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Review Article

Noise Induced Hearing Loss in Iran: (1997-2012): Systematic Review Article

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Abstract

Noise-induced hearing loss, which is one of the 10 leading occupational diseases, is a debilitating and irreversible disease. During the recent 15-years period (1997-2012), several studies have investigated the association between noise, hearing damage and other side effects of noise in Iran. The aim of this study was to review systematically the relevant literature related to noise-induced hearing loss, lead to developing noise exposure limits. In this systematic review, two researchers independently extracted the data from 31 past studies that had considered noise-induced hearing loss (including hearing loss, temporary and permanent hearing threshold shift and auditory trauma). The data were then recorded in a modified form and Statistical analyses were performed using SPSS, version 16.0. In analyzed studies the weighted average equivalent sound pressure level [L_{Aeq}] was 90.29 dB(A) and average hearing loss was 26.44 dB(A). The Highest degree of hearing loss in the right ear was associated at 4000 Hz, and the highest degree of hearing loss in the left ear was associated to 1000 and 4000 Hz. The majority of the reviewed studies have confirmed that exposure to a noise level above 85 dB (A) can lead to an increased chance of hearing loss. Furthermore, the results of the present review indicated that as L_{Aeq} increased up to 85 dB(A), so did the severity of the hearing loss.

Keywords: Noise, Hearing loss, NIHL, Occupational exposure limits, Systematic review

Introduction

Noise is a common harmful agent in workplace (1-5). Nearly 600 million workers around the world and millions of workers in Iran are constantly exposed to occupational noise (5-7). This occupational hazardous factor has adverse effects on the functioning of various body parts such as the auditory (1-7), circulation (2), Cardiovascular (5), neuropsychiatric systems and productivity (7). According to WHO statistics, noise-related damages are estimated to reach 4 million dollars per day (7-8).

Auditory system is one of the main components of the communication (4). Auditory system impairment has always been one of the major concerns of occupational medicine and occupational health specialists. Though preventable, Noise-induced hearing loss (NIHL) is a debilitating and irreversible disease, which is one of the 10 leading

occupational diseases (1, 4-7). This disease normally occurs 10-15 years after exposure to noise and starts mainly in 4000Hz frequency (4, 7). Noise-induced hearing loss starts classically in 3, 4 and 6 kHz frequencies, and extends to the lower frequencies in the chronic exposures (7, 9, 10).

During the recent 30-year period (1980-2012), several researchers have studied the association of noise, auditory system damage and other effects of noise in Iran`s industries (1-2, 5-7, 11-30). This stream of research has investigated various Iranian occupational societies including oil, petrochemical, manufacturing, agriculture, textile, printing, stone production among others (1-2, 5-7, 11-30). Golmohammadi et al. (6) indicated that workers who were exposed to the noise 91.1 ±5.5 dB (A) that overall hearing loss determined 26.28±6.98 dB (A). They also found that the highest amount of hearing loss occurred in 4000 Hz. Bary et al. (12) showed that exposure to the noise level of 87.16 dB(A) induces to 4000 Hz and above hearing loss. Aghilinejad et al. (22) and Neghab et al. (2) showed that exposure to noise above 85 dB, leads to hearing loss and hypertension. Zare et al. (5) suggested that, at all frequencies (except 250 Hz), the hearing thresholds of individuals exposed to upper 85 dB(A) noise, was significantly hearing loss higher than that of the control group at all frequencies (except 250 Hz). Furthermore, Attarchi et al. (1) indicated that the Hearing loss in workers exposed to above 90 dB (A) noise was significantly higher than that in workers who are exposed to lower levels of noise.

"Noise Exposure limits" is one of the important issues in the assessment of relationship between noise exposure and hearing loss. Among existing standards, OSHA uses 90 dB(A) standards with 5 dB(A) rule, ISO and Euro countries use 90 dB(A) standard with 3 dB(A) rule, and ACGIH and NIOSH use 85 dB(A) standard with 3 dB(A) rule. The second version Occupational Exposure Limits (OEL) in Iran is similar to ACGIH Threshold Limit Values (TLVs) (4).

