Archives of Occupational Health | Volume 6 | Issue 3 | July 2022 | 1265-71.

Original

Assessment of Workers' Occupational Exposure to Noise and Hearing Loss in One of the Cement Factories

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ABSTRACT

Background: Noise is one of these factors and it is considered as a concern through the world. The purpose of this study is to provide information about the rate of noise-induced hearing loss (NIHL) among workers in one of the cement. **Methods**: 283 workers were randomly selected from different production units in a cement factory. Equivalent Sound Level (Leq) was measured by using a Casella CEL-320 dosimeter and Sound Pressure Level (SPL) was measured by using a TES-1358 sound level meter (SLM) (sn: 090717269), with high accuracy. Audiometric tests were conducted by using an AVA C88 audiometer. Collected data were analyzed by using SPSS.16 software and statistical tests. **Results**: The mean Hearing threshold limit (HTLs) at frequencies (3 and 4 KHZ) in the study group is significantly higher than the control group (P <0.001). There was a significant difference between the mean HTLs in the left and right ear at all frequencies, except for the frequency of 500 HZ. At higher frequencies (3-8 KHZ), the difference between the mean HTLs in both ears is more evident and it has significantly increased, compared to lower frequencies (0.5-2 KHZ). **Conclusion:** Long-term occupational exposure to noise has the potential to cause hearing loss in cement factory workers. Therefore, it is necessary to perform effective measures, such as utilizing technical and engineering techniques and procurement and effective use of hearing protection devices in order to prevent the prevalence of hearing loss in units with high exposure risks.

Keywords: Hearing Loss; Noise ; Audiometry

Introduction

Exposure to noise is one of the most important risk factors in the workplaces, Continuous and prolonged exposure to noise with levels higher than 85 dB may lead to hearing loss. [1,2] According to the National Institute of Deafness, about 15% of Americans between the ages of 20 and 69 have high-frequency hearing loss that may be caused by noise exposure in the workplace. Occupational hearing loss is an important health problem that has economic consequences. [3] Noise pollution is a main environmental problem in the cities.[4,5] Noise exposure is harmful effect in health. [6,7]

Citation: Omidi A, Gharavandi S, Askari Majdabadi M, Golbabaei F, Besharatipur M, Khammar A. et al **Assessment of workers' occupational exposure to noise and hearing loss in one of the cement factories.** Archives of Occupational Health. 2022; 6(3): 1265-71.
Article History: Received: 31 January 2022; Revised: 22 March 2022; Accepted: 15 July 2022

[DOI: 10.18502/aoh.v6i3.10701]

Prolonged noise exposure and more than the permissible limit may lead to noise-induced hearing loss (NIHL). [8]. Although many workers may be at risk for noise-induced hearing loss in their work environment, workers in agriculture, mining, construction, manufacturing and welfare services, transportation, and the military are at greater risk. [9] Exposure to sound increases the levels of adrenaline and noradrenaline, which in turn leads to stress responses in the body. [10]

Although many workers may be exposed to noise-induced hearing loss at their workplace; however, workers in agriculture, mining, construction, manufacturing and welfare services, transportation and military sectors are at higher risks. [11] Hearing loss due to exposure to severe noises is unavoidable in many occupations; especially in industry-related occupations and in military service. It has also been reported that some people who have experienced noise-induced hearing loss suffer from balance disorders, too. [12]

Noise pollution is a serious issue in the process of cement production and it is one of the most important causes of occupational diseases in the cement industry. [13] This issue has been raised in the cement industry for many years and in these factories, production and maintenance personnel are exposed to extreme noise levels and their physical and psychological adverse effects. The results of a study showed that, raw mill unit with 109.8dB had the highest sound pressure level (SPL) and the lowest sound pressure level belonged to mixture hall, with a sound pressure level of 82.1dB. [14] Another study was conducted at a cement factory, diesel generator unit, crushing unit and grinding unit had the highest sound pressure levels. Sound pressure levels were above 85dB in 14 units. Among 29 units, 12 units had sound pressure levels above 85dB. Workers in all units suffered from some degrees of hearing loss. [15]

Loud noise may reduce labor efficiency. It can also lead to work-related accidents through disrupting the audibility of safety warnings. [16] Many studies have been done in this field. But what distinguishes the present study is the large sample size and the importance of the cement industry that many workers in this industry are exposed to high noise, which requires the attention of occupational health care providers. The aim of this study is to provide information on the rate of noise-induced hearing loss (NIHL) among cement factory workers.

