Original Article

Access this article online

Quick Response Code:

Website: www.jehp.net

DOI: 10.4103/jehp.jehp_1452_20

An assessment of noise exposure and hearing health status among auto body workers in Kermanshah, Iran

Masoud Ghanbari Kakavandi[1], Ali Omidi[1], Amir Hossein Hashemian[1], Mehdi Jabari[1], Arsalan Hamidi[2], Ebadolah Bavandpur[1], Naser Dehghan[3]

Abstract:

BACKGROUND: Unwanted sound is recognized as the most extensive source of contaminant in the workplace. Exposure to intense, continuous, and higher than 85 dB level noise can lead to noise-induced hearing loss.The aim of the present study was to determine the level of noise exposure and its impact on hearing health among auto body workers.

MATERIALS AND METHODS: This descriptive-analytic study was conducted in 2020 to investigate the hearing health status of workers in auto body workshops. Sixty-one participants were randomly selected for audiometric testing. The equivalent sound level (Leq) of the workers was measured using a Casella CEL-320 noise dosimeter. Audiometric testing was performed using an AC40 audiometer. The mean hearing threshold levels (HTLs) of both ears were calculated for different frequencies. The results obtained were analyzed using SPSS v21.0 at a significance level of 95%.

RESULTS: The participants had an average age of 35.5 ± 11.8 years and an average work experience of 16.5 ± 9.8 years. The mean Leq was 92.3 ± 4.7 dB. The mean HTLs for the right ear and left ear were 20, 15, 17.6, 19.2 dB, respectively with the right ear suffering more loss. A significant relationship was found between hearing loss in both ears ($P < 0.001$). The highest prevalence of hearing loss in both ears was observed at a frequency of 4 kHz. About 73.8% of the subjects had a normal HTL, 23.3% had mild hearing loss, and 3.3% had severe hearing loss. With increasing work experience, HTLs also increased significantly, particularly at 2–8 kHz.

CONCLUSIONS: Chronic exposure to noise pollution threatens hearing health. Therefore, it is necessary to raise the level of awareness among workers in order to enable better hearing health protection and also to promote the use of hearing protection devices.

Keywords:

Audiometry, auto body workers, hearing threshold levels, noise, noise-induced hearing loss

[1]Research Center for Environmental Determinants of Health (RCEDH), Health Institute, Kermanshah University of Medical Sciences, Kermanshah, Iran, [2]Department of Occupational Medicine, Iran University of Medical Sciences, Tehran, Iran, [3]Occupational Medicine Research Center, Iran University of Medical Sciences, Tehran, Iran

Address for correspondence:
Dr. Ali Omidi, Research Center for Environmental Determinants of Health, Health Institute, Kermanshah University of Medical Sciences, Kermanshah, Iran.
E-mail: aomidian89@gmail.com

Received: 29-10-2020
Accepted: 09-01-2021
Published: 31-08-2021

Introduction

Noise is considered to be the most widespread pollutant in the workplace. The National Institute of Deafness reports that about 15% of Americans between the ages of 20 and 69 suffer from high-frequency hearing loss that may be caused by loud noise in the workplace.[1] Noise-induced occupational hearing loss is an important health issue which has economical ramifications.[2]

There is general agreement that exposure to sound levels higher than 85 dB for more than 8 h is potentially harmful.[3] Personality traits such as higher sensitivity along with psychological variables such as irritability of the noise can have an influence on the harmful effects of noise.[4] Physiological studies on certain species of rodents have shown that exposure to noise can lead to significant permanent physiological damage to synapses that connect the inner hair cells to the auditory nerves leading to

How to cite this article: Kakavandi MG, Omidi A, Hashemian AH, Jabari M, Hamidi A, Bavandpur E, *et al*. An assessment of noise exposure and hearing health status among auto body workers in Kermanshah, Iran. J Edu Health Promot 2021;10:290.

their inflation and eventual death.[5] Other health-related effects include high blood pressure, sleep disorders, stress, anxiety, and temporary threshold shift.[6]