Laboratory and epidemiological studies are basics in occupational exposure limits, in order to develop the third Iranian occupational exposure limit (OEL), we decided to review various studies conducted over the past 15 years in Iran. Then, the purpose of present study was a systematic review of relevant literatures related to the noise-induced hearing loss, lead to developing noise exposure limits.

Methods

Article search

In November 2012, through a systematic review we searched for all published papers in this field, looking into such databases as ISI Web of Knowledge, Scopus, PubMed, SID, ISC, ScinceDirect and Iran Medex. Key words used included noise plus hearing loss; noise induced hearing loss, NIHL, and hearing threshold shift. In addition, the websites of occupational health related journals (including Iran occupational health, health and environment, JHOE journals and scientific medical journals) were explored. Furthermore, the libraries of major Iranian universities of medical sciences (Including Tehran, Shahid Beheshti, Hamadan, Esfahan and Shiraz) were investigated and relevant thesis and research reports were reviewed.

Inclusion and Exclusion Criteria

In this systematic review, all laboratory and epidemiological studies that had investigated the effects of noise on auditory system (including hearing loss, temporary and permanent hearing threshold shift and auditory trauma) were studied. Papers were selected using clear criteria, without prejudice.

Data extraction

Two coders independently extracted the data and recorded them in a standard form. The data that were extracted from each study included information about study selection process, study design, the studied industry, exposure levels, methods, results and qualitative aspects. For statistical analysis of studies results, we analyzed them by case number weighted for work experiences, ages, exposed noise levels and overall hearing loss and un-

weighted method for separated hearing thresholds in each ears and those frequencies. Disagreements between the two coders were resolved by discussion. Statistical analyses were performed using SPSS, version 16.0.

Results

Study selection

A total of 59 published studies and one academic thesis were reviewed. 28 studies and finally 31 papers were excluded. Most of which were cross-sectional studies were analyzed (Fig. 1). From the 31 reviewed articles, 3 were presented at the fourth congress of occupational health (Table 1) (Hamadan; 2004) and 28 papers were published in Persian and English scientific outlets.

Noise-Induced Hearing Loss (NIHL)

Two studies had not reported noise exposure and the relationship between hearing loss and noise levels i.e. they had addressed the hearing status of urban drivers and dentists (Table 2). In the third study, the qualitative results of which are provided, there was no correlation between hearing loss and noise level.

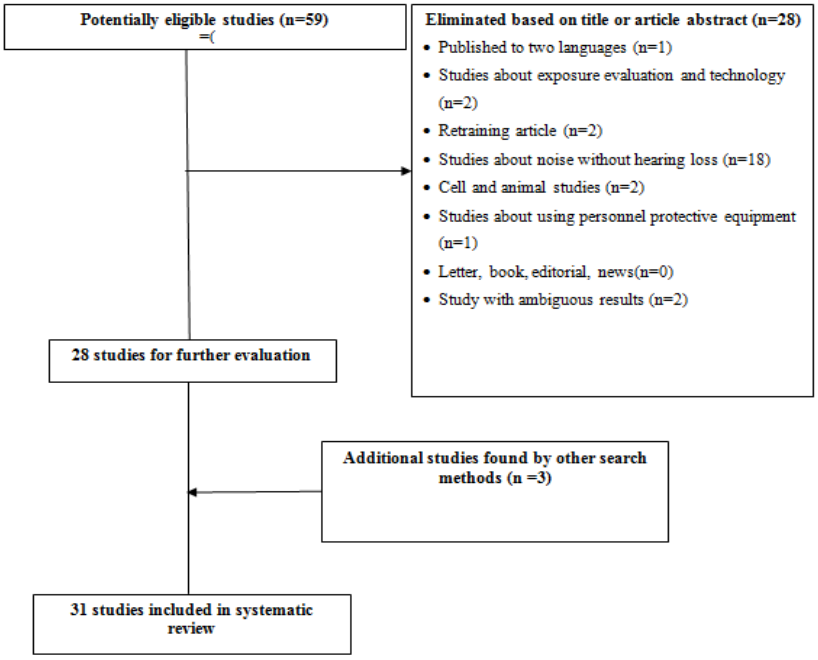

Fig. 1: The process of articles selection

Table 1: Papers presented at the Congress of Occupational Health (Hamadan -2004)