Methods

Noise measurement

Sound pressure levels were measured by using a TES-1358 sound level meter (SLM) (sn: 090717269), with high accuracy and it was calibrated by using a SC-941 (sn: L0812740) calibrator. ISO 9612: 2009 method was used for measurement and sound pressure level (SPL) was calculated. [17] To do this, we firstly illustrated the plan of different units of factory.

To measure various indicators, different stations were determined -by considering places with greater probability of presence of workers. Equivalent Sound Levels (Leq) were measured for 15 workers by using a Casella CEL-320 noise dosimeter. All the measurements were performed when the noise generating equipment were active. In this factory, workers work in two 12-hour shifts

Audiometric tests were performed by an audiologist and all subjects underwent this test to determine HTLs at frequencies of 0.5, 1.2, 4.6 and 8 kHz for both ears. For this purpose, we used an AVA C88 audiometer. The audiometer was calibrated based on a standard method presented by American National Standards Institute (ANSI) S3.6-1969 Standard. [18] Audiometric test was performed 16 hours after the end of the work shift. In each frequency, the hearing test was firstly began at 70 dB and if the subject signaled that he has heard the sound, it was 10 dB reduced and this process continued until the subject did not hear the sound. At this stage, we played the sound up to four times

[DOI: 10.18502/aoh.v6i3.10701]

and if the subject signaled -at least two times- that he has heard it, then we would record it as his hearing threshold at that frequency. If he signaled that he has not heard it, we increased the intensity for 5dB. This process was repeated for each frequency and sound transmission lasted for one second.

Procedures

Following measures were performed to estimate the degree of hearing loss. First, hearing loss was estimated without using any age adjustments to measure the real status of workers' hearing which is a technique proposed by NIOSH. [2] Second, 25dB was considered as the lower limit of hearing threshold. Third, -if hearing loss in both ears is not equal- HTLs is measured in the worst ear for measuring the real extent of hearing loss. Fourth, the degree of hearing loss in each test frequency is determined 0.5-8 kHz and the pure-tone average (PTA) is determined at (PTA [0.5, 1, 2, 3 KHZ]) and (PTA [4,6 KHZ]). The degree of hearing loss in PTA (0.5, 1, 2, 3 KHZ) is determined by using a method proposed by American Academy of otolaryngology (AAO)-79 which is the most popular method for calculating hearing impairment is in order to assess the risk of NIHL. [19] Hearing loss in PTA (0.5,1, 2,3 KHZ) has been estimated, since speech perception is the most vital human hearing function. Also, hearing loss in PTA (4, 6 KHZ) has been estimated, because NIHL is more severe at higher frequencies. The extent of NIHL was assessed using the grading method of follows: Less than 25 dB (normal), 25–40 dB (slight), 41–60 dB (moderate), 61–80 dB (severe), and above 80 dB (extreme). [20]

Participants: inclusion and exclusion criteria

In this descriptive-analytical study, 283 workers of one of the cement factories in Kermanshah in a period of one year from 2020 to 2021 were randomly selected and studied. All workers in the production units who were exposed to noise were considered as a control group. The control group was consistent with the case group only in terms of no noise exposure and no other confounding variables were considered because both groups were affected by the confounding variables almost equally and therefore had no effect on the results. The study group included 190 workers in different units of a cement factory. The control group consisted of 93 personnel in administrative units who were not exposed to high levels of the noise.

Workers who have the following problems were excluded from the study; using drugs with toxic effects on auditory system (ototoxic drugs) and current and previous occupational records, high blood pressure, with a history of middle ear Disorder, thyroid disorders, diabetes, current or previous occupational exposure to chemicals. This study was approved by the Research Ethics Committee number 2017.661.

