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Evaluation of Noise-Induced Hearing Loss on the Workers of one of the Ahvaz Steel Companies

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Abstract

Background: Noise-Induced Hearing Loss (NIHL) is a preventable occupational health problem, which is considered among the 10 major work-related illnesses. According to the World Health Organization, repair of noise damage around the world costs four million dollars.
Objective: The aim of this study was to determine noise-induced hearing loss in a number of workers of the Kaviyan Steel Industry.
Methods: In this descriptive-analytical study being of cross-sectional type, hearing status of 34 male workers was investigated. In the present study, workers were divided to 3 occupational groups; mechanics, turner and millers, and welders, and to determine a more exact noise exposure level based on network methodology, dosimeter was done using a TES 1358 audiometer for each group. Statistical analysis was performed with the SPSS 16 statistical software using correlations, Analysis of Variance (ANOVA) and independent-samples t test.
Results: The average age and work experience of the subjects was 36.58 ± 7.48 and 11.11 ± 6.8 years, respectively. No significant relationship was observed between sound pressure level and work experience with hearing loss ($P > 0.05$), yet a significant relationship was found between the decline in hearing threshold in 3000 Hz, 4000 Hz, and 6000 Hz frequencies in the left ear and a frequency of 8000 Hz in the right ear and work experience ($P \leq 0.05$). The relationship between age and Noise-Induced Hearing Loss (NIHL) was significant ($P \leq 0.05$).
Conclusion: The results showed that even in a situations where people are imposed to lower levels of noise exposure standards, increasing working experience and age may cause hearing loss.

Keywords: Noise-Induced Hearing Loss, Noise, Age, Hearing Loss, Steel Industry

1. Background

Noise-Induced Hearing Loss (NIHL) is one of the most serious occupational issues, and is an irreversible but preventable disorder. Studies conducted in 2014, showed that 360 million people worldwide have hearing disabilities, and hearing loss was the 13th imposing factor of disease burden measured as Disability Adjusted Life Years (DALYS), with a DALYS value of about 4 million years (1-4). Recent studies show that numerous factors, including noise, age, organic solvents, heavy metals, smoking, high blood pressure and blood fat, are associated with work-related hearing loss (5-9). Age is the most common factor for hearing loss, and age-related hearing loss is known as presbycusis (10, 11). While age-related hearing loss or presbycusis is very common among older people, among all the factors affecting this type of hearing loss, noise is known as the most dangerous (12, 13), and in nearly every industry there is noise pollution (14), including iron and steel, molten metal, wood, textile, aviation, and chemical (15). The steel industry is one of the most important sources of economic development in various fields, structures and construction. A recent European Union report noted that about 28% of workers are exposed to noise levels between 85 and 90 dB (16). In steel industries a lot of noise is produced due to the type of production process and the use of equipment, including compressors, machine grinders, jets, and hammers (17-19). Human exposure to noise could lead to the creation of well-known effects, including temporary and permanent hearing loss, and physiological and psychological adverse effects, such as sleep disturbance and anxiety in the workplace. Also, in industrial environments, cardiovascular problems, sick absenteeism, tired employees, declining productivity, and increasing efficiency and risk of incidents along with a wide range of other indicators of