Reference	Population	Exposure source	Exposure level	Methodology	Findings
(12)	-	Cement factory	SPL_{ave}= 87.7 dB(A)	Audiometric	Hearing thresholds in high frequencies>low frequencies Right ear impairment (1.5%), left ear (0.3%)
(32)	80	Assembly work shop of automobile industry	L_{eq} for 77.5% of individuals >85 dB(A), for 22.5% of individuals <85 dB(A)	Audiometric	Right ear hearing loss: frequencies 500, 4000, 6000 Hz. left ear hearing loss: frequencies 4000, 6000 Hz.
(33)	80	Repair & maintenance section	Sound pressure level higher than 70 dB(A)	Audiometric	Overall hearing loss: 6.2%

Table 2: Studies of urban drivers and dentists hearing status

Reference	Population	Exposure source	Exposure level	Methodology	Findings
(16)	4300 drivers, Esfahan, (age>20 ears)	Vehicles and traffic	-	Audiometric	Hearing loss prevalence=18.1% Prevalence in the left ear (6.5%) and the right ear (0.3%) (P_{value}<0.0001)
(31)	60 dentists (average age=38.2 years) (21 female, 39 male)	Dentist equipment	-	Audiometric	Hearing loss in all frequencies, almost hearing loss in 8000 Hz, 4000 Hz respectively. Hearing loss in females is lower than in males

One of the reviewed studies was a project recently approved by Hamadan University of Medical Sciences focusing on Iran's tractor manufacturing industries (Table 3). In the study, 1017 subjects were divided into two groups of workers, i.e. workers who were exposed to a noise level higher vs. lower than 85 dB (A). Audiometric test was carried out for two consecutive years. The results of that study indicated that the prevalence of hearing loss was higher in workers who were exposed to noise higher than 85 dB (A). Within a year, the incidence rate in this group was higher than in the other group [SPL<85 dB (A)]. In addition, statistical analysis showed a strong statistical relationship between hearing loss and noise exposure levels.

Table 3: Research design

Reference	Population	Exposure source	Exposure level	Methodology	Findings
(34)	1017workers (age_{ave}=35.08)	Tractor factory	SPL for 670 workers <85 dB(A), SPL for 392 workers >85 dB(A)	Noise measurement-Audiometric	2008: slight hearing loss,9%- mild hearing loss, 0.9%- moderate hearing loss, 0.7% 2009: slight hearing loss, 15.4%- mild hearing loss, 1.5%- moderate hearing loss, 1.1% Significant relationship between sound pressure level and hearing loss(P_{value}<0.001)

Methodology of 3 reviewed studies was the historical cohort. In these three studies, Noise-induced hearing loss was investigated at four levels: exposed group, above the permissible level [SPL>85dB (A)], control group and less than permissible level [SPL<85 dB (A)]. Results of the study showed that the prevalence of hearing loss was higher in the exposure group compared with the control group. Moreover, there was a significant relationship between hearing loss and sound exposure level (table4).

Two reviewed articles were case-control. A study examined the effects of smoking and exposure to noise on hearing loss. The results of this study demonstrated that smoking could increase the effect of noise on the auditory system. The second paper assessed the relationship between hearing loss and noise exposure. The findings of this paper suggested a strong relationship between the level of noise exposure and noise-induced hearing loss (Table 5).