Statistical analyses

Analysis of variance (ANOVA) was used to evaluate the effect of independent variables on hearing threshold level. Student's t-test was used to investigate the relationship between variables. The statistical significance level was considered 0.05.

Ethical considerations

The results were collected and reported based on the approved ethical code of Kermanshah University of medical sciences Informed consent was prepared for all the participants as well as they were informed that inclusion and exclusion from the study were voluntary. All the information of participant's kept confidential.

Results

Hearing tests were conducted on 283 individuals. The study group included 190 workers in different units of a cement factory and the control group consisted of 93 personnel in administrative units. The mean age of participants was 35.55 ± 9.57 years. Considering that this factory has been founded 5 years ago and since all the workers under study have been employed here. since the establishment of the factory;

[DOI: 10.18502/aoh.v6i3.10701]

So they have all the same work experience that is 5 years. Workers in different parts of the factory reported 2-6 hours of exposure to high levels of noise. Although, they should have used their HPDs (hearing protection devices) during the entire work shift; however, they used them only during their exposure with high levels of noise. The highest level of Leq was measured in crusher unit and the lowest exposure occurred in raw-mill unit and the Leq is above the standard level in all units, except the raw-mill unit. The highest mean of SPL was measured in crusher unit and the lowest mean occurred in bag-filling unit and SPL were above the standard level, except the raw-mill unit and bag-filling unit (Table 1).

The mean HTLs at frequencies (3 and 4 KHZ) in the study group is significantly higher than the control group (P <0.001). However, in the frequency range of (3-8 KHZ) the mean of hearing threshold level in the study group is higher than the control group. At lower frequencies (0.5-2 KHZ) the mean HTLs is the same in both groups (Table 2).

There was a significant difference between the mean HTLs in the left and right ear at all frequencies, except for the frequency of 500 HZ. At higher frequencies (3-8 KHZ), the difference between the mean HTLs in both ears is more evident and it has significantly increased, compared to lower frequencies (0.5-2 KHZ). The highest mean HTLs in both ears was related to the frequency of 4 KHZ. The mean HTLs for both ears were in the normal range, at all frequencies; however, in the worst ear and at frequencies above 4 KHZ, it was above the normal range of 25dB. The prevalence of hearing loss at all frequencies is estimated based on the HTLs of the worst ear and results are presented in Table.3. The prevalence of hearing loss has dramatically increased from the frequency of (3 KHZ) and about 55 percent of subjects have experienced hearing loss, after frequencies of 4-8 KHZ.

Table 1. Estimated Mean (SD) of SPL, Leq, Dose (%), Exposure time

Workplace	Mean of SPL	Mean of Leq /dB (A)	Mean of Dose (%)	Exposure time
Crusher	94.5(2)	88.5	120	4
Raw material mill	81.5(3.9)	78.5	50	4
Cement mill	94(4.5)	86	63	4
Packaging machine room	81(3)	85.7	160	7
kiln	92.5(3.7)	85	50	3

Table 2. Estimated Mean of HTLs at all test frequency (n = 283) by Exposed to noise

	HTLs(dB)	frequency(HZ)						
		500	1000	2000	3000	4000	6000	8000
Mean	Exposed (Case)	19	19	19	22	24	24	23
	Non- Exposed (control)	19	19	19	19	22	23	22
	P value	0.9	0.6	0.7	0.0001	0.04	0.4	0.45

Table 3. Estimated Mean, standard deviation (SD) of HTLs, and prevalence of hearing loss at all test frequencies (n =190)

HTLs (dB)		Frequency (HZ)						
		500	1000	2000	3000	4000	6000	8000
Mean (SD)	Left ear	19.2±3.1	19.4±3.8	19.9±5.9	22.6±10	24.57±11	24.6±13	23.7
	Right ear	19±2.7	19.4±4.5	19.84±6.3	22 ±9.7	24±12.3	23.5±13.3	22.8±12.4
Mean differenc between two ear		0.18	- 0.05 *	0.06**	0.53 **	0.54**	1.05 **	0.92**
Mean (SD) Worst ear		19.4±3.4	19.7±5	20.3±7.2	23.9±11.5	26.7±13.6	26.7±15.7	25.8±15
Frequency (%) of hearing loss		7(2.6)	9(3.3)	10(3.7)	38(12.8)	58(20.6)	48(18.1)	46(16.4)

Note: * p < 0.05, ** p < 0.001.