physical health could be related to exposure to noise (20-22). Being continually exposed to high levels of sound pressure causes damage to the hair cells of the organ of Corte external and internal, which is associated with hearing loss (23). Studies have shown that equivalent sound pressure levels continuously for more than 8 hours of exposure are two important parameters that describe the relationship between "constant noise and hearing loss" (4, 23-25). Noise-Induced Hearing Loss (NIHL) occurs along sensorineural hearing loss in high frequencies (between 3000 Hz and 6000 Hz) and the highest amount of hearing loss is usually seen around 4000 Hz (26, 27). Noise-induced hearing loss occurs often during the first 10 to 15 years of exposure and at high frequencies and will mostly start at 4000 Hz frequency, yet its rate will vary depending on the individual and environmental factors (28). Classically, it initially occurs in under frequencies and if it continues, it expands to Bam frequencies (29, 30). Age and work experience are two important factors in relation to Temporary Hearing Loss (TTS) or Permanent Hearing Loss (PTS). Research shows workers around the world, especially in developing countries, are faced with the problem of hearing loss (28). So that in Singapore, the most common work-related disease, is hearing loss due to noise exposure. Workers in Korea, Hong Kong, Singapore, and the Philippines are exposed to noise, and 12%, 15%, 40% and 74%, of workers had hearing loss of more than 30 dB, respectively (28). The National Institute for Occupational Health and Safety (NIOSH) suggested that nearly two million workers in the United States of America have developed noise-induced hearing loss (31). This inability is among the most common job-induced disabilities and imposes enormous costs on the society. For example, Sweden paid approximately 100 million dollars of its job compensation for noise-induced hearing loss, annually (32). Because developing country do not have adequate facilities for the design, implementation and operation of industrial and working processes, the problem of noise pollution is more important and an estimated 2% of Gross Domestic Product (GDP) in these countries is spent on reparations and compensation for noise-induced damage (33). However, despite extensive studies conducted in developed industrial countries on the risk of exposure to noise, the importance of this issues is neglected in developing countries (34, 35). According to studies, it has been estimated that 9 million workers are at risk of hearing loss due to occupational exposure to noise, and the situation is usually more severe in developing countries. In addition, due to non-compliance with laws and lack of attention of the need to protect individuals and collective actions, workers are exposed to high levels of noise (23, 36). Several studies have been done to assess the degree of hearing loss caused by exposure to noise generated from equipment used in the steel industry. A study by Aliabadi et al. done at one of the steel industries of Iran showed that hearing loss increased by 1.5 dB per year, in industry workers (37). In another study on the prevalence of deafness caused by work-related damage, hearing loss in workers of the steel industry was found at a rate of 33.5% (23).

2. Objective

Considering the importance of the steel industry in economy and entrepreneurship of developing countries and the results of previous studies, which suggest that exposure of workers to high levels of noise causes hearing loss, this study aimed at determining the extent of hearing loss and informing people of the risks of complications arising from their environment.

3. Methods

This analytical cross-sectional descriptive study was done during year 2016 at a number of sites and Kavian steel company, including a lathe mechanical and construction and renovation workshop. In the present study, to evaluate the process of sound production, primarily, a map of the salon and location of devices was prepared for each workshop. To compare the sound intensity with standard levels data analysis was performed by the Analysis of Variance (ANOVA), correlations, and independent samples t test. After surveys, the status of noise pollution of the Kavian steel company, sound measurements were carried out using a TES 1358 sound level meter, made in Taiwan. To ensure the accuracy of the measuring device, the device was calibrated by a TES1358 calibrator. One of the methods used to measure the sound pressure level in workshops, is the grid method. In this method, after providing a simple map of the studied area in the Kavian steel company, the workshop's area was divided proportional to the dimensions of the 5- to 10-meter raster stations. Then, the sound pressure level was measured in the center of each station using a sound meter. For detailed assessment of sound pressure level on places higher than the occupational exposure limit (85 dB), frequencies analysis was performed and were then compared with the standards of ACGIH (American conference of governmental) (38). In this study, people were divided to 3 occupational groups (n = 8 mechanics, 12 Lathe and milling, and 14 welder and cutter) and to calculate the received sound exposure level, the basic method by occupation was used. Due to the type of sound (continuous and periodic) for the welders and cutters, sound was measured during an 8-hour shift. For mechanics, turners, and millers because of the available sound (steady), a dosimeter was used for a period of 15 minutes at an exposure time

and doses were calculated for the entire period (39). After setting a dose meter on the C network, a dosimeter was used for each worker representing each job group and the results were extended to other group workers, then using equation (1), values were converted to the equivalent level of sound exposure (38).

$$D = 12.5 \times 8 \times 10^{\left(Leq - \frac{85}{10}\right)} \quad (1)$$

In this equation:
Leq: Equivalent sound level in dB
D: The dose received noise in percent

Hearing status was extracted and evaluated by hearing factors extracted from the audiogram paper of medical files by expert people in the field. For determination of hearing loss due to noise, it is necessary to remove the effects of age. Therefore, at this stage, using equation (2), age-induced hearing loss was obtained (39).

$$\text{Presbycusis Loss} = \frac{K}{1000} \times (N - 20)^2 \quad (2)$$

In this case, N is age and value of K is determined using setting frequency of device from Table 1, respectively.