Three of the reviewed studies were cross-sectional with reference group. These studies investigated the relationship between noise exposure and hearing loss in two groups, i.e. case and reference group. Overall results indicated a strong statistical correlation between the intensity of noise exposure and hearing loss. Hearing loss was higher in the case group compared with the reference group (Table 6). Of the studies reviewed, 16 articles were cross-sectional studies that investigated hearing loss in employers that exposure to harmful noise. In most of these studies, subjects were constantly exposed to high noise levels [SPL>85 dB (A)]. The results not only confirmed the high prevalence of hearing loss in these subjects but also

demonstrated a significant relationship between the level of noise exposure and the prevalence of hearing loss. Furthermore, a significant relationship was observed between work experience and the prevalence of hearing loss (Table 7).

Table 4: Historical cohort studies

Reference	Population	Exposure source	Exposure level	Methodology	Findings
(35)	Exposure group:100 Control group:31	Agro Industry	Exposure group SPL>85 dB(A) Control group SPL<85 dB(A)	Noise measurement-Audiometric	Exposed group hearing loss=49% Control group=9.7% (P_{value}<0.001) OR=5.1($CI_{95\%}$=1.7-15.1)
(36)	Exposure group: 80 Control group:50	Esfahan group	Exposure group SPL>95 dB(A) Control group 65<SPL<95 dB(A)	Noise measurement-Audiometric	Hearing threshold difference in 2000Hz frequency and higher in the exposure and case groups (P_{value}<0.05) Exposure group Hearing damage,22.3% , control group 3.8% (P_{value}<0.05)
(2)	Exposure group: 140 Control group:140	Five noisy workshops in petrochemical industry	Exposure group SPL>85 dB(A) Control group SPL=55 dB(A)	Noise measurement-Audiometric	The prevalence of hearing loss in the Exposure group,38.5% - case group 7.8% (P_{value}<0.001)

Table 5: Case-control studies

Reference	Population	Exposure source	Exposure level	Methodology	Findings
(37)	Case group:225; Control group:253	Assembly workshops of an automobile factory	90 dB(A)	Noise measurement-Audiometric	Case group hearing loss in 1000,4000 Hz >= 30 dB(A) (P_{value}<0.001)
(38)	Case group:109; Control group:109	Tehran small-scale industries	Case group: 94 dB(A); Control group:80 dB(A)	Noise measurement-Audiometric	Case group: right ear hearing loss=49.5% ,left ear=46.8% , total=46.8% Significant relationship between noise exposure and hearing loss(P_{value}<0.001)

Table 6: Cross-sectional studies with references

Reference	Population	Exposure source	Exposure level	Methodology	Findings
(39)	Case group:156; Control group:186	Tile Industry	Case group SPL>82 dB(A); Control group SPL<82 dB(A)	Noise measurement; Audiometric	The average hearing threshold was higher for Case group than control group. In the right ear, there was significant difference in frequency 3000 Hz(P_{value}=0.02), 4000 Hz (P_{value}=0.04)
(5)	Case group: 55; Control group:55	Oil industry	case group SPL=91.8 dB(A); Control group: office staffs	Noise measurement; Audiometric	Significant difference in the hearing threshold of Case and control group, frequencies 500,1000,2000,4000,8000 Hz (P_{value}<0.001)

Table 7: Cross-sectional studies (without controls)