[DOI: 10.18502/aoh.v6i3.10701]

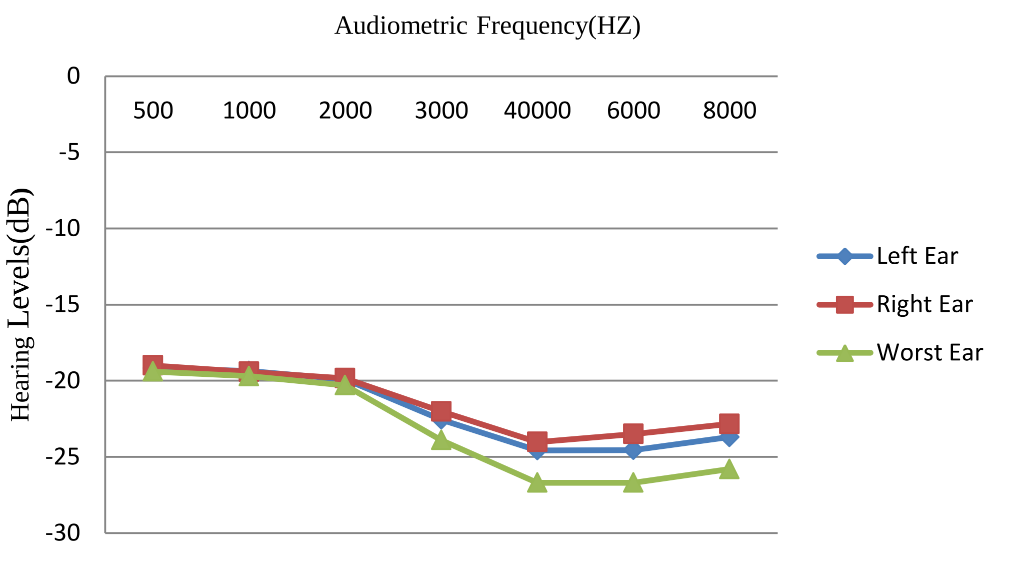

Figure 1. The Mean of HTLs at all test frequencies (n = 190)

Table 4. Estimated Distribution of hearing loss (n =190)

Extend of hearing loss	PTA (0.5 , 1 , 2 and 3) n	%	PTA (4 , 6 , 8) n	%
Normal (<25 dB)	182	95.8	128	67.4
Mild (25-40dB)	8	4.2	34	17.9
Moderate (41-60 dB)	-	-	18	9.5
Severe (61-80 dB)	-	-	8	4.2
Extreme (>80 dB)	-	-	2	1.05

The severity of hearing loss in PTA (4, 6, 8 KHZ) has increased. In PTA (4, 6, 8 KHZ) about 15 percent of subjects showed above moderate hearing loss (HTLs> 45dB) that was significantly higher than hearing loss at lower frequencies PTA (0.5-3 KHZ). In PTA (4, 6, 8 KHZ) about 18 percent had mild hearing loss (HTLs = 26-40 dB) which has significantly increased (P <0.001), compared to PTA (0.5-3 KHZ (Table 4).

by increasing the frequency the mean HTLs have increased and they have further increased after passing 3-8 KHZ frequency (Fig 1).

Discussion

The highest level of Leq was measured in crusher unit and the lowest exposure occurred in raw-mill unit and the Leq is above the standard level in all units, except the raw-mill unit. The highest mean of SPL was measured in crusher unit and the lowest mean occurred in bag-filling unit and SPL were above the standard level, except the raw-mill unit and bag-filling unit. Based on the findings of this study, workers in different parts of the factory are exposed to the risk of hearing loss. There was a significant difference between the mean HTLs of left and right ear at all frequencies. At higher frequencies (3-8 KHZ), the difference between the mean HTLs in both ears was more evident and it has significantly increased, compared to lower frequencies (0.5-2 KHZ). In both ears, the highest mean HTLs occurred at the frequency of 4 KHZ and this issue is very important in monitoring and controlling noise. The mean HTLs for both ears were in the normal range, at all frequencies; however, in the worst ear and at frequencies above 4 KHZ, it was above the normal range of 25dB. The prevalence of hearing loss has dramatically increased from the frequency of 3 KHZ. About 55 percent of subjects have experienced hearing loss, at frequencies of 4-8 KHZ. The results of a study done at a cement factory showed that 55 percent of workers suffer from hearing loss because of exposure to high sound levels and this confirms our findings (21). Other