4. Results

Noise pollution in Kavian steel company is due to the use of machines, such as grinders, jets and mechanical equipment. In this study, people were reviewed in different occupational groups, including 34 workers (8 mechanics, 12 Lathe-milling and 14 cutters and welders). The average, minimum and maximum age was 36.58 $\pm$ 7.48, 23, and 53 years old. Also, work experience average, minimum and maximum was 11.11 $\pm$ 6.8, 1, and 29 years, respectively (Table 2). After examining 8-hour sound exposure equivalent level and comparison with the proposed standard ACGIH (85 dB), it was found that only in welders and cutters workplace, sound pressure level was above the standard level (89.67 dB). Whereas for the mechanics, turners, and millers, the sound pressure level was 63.7 dB and 79.78 dB, which is less than the proposed standard of ACGIH (In In this study, average, minimum and maximum values of noise-induced hearing loss in the right ear, was 11.98 $\pm$ 6.51, 6.59, and 44.96 Hz, respectively and in the left ear, this was 12 $\pm$ 4.34, 6.09 and 24.96 Hz, respectively and for both ears, these values were 11.19 $\pm$ 3.85, 6.3, and 24.96 Hz, respectively. However, the results of the statistical analysis did not show a significant relationship between right and left ear hearing loss and noise levels, and between different occupational groups (P > 0.05) (Furthermore, Furthermore, there was an absence of a significant relationship between hearing loss and noise level. A significant relationship was observed between decline in hearing threshold at frequencies 3000, 4000, and 6000 Hz for the left ear and 8000 Hz for the right ear with work experience (Table 4). The results of the relationship between age and Noise-Induced Hearing Loss (NIHL), after dividing people to 2 age groups of over 35 and under 35 years old, indicated that there was a significant relationship between these variable (P $\leq$ 0.05) (Table 5). In order to evaluate the effects of severity of sound and work experience on NIHL, regression analysis was performed. Also, based on test results, there was no significant relationship between noise and NIHL and there was only a significant relationship between work experience in the left ear and NIHL (P $\leq$ 0.05) (Table 6). The regression equation of Noise-Induced Hearing Loss in the left ear ($NIHL_{LE}$) in dB with work experience (X) in year was:

$$NIHL_{LE} = 0.219X + 9.81 \quad (3)$$

Therefore, assuming that constant sound pressure level will increase with one-year work experience, NIHL will increase by as much as 0.219 dB.

Figure 1. Amount Equivalent Level of Sound Exposure (Leq) in Decibels in Different Occupational Groups

5. Discussion

This study aimed at evaluating noise-induced hearing loss in workers of one of the Khuzestan steel industries. Noise-induced hearing loss is one of the most common hearing problems in adults so that about 30% of the causes of hearing loss are within this group. Furthermore, NIHL is one of the most important occupational diseases with a large number of complaints. In addition, NIHL results in a considerable economic burden for the society (40). Many studies around the world in various industries have reported on occupational hearing loss; the European Union report (41, 42) noted that about 28% of workers are exposed to noise levels between 85 and 90 dB (16). In 1996, the National Institute of Occupational Safety and Health (NIOSH) reported that about 30 million workers are exposed to loud noise in the United States of America and this could lead to hearing loss. It has been estimated that 10 million workers experience NIHL in the United States of America (13). Being continually exposed to high levels of sound pressure,

Table 1. K Values at Different Frequencies

K	4	4.3	6	8	12	14
Frequency	500	1000	2000	3000	4000	6000

Table 2. Demographic Characteristics of the Participants

Index	Occupational Groups	Number	Mean ± SD	Min - Max
Work experience	The mechanic	8	7.88 ± 4.73	1 - 12
	Lather-miller	12	9.25 ± 3.54	3 - 14
	Welder and cutter	14	14.57 ± 8.51	5 - 29
	Total occupational groups	34	11.11 ± 6.80	1 - 29
Age	The mechanic	8	34.38 ± 9.57	23 - 48
	Lather-miller	12	36.25 ± 6.78	27 - 53
	Welder and cutter	14	38.14 ± 6.93	29 - 47
	Total occupational groups	34	36.58 ± 7.48	23 - 53