Reference	Population	Exposure source	Exposure level	Methodology	Findings
(40)	2004	Five noisy industries	85 dB(A)	Audiometric	The prevalence of hearing loss: 22.5%, mild hearing loss: 53.6%, moderate hearing loss: 27.3%, severe hearing loss: 14.9%, absolute deafness: 1.3%
(41)	45	Rolling workshop of a Steel Industry	75-105 dB(A)	Noise measurement; Audiometric	Permanent loss in both ears =14 dB(A), correlation between the permanent loss of the right/left ears, with work experience, respectively: 0.7099, 0.7127
(42)	70	Coppersmith	100 dB(A)	Noise measurement; Audiometric	Correlation between Hearing thresholds and work experience: experience <10 years: hearing thresholds at low frequencies16.4 dB(A) at conversation frequencies 7.9 dB(A) 10-20 years of work experience: hearing thresholds, respectively 30.7 and 14.8 dB(A) , 30-20 years of experience: hearing thresholds, respectively 40.9 and 16.7 dB(A), Experience> 40 years: hearing thresholds, respectively 42, 20.5 dB (A).
(43)	209	Cleaning plants	76-103 dB(A)	Noise measurement-Audiometric	Hearing loss had significant relationship with noise levels and work experience in both ears at different frequencies (P_{value}<0.001)
(44)	150	Mining activities	91-140	Audiometric	Relationship between hearing loss and duration of exposure (P_{value}<0.001)
(45)	2016	4 steel industry	>85 dB(A)	Noise measurement-Audiometric	The relationship between Workplace Sound level and hearing threshold shift (P_{value}<0.001) 85-90 dB: hearing threshold shift in 30.1% >90 dB: hearing threshold shift in 56.9%
(46)	441	Paint shop and the assembly of an automobile industry	85 dB(A)	Noise measurement-Audiometric	Hearing loss more than 25 dB(A) at frequencies 3, 4, 6, 8 kHz in workers exposed to noise and mixed organic solvents at levels above the exposure limit were significantly higher than that in workers who were exposed only to noise. In frequencies 0.5, 1 and 2 kHz were not significant.
(47)	809	Glass industry, milk and food industry	82-96 dB(A)	Noise measurement-Audiometric	Average hearing loss in workers who used protective equipment was 43.36 dB (A) and that in unprotected workers 44.3 dB (A) (P_{value}>0. 05). The Prevalence of hearing loss in unprotected group was 93.83% and in protected group was 92.89%
(6)	40	Barry Stone Workshop	61-100 dB(A)	Noise measurement-Audiometric	Correlation between Leq_{8h} and hearing loss for the right, left and both ears were .056, .0135, 0.73, respectively.
(48)	50	Smooth car workshops	90-104 dB(A)	Noise measurement-Audiometric	Hearing loss in both ears was 22.1 dB (A) and the correlation between left and right ear hearing loss was significant (R=0.87,P_{value}<0. 05). 64% healthy adults, 34% had minor damage, and 2% were moderately damaged.
(7)	100	Textile Industry	81.9-99.5 dB(A)	Noise measurement-Audiometric	Minimum, maximum and average overall hearing loss was 10.21 dB, 46.46 dB (A) and 21.11 dB, respectively. The Relationship between sound intensity and hearing loss was significant (P_{value}<0. 05).
(1)	310	Steel industry	>85 dB(A)	Noise measurement-Audiometric	22.3% of workers in 2008 and 41.3% in 2009 had hearing loss in both ears. The Relationship between sound intensity and hearing threshold shift was significant (P_{value}<0. 001). The Relationship between sound intensity and hearing loss in high-frequencies was significant (P_{value}<0. 001).
(23)	60	Manufacturing appliances	87-100 dB(A)	Noise measurement-Audiometric	51.7% normal, 35% with mild hearing loss, 10.4% with moderate hearing loss and 1.7% with severe hearing loss. The relationship of age and work experience with hearing loss was significant (P_{value}<0. 01).
(49)	905	Zanjan city industries	80-104 dB(A)	Noise measurement-Audiometric	<80 dB: hearing loss 6.4 dB 80-85 dB: hearing loss 13.5 dB 85-90 dB: hearing loss 17.9 dB 90-95 dB: hearing loss 26.3 dB 95-100 dB: hearing loss 31.6 dB >100 dB: hearing loss 54.9 dB
(50)	245	Car driven manufacturing workshop	98-115 dB(A)	Noise measurement-Audiometric	Minimal hearing loss: 17.45dB, maximum hearing loss: 56.67dB, the average hearing loss: 27.84 dB (A). there was 0.21dB(A) decrease in the Hearing loss with a 1 dB(A) increase in L_{eq} , the relationship Between noise exposure and hearing loss was significant (P_{value}<0. 05).
(51)	743	Steel Industry	70-101 dB(A)	Noise measurement-Audiometric	Hearing loss in people who were exposed to noise>85 dB (A) was higher than that in people exposed to noise <85 dB(A). Noise levels and hearing loss was significantly associated (P_{value}<0. 05).