A study by Lacerda *et al*. conducted on forestry workers reported NIHL among 23.8% of participants exposed to higher than 85 dB noise, with 5.5% of those exposed to 85–89.9 dB noise and 11% of those exposed to higher than 90 dB noise also experiencing NIHL.[7] Noise exposure can cause stress responses such as increased adrenaline and noradrenaline levels and can also induce changes in the cardiovascular system.[8] Biological studies have shown correlations between high-frequency hearing loss and occupational exposure. Prior studies have proven that audiometric notches at a frequency range of 3, 4, or 6 kHz accompanied by improved hearing at 8 kHz is a sign of hearing loss.[9] Since NIHL is preventable, health and safety protocols usually rely on the use of hearing protection devices (HPDs) for controlling noise exposure at the source.[10] Outside of the workplace, NIHL sufferers experience social isolation and are more likely to be depressed and anxious than those with no hearing loss.[11]

Hidden hearing refers to hearing performance loss without deterioration in hearing sensitivity. This concept is based on recent findings which show extensive noise-induced damage on the synapse ribbon between the inner hair cells and the spiral ganglion neurons (SGNs) within the cochlea without any noticeable significant permanent threshold shifts (SGNs). This is considered to be safe under the current standard.[12]

Given that small industrial workshops (<10 workers) make up a significant portion of occupations in most countries, it is important to examine the role of noise-induced health complications in these industries. Another study reported hearing loss in both ears equal to 22 ± 6.9 dB at a mean sound exposure of 98.2 ± 40.3 dB with 64% of subjects having hearing loss above 40 dB. The difference between the NIHL of the left and right ears was statistically significant. There was an association between mean NIHL for both ears and amount of work experience.[13]

The automobile industry is among those industries where workers are exposed to a significant amount of noise. Given the type of handheld tools used in auto body repairs, it is expected that the sound produced from the impact of these tools with the hard body of an automobile would create a lot of loud noise, with the potential of inducing hearing loss. Very few studies have been conducted on the exposure of auto body workers to noise. Auto body workers are exposed to impact noise and are part of "forgotten jobs;" therefore, it is necessary to pay attention to the health issues of the employees in their workshops. Measuring sound exposure with a dosimeter is one of the strengths of this study. The aim of the present study was to determine the level of noise exposure and its impact on hearing health among auto body workers.

Materials and Methods

Study design and setting

This descriptive-analytic study was conducted in 2020 to investigate the hearing health status of workers in auto body workshops. A custom questionnaire was devised to obtain underlying information, intervening factors, time patterns, and so on. It is worth mentioning that in order to eliminate interfering factors, people with long-term use of certain drugs (streptomycin and gentamicin), those suffering from diabetes mellitus, patients with underlying ear diseases, ear trauma, and prolonged exposure to certain chemical solvents such as toluene (which have an ability to affect hearing) were excluded from the study.

Study participants and sampling

A total of 61 dosimeters were used by workers working in 40 auto body workshops in different locations. Considering the results of Taheri and Kalate Arabi.[14] in which the sound level was 92.8 ± 3.4 dB, the required minimal sample size was initially calculated to be 45, at a confidence interval of 95% and an accuracy of 1 dB using the equation below.

This was increased to 61 participants for improved accuracy and reliability. It must be noted that due to the variation in the amount of noise exposure among the workers, it was not possible to take hearing tests from those participants who did not have any dosimetry test results. This means that we could not link their noise exposure results to their hearing test results.

$$n = \frac{z^2 \sigma^2}{d^2} = \frac{1.96^2 \times 3.4^2}{1^2} = 45 \quad (1)$$