Table 3. Comparison of Results Between Noise-Induced Hearing Loss in Various Occupational Groups and Right and Left Ears

Index	Occupational Groups	Number	Mean ± SD	Min - Max	P-Value	P-Value
Hearing loss in right ear	The mechanic	8	9.51 ± 1.56	7.34 - 11.21	0.475	0.639
	Lather-miller	12	12.24 ± 4.16	6.59 - 20.48		
	Welder and cutter	14	13.06 ± 9.32	8.35 - 44.96		
	Total occupational groups	34	11.98 ± 6.51	6.59 - 44.96		
Hearing loss in left ear	The mechanic	8	11.07 ± 3.95	7.34 - 11.21	0.476	
	Lather-miller	12	11.63 ± 3.23	18.10 - 7.77		
	Welder and cutter	14	13.43 ± 5.28	8.35 - 24.96		
	Total occupational groups	34	12.24 ± 4.34	6.09 - 24.96		

Table 4. The Relationship Between the Threshold of Hearing and Work Experience

Ear	Frequency	Correlation Coefficient, r	P-Value
Left	3000	0.033	0.001
Left	4000	0.425	0.012
Left	6000	0.419	0.014
Right	8000	0.343	0.047

causes damage to the hair cells of the organ of Corte external and internal, which is associated with hearing loss (23). Numerous study results show that occupational hearing loss usually starts at frequencies above or below sounds so that hearing loss at 4000 Hz is greater than 1000 and 2000 Hz, which means that early signs of hearing loss occurs at frequencies beyond the limits of conversation (38) and in this study, the results were consistent with this principle. In this study, the mean hearing loss in the right and left ear was 11.97 and 12.24, respectively. This shows that the left ear is more sensitive than the right ear and this has also been observed in other studies (43, 44). The present study was performed on three occupational groups. Hearing loss in welders and cutters was more than other groups, which can be due to factors, such as higher sound pressure level, and the average age and work experience in studied groups, which is consistent with the study of Golmohamadi et al., Halvani et al, Tajik et al. and dehghani et al., who reported that hearing loss increased following an increase in sound pressure level, age, and work experience (28, 45-48). In this study, a significant relationship was found between hearing loss and an increase in sound pressure level ($P \leq 0.05$). It could be concluded that because noise pressure level in the work environment of welders

Table 5. The Relationship Between Noise-Induced Hearing Loss and age in the Two Different Age Groups

Relationship Between NIHL and Age	Age Groups	Number	Mean ± SD	P-Value
Right ear	More than 35 years	18	13.06 ± 8.85	0.023
	Less than 35 years	16	10.76 ± 1.26	
Left ear	More than 35 years	18	13.05 ± 5.38	0.025
	Less than 35 years	16	11.32 ± 5.63	
Total	More than 35 years	18	11.66 ± 5.15	0.017
	Less than 35 years	18	10.65 ± 1.39	

Table 6. The Relationship Between Noise-Induced Hearing Loss and Work Experience

Hearing Loss	Correlation Coefficient, r	P-Value
Right ear	0.064	0.721
Left ear	0.343	0.047
Total	0.119	0.504

and cutters was a little more than the standards, it caused a slight loss in the left ear; this is consistent with the studies of Bogre et al., Zhang et al., and Win et al.; in these studies, an increase in sound pressure level led to an increase in hearing loss (4, 23, 27). Hearing loss did not occur in other groups due to lower sound pressure level than proposed standards by ACGIH and national standards in their work environment.

5.1. Conclusion

The findings of this study showed that sound pressure level in the cutting sector was more than permissible exposure levels while in the other sites, it was less than the permissible exposure levels. According to the significant relationship between people's work experience and hearing loss and the lack of relationship between hearing loss and noise levels and lower levels of standard limit noise levels in this industry, it could be concluded that in industries where people are exposed to lower levels of standard permissible limits, increase in work experience and thus the amount of exposure will increase the incidence of hearing loss. Therefore, it is necessary to reduce the risk of NIHL for workers exposed to noise over 85 dB as well as those, who despite low sound pressure level, have work experience and have been exposed to noise for many years.

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