After extracting the studies data, the data were analyzed using SPSS software, version 16.0; the results of the statistical analyses are presented in Table 8. According to the results, the weighted average equivalent sound pressure level in the studies was 90.29 dB (A) and overall hearing loss was 26.44 dB (A). The Highest mean un-weighted hearing loss levels in the right ear occurred at 4000 Hz, and the highest mean hearing loss in the left ear occurred at 1000 and 4000 Hz.

Table 8: Results analysis of the investigated studies

Variable	Frequency	Missing	Mean± SD
Work experience(year)	31	0	13.13±7.84*
Age(year)	22	9	37.59±12.62*
L_{eq8h}[dB(A)]	20	11	90.29±2.45*
Overall hearing loss (dB)	21	10	26.44±8.09*
Right ear hearing loss(dB)	17	14	19.36±6.85**
Left ear hearing loss(dB)	18	13	20.02±6.59**
Left ear hearing loss, frequency 500 Hz (dB)	11	20	17.12±6.21**
Left ear hearing loss, frequency 1000 Hz (dB)	11	20	25.28±4.78**
Left ear hearing loss, frequency 2000 Hz (dB)	11	20	15.37±5.30**
Left ear hearing loss, frequency 3000 Hz (dB)	6	25	19.59±5.38**
Left ear hearing loss, frequency 4000 Hz (dB)	11	20	24.38±7.84**
right ear hearing loss, frequency 500 Hz (dB)	10	21	17.15±7.60**
right ear hearing loss, frequency 1000 Hz (dB)	10	21	15.23±5.15**
right ear hearing loss, frequency 2000 Hz (dB)	10	21	14.58±3.35**
right ear hearing loss, frequency 3000 Hz (dB)	5	26	17.67±3.59**
right ear hearing loss frequency 4000 Hz (dB)	10	21	22.25±7.45**

*Weighted for case numbers in each studies

** Un-Weighted

Discussion

Noise is a common harmful agent in workplaces and noise induced hearing loss (NIHL) is the most prevalent occupational diseases (1-6, 52). In Iran, more than 2 million workers are exposed to potentially hazardous levels of noise in manufacturing and utilities (49). The purpose of this study was a systematic review of past 15 years relevant literatures related to the noise induced hearing loss, lead to developing noise exposure limits in Iran.

Some countries such as Australia, France, Germany and Japan have been determined, 85 dB (A) for noise exposure limits of 40 hours of work per week (8 hours per day) (27). In response to public concerns about this noise exposure limit [85 dB(A)]; several studies have been conducted in Iran, all of which have reported a high prevalence of hearing loss in noise levels above 85 dB(A) compared to noise levels below 85 dB(A). They also have demonstrated a highly significant relationship between noise level and work experience with hearing loss (1, 36, 39-40, 45, 49-50).

During the recent 15-years period (1997-2012), several studies have addressed different noise effects (e.g. hearing damage and association and other noise effects) (1-2, 5-7, 11-30). This stream of research has studied different Iranian industries and workers, including oil, petrochemical, manufacturing, textile, printing, stone production, municipal and agricultural vehicle drivers, and dentists, among others (1-2, 5-7, 11-30).