[DOI: 10.18502/aoh.v6i3.10701]

study results showed that at frequencies 4 and 6 kHz there is a significant difference between workers in different industries, in terms of hearing threshold levels. [22] The prevalence of hearing loss in the study group was more than the control group. At frequencies (3 and 4KHZ) the mean HTLs in the study group was significantly higher than the control group (P =0.05) which confirms previous similar studies. Most of other studies have reported the Leader Frequency at the range of 3 and 4 kHz. Another study showed that at the frequency of 4KHZ, workers had the highest level of hearing threshold and they had the lowest level of hearing threshold at frequencies lower than 2KHZ which was consistent with the present study. [23] the highest level of hearing threshold in the study group was obtained at the frequencies of 4 and 6 kHz that was more than the normal level of 25 Db. [24] At higher frequencies (3-8KHZ) the hearing threshold level in the study group is higher than the control group and this implies that exposure to noise -especially at higher frequencies- causes hearing loss and it also reflects the high risk of NIHL among cement factory workers. In packaging unit, the mean HTLs at all frequencies (0.5-8KHZ) are higher than other parts of the factory and in the frequency of 4.6 KHZ; it is higher than the threshold limit of 25 dB and this indicates the importance of paying more attention to packaging unit in terms of applying technical and management controls to prevent the development of NIHL. With the exception of furnace unit, after the frequencies of 4-8KHZ, the mean HTLs are significantly higher than lower frequencies (0.5-3KHZ) and therefore proper planning to control noise in these units is recommended. Compared with other parts of the factory, crusher unit has the second rank in terms of the risk of exposure to noise and it is placed after the packaging unit. The mean HTLs in the raw-mill unit and cement-mill unit are very close; however, it is a little higher in the cement-mill unit. The duration of noise exposure in workers working in bag-filling unit is more than other units and this justifies their higher hearing threshold, compared to other units. In the furnace unit, because of large space, using sound shelter and due to less exposure time -despite the high sound pressure level- hearing threshold level is lower than other parts of the factory. Based on the results, in PTA (4, 6, 8 KHZ) about 15 percent of subjects showed above moderate hearing loss (HTLs> 45dB) that was significantly higher than hearing loss at lower frequencies PTA (0.5-3 KHZ). About 18 percent had mild hearing loss (HTLs = 26-40 dB) which has significantly increased (P <0.001), compared to PTA (0.5-3 KHZ) .One of the strengths of this study is the large sample size and its generalization to all employees exposed to noise. Attention to the employees of the cement factory, which are among the important and strategic industries in the development of the country, is also one of the strengths of the study. The limitation of the study is the lack of innovation and one-dimensionality due to the effect of sound exposure alone on hearing loss. It is suggested that while considering innovations in future studies, the issue of intervention strategies to reduce workers' noise exposure should also be studied.

Conclusion

Long-term occupational exposure to noise has the potential to cause hearing loss in cement factory workers. Therefore, it is necessary to perform effective measures, such as utilizing technical and engineering techniques and procurement and effective use of hearing protection devices in order to prevent the prevalence of hearing loss in units with high exposure risks.

Conflict of Interest

The authors declare that there are no competing or potential conflicts of interest

Acknowledgements

We announce our appreciation for the research

[DOI: 10.18502/aoh.v6i3.10701]

grant from the Kermanshah University of Medical Sciences for funding this project (No: 95450). We also thank the respected management of the cement factory for supporting this project.

Authors Contribution

The first and second authors had the main role in the design and execution of the study, and the other authors participated equally in doing the work.

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