Data collection tool and technique

The equivalent sound level (Leq) of each worker was measured using a Casella CEL-320 sound dosimeter in Network A and Slow Mode while the subjects were working with trunks and grinding machines. The audiometric tests of the subjects were performed inside an AC40 audiometry and acoustic chamber according to the ANCI standard method.[15] The calibration of the audiometer was performed according to the American National Standards Institute (S3.6-1969). The mean hearing threshold levels (HTLs) of the subjects were measured for both ears at 500, 1000, 2000, 4000, and 8000 Hz according to the ANCI standard.[16] Auditory tests were performed on the subjects 16 h after the end of their work shift. The test begins by playing a tone for the

subject at 70 dB in each frequency. If the subject responds to confirm they have heard the tone, the intensity of the tone would be reduced by 10 dB, and the process repeated until the subject can no longer hear the tone. At this sound level, the tone is played 4 times and if the subject is able to respond correctly at least 2 times, this sound level will be considered as his HTL. If the subject is unable to respond correctly at least three times, the sound intensity of the tone is increased by 5 dB until a correct response is given by the subject. This process is repeated for each frequency. Finally, hearing loss spread was estimated using the WHO recommendation system per the following: <25 dB (normal), 40–25 dB (mild), 60–41 dB (moderate), 80–61 dB (intense), and above 80 dB (very intense).[17]

Data analysis was performed using SPSS v21.0 (SPSS Inc., Chicago, IL) in order to determine any correlation between noise exposure and the prevalence of hearing loss based on mean HTLs at the various tested frequencies. This included a general assessment of the overall prevalence of hearing loss in both ears and the worst ear using paired T-tests. The ANOVA test was used to evaluate the relationship between the level of education, age, and the prevalence of hearing loss.

Ethical consideration

Ethical approval for this study was provided by the Ethical Committee of the Kermanshah University of Medical Sciences, on the 5th of January 2016 (code: IR. KUMS. REC.1394.462).

Results

Sixty-one employees occupied in flatbed workshops were randomly selected as the target community in order to determine noise exposure levels as well as the amount of NIHL in both ears. The mean age and the mean work experience of the subjects were 35.5 ± 11.8 and 16.5 ± 9.8 years, respectively. Of the studied population, only two subjects were already using HPDs. The mean age at which the subjects had started their employment was 19.26 ± 6.3 years, with a minimum of 11 and a maximum of 37 years. The mean and standard deviation pertaining to daily working hours, the equivalent sound level, and the received sound doses are given in Table 1.

Based on the results, the mean Leq equation was 92.3 ± 4.7 dB in the A network, with a minimum of 84 dB and a maximum of 98 dB, which was higher than the limit established by the Iranian Occupational Health and Safety Committee (ACGIH) (85 dB). The mean daily working hours for the subjects was 6.4 ± 1.44 h with a minimum of 3 and a maximum of 8 h.

Table 1: Mean, standard deviation, minimum and maximum equivalent sound level values, and daily work time of workers

Variable	Mean±SD	Minimum	Maximum
Daily work hours (h)	6.4±1.44	3	8
Leq (dB)	92.3±4.7	84	98

SD=Standard deviation, Leq=Equivalent sound level

The mean HTLs of the population under study is shown in Figure 1 and is presented according to the various frequencies. As is apparent, the mean HTLs in both ears are highest at 4000 Hz which has gradually expanded to adjacent frequencies.

The mean HTLs is worse in those who have been working longer in the body shops as shown in Figure 2. As can be seen, with the increase in employment duration, the mean HTLs have also dramatically increased, especially at the 2–8 kHz frequency range.

The mean values and standard deviations of HTLs for both ears as well as for the worst ear are presented in Table 2.[18] Based on the results, the highest amount of HTLs observed in both ears occurs at 4000 Hz and then 8000 Hz. The mean HTLs at a frequency of 500–2000 HZ were in a normal range for both ears which shows an increase in hearing loss at higher frequencies (4 and 6 kHz).

Table 3 shows the prevalence of NIHL based on the categories defined earlier in the study. As can be seen, 73.8% of subjects had normal auditory thresholds, 23.3% had mild hearing loss, and 3.3% had severe hearing loss.