Golmohammadi et al. (34) investigated 1,017 workers audiometric features for two consecutive years in the tractor manufacturing industry. The results of this study showed that, within a year, the prevalence of hearing loss and also the incidence rate, was higher in the high noise exposure group [SPL>85 dB(A)], compared to control group

[SPL<85 dB(A)]. In addition, statistical analysis confirmed a strong statistical relationship between hearing loss and noise exposure levels. As the noise equivalent level rises, so do the incidence of hearing loss and severe hearing.

Jafari et al. (49) conducted a study to assess the noise exposure standard**.** In their study, 905 industrial workers were studied in the city of Zanjan. In this study, control subjects were exposed to noise level below 80 dB(A) and case group individuals were exposed to noise above 80-131 dB(A) with an average of 89.4 dB(A) in several domains (80-85, 85-90, 90-95, 95-100, and above 100 dB(A)). The results showed that hearing loss in people who were exposed to noise level below 80 dB, 80-85 dB, 85-90 dB,90-95 dB(A), 95-100 dB(A) and above 100 dB(A) were, 6.4 dB, 13.5 dB, 17.9 dB(A) ,26.3 dB, 31.6 dB(A) and 54.9 dB, respectively. The results indicated that with an increase in the noise level, the severity of hearing loss increases dramatically.

The majority of the reviewed studies have demonstrated that the exposure to noise levels higher than 85 dB (A) might lead to an increase in the likelihood of hearing loss. Moreover, in the conditions that the equivalent sound pressure level is higher than 85 dB, the severity of hearing loss will be even greater. Our results also showed that with a 5.3 dB (A) increase in the permissible noise exposure, the overall hearing loss would reach 26.4±8.1 dB (A) which is the typical hearing loss for the average work experience 13.1±7.8 years.

According to the definition of occupational noise exposure limit (The sound pressure level that causes no harmful effect during the employment of a worker who works eight-hour per day and 40 hour per week) and considering the fact that average Iranian workers have about 44 hours work per week and 30 years of experience, our results show that development the mild hearing loss occurred when noise exposed workers have an average 13.1±7.8 years of work experience. Furthermore cautious about the occupational noise exposure limits should be considered. Note that the aim of the above standards is just to prevent hearing loss and unfortunately, there is no standard for neurological - plant noise effects and annoyance that occur in low levels. On the other hand, it should also be noted that in most of the Iranian industries workplaces produce a lot of noise and their life expectancy is relatively high. This means that there exist many industries in Iran that almost all of them produce high levels of noise in their life cycle. In development of the allowable noise exposure should also note that the most industries noise control techniques have the ability to access and use this criterion.

Conclusion

For prevention of Noise-induced hearing loss needs hearing conservation programs. Noise assessment, education and hearing protection and keep the occupational exposure limits could help to reduction of hearing damages. Results showed that the exposure to noise levels higher than 85 dB (A) might lead to an increase in the hearing loss, therefore it recommended of 85 dB (A) for occupational noise exposure limit. We suggest that future research continue this line of research by, for example, conducting a comprehensive and long-term study that investigates the specific situation of each industry. Mentioned effective factors and industries situation, carried out and to clarify, the current occupational noise exposure limit should be treated with caution.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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References

