 Hz, which was consistent with a study [25], and inconsistent with two other studies in which audiometric notch was mostly in 4000 Hz [26, 28]. These studies have been performed in different industries with different level of noise exposure and different noise spectrums, so this difference in the affected frequency can be expected.

Overall, 4000 Hz notch is mostly associated with continuous noise exposure and they mentioned that 6000 Hz notch might be unrelated to noise exposure [29]. Some studies have shown 6000 Hz notch in the general population not exposed to noise [15, 30], so attributing this result only to noise should be interpreted with caution.

By continuation of noise exposure, hearing loss may extend to other frequencies (lower or higher than 4000 and 6000 Hz) and the characteristic notch may eventually disappear [31]. In this study, notch at 4000 or 6000 Hz was not so common, which can partly be due to chronic exposure to high level of noise that may disappear the primary notch. In this study, unilateral notch was more common than bilateral, consistent with study on railway workers [32]. Unilateral hearing loss may appear due to asymmetric exposure to noise or head position in relation to the source of noise.

Usually, NIHL is bilateral and symmetric, although some asymmetry is not uncommon [18]. In this study, a considerable amount of workers showed unilateral hearing loss. Left ear is much more commonly affected by noise [7, 17, 33]. However, job type is very important in this issue; in this study on tile workers in which both ears were uniformly exposed to noise, we did not find any

difference between right and left ears regarding mean hearing threshold or prevalence of hearing loss, which was similar to study conducted by Ketabi et al. [34], and inconsistent with the results of some previous studies [20-21].

This study had some limitations, as we could not consider the effect of ototoxic substances, and the effect of hearing conservation.

CONCLUSION

NIHL is common in tile and ceramic workers, although most workers suffer from slight and mild hearing loss. Audiometric notch was not common in tile and ceramic workers and 6000 Hz was the frequency, which was most commonly affected.

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