Table 4 presents the mean NIHL for the worst ear based on the education level of the participants. Based on these results, there is no significant relationship between those with a primary education and those with a secondary education or higher. However, participants with primary education show higher NIHL compared to other groups. The mean and standard deviation of the NIHL in terms of age groups are presented in Table 4. The results show that with increasing age, the mean NIHL increases significantly. The mean and standard deviation of the

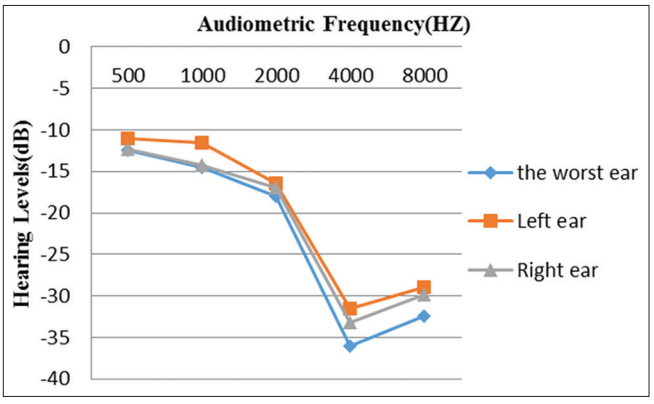

Figure 1: Mean hearing threshold at all tested frequencies

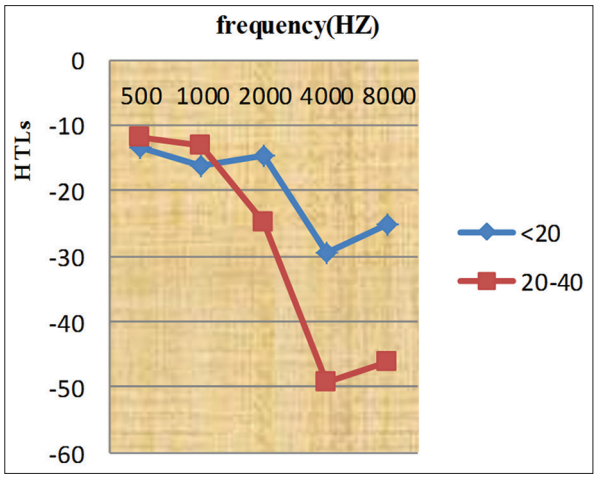

Figure 2: Mean hearing thresholds at all tested frequencies based on employment duration

NIHL in the left and right ears are presented in Table 4. Based on the results, NIHL in the left ear was higher than the right ear, and a significant correlation was found between NIHL in both ears ($R = 0.784$, $P < 0.001$).

Discussion

Sixty-one employees were randomly selected from 40 auto body workshops as the target community in order to determine noise exposure levels as well as the amount of NIHL. The mean age of the subjects was 35.5 ± 11.8 years and their mean employment duration was 16.5 ± 9.8 years. The participants' mean daily working hours was 6.4 ± 1.44 h with a minimum of 3 and a maximum of 8 h. The mean age at which the participants began their employment was 19.26 ± 6.3 years with a minimum of 11 and a maximum of 37 years. The mean Leq exposure level of the workers was 92.3 ± 4.7 dB in network A with a minimum of 84 dB and a maximum of 98 dB, which was higher than the permissible limit set by the Iranian Occupational Health Committee and ACGIH (85 dB).

Workers occupied in heavy industries, mining, construction, cement production, or the petrochemical sector are exposed to noise. For instance, the potential NIHL cases in a metal factory in Brazil were 15.9%.[19] In our industrial society, a considerable portion of the working population is exposed to the health implications and economic hardship of occupational noise pollution. This can reduce the quality of life due to disruptions in sleep, cognition, and other harmful nonauditory health effects.[20]

The mean HTLs at 4000 Hz were the highest in both ears, followed by 8000 Hz. The mean NIHL of the right ear was 17.6 dB, while this was 19.2 dB in the left ear. This shows that the left ear is more susceptible to noise exposure. A significant correlation was found between the NIHL of both ears ($P < 0.001$). The prevalence of hearing loss in the tested frequencies was estimated based on the threshold of the worst ear, according to which the incidence of hearing loss increased at higher frequencies (4 and 6 kHz).

Workers suffering from hearing loss may be occupied in jobs where reduced hearing can inhibit communication which can lead to increased health and safety risks.[21] Exposure to occupational noise and the resulting hearing loss has an undesirable effect on safety and can increase potential occupational accidents. This means that reducing occupational noise exposure can increase occupational safety. The use of hearing aid devices can also reduce occupational risk among workers with impaired hearing.[22]

Table 2: Mean, standard deviation, hearing threshold levels in both ears and the worst ear, and the prevalence of hearing loss in all tested frequencies

HTLs (dB)	Frequency (HZ), mean±SD				
	500	1000	2000	4000	8000
Left ear	12.3±10.1	12.7±10.6	17±14	32±19	28±23
Right ear	11±5.4	11.6±6.2	16±12	32±20	29±21
P	0.194	0.215	0.472	0.902	0.532
Worst ear	12±10	14±15	18±14	36±22	33±23
Frequency (%) of hearing loss*	28±45.9	39±63.9	13±21.3	3±4.9	3±4.9

*The prevalence of hearing loss based on the values of HTLs in the worst ear is estimated. SD=Standard deviation, HTL=Hearing threshold levels

Table 3: The prevalence of noise-induced hearing loss based on the severity of hearing loss

Hearing loss	*n* (%)
Normal	45 (73.8)
Partial	14 (23)
Mild	-
Severe	14 (23)

Table 4: Mean and standard deviation of noise-induced hearing loss based on the level of education, age, and ears

Education/age (years)/ears	Mean (dB)±SD	*P*
Education		
Primary	26.7±16.3	0.056
Secondary	18.3±10	
Diploma	16.5±8.5	
Age (years)		
<20	10±6.7	0.034
20-30	15±21	
30-40	26.3±7.6	
>40	23.7±12.7	
Ears		
Left	19.2±12.2	>0.001
Right ear	17.6±9.3	
Worst ears	20.15±12.26	

SD=Standard deviation

In another study conducted in a ceramic tile complex, noise exposure had an increased effect on mean hearing fluency (HTLs) at all frequencies with significant effects at 6 and 4 kHz in both ears. Furthermore, NIHL levels were significantly higher in the exposed group than in the control group.[23]

NIHL begins to occur subtly at a frequency of 4 kHz and extends overtime to adjacent frequencies. The first sign of NIHL is a V-shaped split in the V-shaped region (V-shape) and this is a general pattern for all those who have long been exposed to high levels of noise. The results presented in Figure 2 show that with increasing mean employment duration, average HTLs increase significantly, especially at 2–8 kHz.

Theodoroff *et al*. (2015) conducted a study on occupational noise in dental clinics where they showed that dentists who are regularly exposed to noise from high-speed dental handpieces had reduced hearing compared to dental students or dental professionals.[1]

NIHL continues to be an issue even in developed countries even despite the overall reduction in occupational exposure, tougher hearing protection safety standards, and extensive awareness campaigns. The bulk of the research done in recent years reinforces the fact that reduced hearing due to noise exposure is still an ongoing social health issue. NIHL is currently irreversible, and thus prevention is essential. This must include identifying workers at risk of exposure, improving regulations related to noise, and promoting the use of HPDs.[24]

The results of the present study on the prevalence of NIHL showed that 73.8% of the subjects had normal hearing threshold, 23.3% had mild hearing loss, and 3.3% had severe hearing loss in terms of severity. The results of this study were highly correlated with another study conducted on auto body workers.[13]

Based on the results of Table 4, there is no significant relationship between those with a primary education and those with a secondary education or higher. However, NIHL rates were higher among those with a primary education compared to others. Given that only 2 of the subjects being studied used hearing protection, it seems that this is related to the longer employment duration of elementary students who have entered this occupation. The results of this study suggest that hearing loss increases significantly with age.

Numerous studies have shown that exposure to higher noise intensities and exposure durations increase the severity of NIHL. These studies have also shown that the individual's sensitivity to noise is varied meaning that NIHL also varies depending on the individual. Other influencing factors include age, prior nonoccupational neurological hearing loss, smoking habits, use of ototoxic drugs, and type 2 diabetes.[25]

Hoffman *et al*. showed that among 3831 participants with full hearing threshold measurements, during 2011–2012, the prevalence of unilateral and bilateral NIHL at speech-frequencies was 14.1% which shows a meaningful reduction compared to the period between 1999 and 2004 when this prevalence was 15.9%. This suggests a reduction in speech-frequency hearing loss in the United States during the preceding two decades. For those between 60 and 69 years of age, the prevalence of speech-frequency hearing loss was 39.3%. Although age was the main risk factor, other factors such as sex, ethnicity, low education, and the constant use of firearms were also influential. Hearing loss among the elderly is common and is dependent on age and other demographic characteristics (sex, ethnicity, and education) and also exposure to noise. The prevalence of age and sex-related hearing loss is continuously dropping. Although this has certain benefits, growing and aging populations require hearing health care.[26]

Auto body shops are forgotten jobs since they are usually located in the periphery of urban cities and are also considered to be part of the service sector. These occupations are less likely to be inspected by health officials as they are not considered to be high priority. Only one such study has been conducted in Iran during the last 10 years with the present study being the second. Thus, it is necessary that the health problems of these workshops be studied so that occupational health inspectors can provide suitable programs for the monitoring of workers' health and employers can also take actions to protect the hearing health of their workforce.

The limitations of the present study include that lack of worker audiometry history, the reluctance of workers and employers to cooperate with the study due to the distance between the periodic medical examination center and their workplace, and the difficulty of workers carrying the dosimeter during their work. On the other hand, the strong points of the present study include measuring exposure using a dosimeter, conducting hearing tests according to relevant standards (use of an acoustic room), educating workers and employers regarding hearing protection after the measurements were taken, providing the results of the study to health and safety experts, and the attention paid to forgotten workshops.

Conclusion

Chronic exposure to noise pollution threatens hearing health. Various factors such as age, exposure to high

levels of noise, not using hearing protection, low levels of education, and the lack of regular or even annual health inspection have caused the workers in this profession to be subjected to hearing impairment. Therefore, in order to maintain hearing health, it is necessary to raise the level of awareness among workers in order to promote health and safety principles and the use of HPDs.

Acknowledgments

We wish to thank the Kermanshah University of Medical Sciences for their financial support. The authors also wish to thanks everyone for their valuable contributions.

Financial support and sponsorship

This article is the result of a research project approved by the research deputy of Kermanshah University of Medical Sciences (code: 95251).

Conflicts of interest

There are no conflicts of interest.

References

1. Theodoroff SM, Folmer RL. Hearing loss associated with long-term exposure to high-speed dental handpieces. Gen Dent 2015;63:71-6.
2. Lie A, Skogstad M, Johannessen HA, Tynes T, Mehlum IS, Nordby KC, *et al.* Occupational noise exposure and hearing: A systematic review. Int Arch Occup Environ Health 2016;89:351-72.
3. Jariwala HJ, Syed HS, Pandya MJ, Gajera YM. Noise Pollution and Human Health: A Review. Noise and Air Pollutions: Challenges and Opportunities. Ahmedabad, India: LD College of Engineering; 2017 Mar.
4. Abbasi M, Yazdanirad S, Habibi P, Arabi S, Fallah Madvari R, Mehri A, *et al*. Relationship among noise exposure, sensitivity, and noise annoyance with job satisfaction and job stress in a textile industry. Noise Vib Worldw 2019;50:195-201.
5. Oxenham AJ. Predicting the perceptual consequences of hidden hearing loss. Trends in Hearing 2016;20:1-6. DOI: 10.1177/2331216516686768.
6. Gyamfi CK, Amankwaa I, Owusu Sekyere F, Boateng D. Noise exposure and hearing capabilities of quarry workers in Ghana: A cross-sectional study. J Environ Public Health 2016;2016:7054276.
7. Lacerda A, Quintiliano J, Lobato D, Gonçalves C, Marques J. Hearing profile of Brazilian forestry workers' noise exposure. Int Arch Otorhinolaryngol 2015;19:22-9.
8. Stansfeld S, Clark C. Health effects of noise exposure in children. Curr Environ Health Rep 2015;2:171-8.
9. Chang TY, Liu CS, Huang KH, Chen RY, Lai JS, Bao BY. High-frequency hearing loss, occupational noise exposure and hypertension: A cross-sectional study in male workers. Environ Health 2011;10:35.
10. Leensen MC, van Duivenbooden JC, Dreschler WA. A retrospective analysis of noise-induced hearing loss in the Dutch construction industry. Int Arch Occup Environ Health 2011;84:577-90.
11. Roberts B, Seixas NS, Mukherjee B, Neitzel RL. Evaluating the risk of noise-induced hearing loss using different noise measurement criteria. Ann Work Expo Health 2018;62:295-306.
12. Song Q, Shen P, Li X, Shi L, Liu L, Wang J, *et al.* Coding deficits in hidden hearing loss induced by noise: The nature and impacts. Sci Rep 2016;6:25200.
13. Ahmadi S, Karboro AA, Einanlo M, Aubi ZH, Zarei M. Occupational noise exposure and hearing loss among car smoothers in Qazvin. Iran J Health Environ 2010;3:85-92.
14. Taheri M, Kalate Arabi H. Hearing Loss Assessment in Sabzevar Carpenters. In Proceedings of the First International Conference on HSE; 2008. p. 15-7.
15. American National Standards Institute (ANSI.S3.1- 1977). Criteria for Permissible Ambient Noise during Audiometric Testing. New York: American National Standards Institute; 1977.
16. American National Standards Institute (ANSI-S3.6-1969). Specification for Audiometers. New York: American National Standards Institute; 1969.
17. World Health Organization. Prevention of Deafness and Hearing Impairment. Thirty-Ninth World Health Assembly, EB 79.10. Annex A 14.39. Geneva, Switzerland: World Health Organization; 1986.
18. Hong O. Hearing loss among operating engineers in American construction industry. Int Arch Occup Environ Health 2005;78:565-74.
19. Azizi MH. Occupational noise-induced hearing loss. Int J Occup Environ Med 2010;1:116-23.
20. Seidman MD, Standring RT. Noise and quality of life. Int J Environ Res Public Health 2010;7:3730-8.
21. Cantley LF, Galusha D, Cullen MR, Dixon-Ernst C, Rabinowitz PM, Neitzel RL. Association between ambient noise exposure, hearing acuity, and risk of acute occupational injury. Scand J Work Environ Health 2015;41:75-83.
22. Amjad-Sardrudi H, Dormohammadi A, Golmohammadi R, Poorolajal J. Effect of noise exposure on occupational injuries: A cross-sectional study. J Res Health Sci 2012;12:101-4.
23. Mostaghaci M, Mirmohammadi SJ, Mehrparvar AH, Bahaloo M, Mollasadeghi A, Davari MH. Effect of workplace noise on hearing ability in tile and ceramic industry workers in Iran: A 2-year follow-up study. ScientificWorldJournal 2013;2013:923731.
24. Sliwinska-Kowalska M, Davis A. Noise-induced hearing loss. Noise Health 2012;14:274.
25. Hong O, Kerr MJ, Poling GL, Dhar S. Understanding and preventing noise-induced hearing loss. Dis Mon 2013;59:110-8.
26. Hoffman HJ, Dobie RA, Losonczy KG, Themann CL, Flamme GA. Declining prevalence of hearing loss in us adults aged 20 to 69 years. JAMA Otolaryngol Head Neck Surg 2017;143:274-85.