1. Attarchi MS, Sadeghi Z, Dehghan F, Sohrabi MM, Mohammadi S (2010). Assessment of Hearing

Standard Threshold Shift Based on Audiometric Findings in Steel Company Workers. *Iran Red Crescent Med J,*12 (6): 644-649.
2. Neghab M, Maddahi M, Rajaeefard AR (2009). Hearing Impairment and Hypertension Associated with Long Term Occupational Exposure to Noise. *Iran Red Crescent Med J*, 11: 160-65.
3. Franks J, Stephenson MR, Merry CJ (2004). Preventing occupational hearing loss - A practical guide. New York. DHHS (NIOSH) Publication, 96-110.
4. Golmohammadi R (2010). Noise & Vibration Engineering, 5th edition; Hamadan: Daneshjoo Publication. Pp. 139-140.
5. Zare M, Nasiri P, Shahtaheri S.J, Golbabaei F, Aghamolaei T (2007). Noise Pollution and Hearing Loss in One of The Oil Industries. *Hormozgan Medical Journal*, 11(2): 121-126.
6. Golmohammadi R, Ziad M, Atari SG (2006). Assessment of Noise Pollution and Its Effects on Stone Cut Industry Workers of Malayer District. *Iran Occupational Health*, 3 (1): 23-27.
7. Halvani GhH, Zare M, Barkhordari A (2009). Noise Induced Hearing Loss Among Textile Workers of Taban Factories in Yazd. *Journal of Birjand University of Medical Sciences*, 15 (4): 69-74.
8. Motalebi Kashani M, Hanani M (2003). The effect of training of work correct procedure on the rate workers exposure with noise at Macaroni manufacture in Kashan. The first national symposium of noise, health and development. Mashhad-Iran.
9. Aghili Nejad M, Farshad AA, Mostafai M, Ghafari M (2000). *Occupational medicine.* 1st ed. Tehran: Arjmand Publication. pp 129-156.
10. McBride DI, Williams S (2001). Audiometric Notch as a Signal of Noise Induced Hearing Loss. *Occup Environ Med*, 58: 46-51.
11. Geshani A, Sedaie M, Nassiri P, Jalaie Sh (2005). Noise Measurement and Frequency Analysis of Commercially Available Noisy Toys. *Audiology,* 14 (1): 6-11.
12. Sadegh Bari O, GHolamnia R, Rasoolzadeh Y, Mohebbi I, Mohammadi N (2004). Evaluation of Workers Occupational Noise Exposure and Hearing Loss, Fourth congress of occupational health, Hamadan-Iran.
13. Regha M, Amiri Davan M, Abtahi SHR, Sonbolestan Sm, Abtahi S.M (2007). Development High Frequency Audiometery: Early Diagnosis for Noise Induced Hearing Loss. *Journal of Esfahan Medical Faculty*, 25 (84): 16-22.
14. Sarkaki A, Heidari A, Shahraki M (2000). Effect of Noise Stress on Threshold of Rat Fetal Pain. *Journal of Kerman University of Medical Sciences,* 7 (2): 53-59.
15. Mirzaei R, Allame AA, Mortazavi SB, Khavanin A, Kazemnejad A, Akbari M, Kamalian N (2004). Effects of High and Low Frequency on Hearing Loss and Blood and Liver Oxidative Stress System of Rabbits. *Shahed University Scientific Research Journal*, 12 (53): 37-42.
16. Janghorbani M, Sheikhi A, Pourabdian S (2009). The Prevalence and Correlates of Hearing Loss in Drivers in Isfahan, Iran. *Arch Iran Med*, 12 (2) :128-134.
17. Sabahi A.R, Moradi I (2002). The Effects of Noise Exposure on Rat's Hematologic Parameters and Red Cell Indices. *Iran J Med Sci*, 2 (27): 85-86.
18. Naderzadeh M, Monazzam M.R, Nassiri P, Momen Bellah Fard S (2011). Application of Perforated Sheets to Improve the Efficiency of Reactive Profiled Noise Barriers. *Applied Acoustics*, 72: 393–398.
19. Hassan-Beygi SR, Ghobadian B, Kianmehr MH, Amiri Ghayjan R (2007). Prediction of a Power Tiller Sound Pressure Levels in Octave Frequency Bands Using Artificial Neural Networks. *Int J Agri Biol,* 3 (9): 494-496.
20. Mojarad F, Massum T, Samavat H (2009). Noise Levels in Dental Offices and Laboratories in Hamedan, Iran. *Journal of Density Tehran University of Medical Sciences*, 4 (6): 181-186.
21. Behroozi Lar M, Khodarahm Pour Z, Payandeh M, Bagheri J (2011). Noise Level of Two Types of Tractor and Health Effect on Drivers. *J Am Sci*, 7 (5): 382-38.
22. Aghilinejad M, Ghiasvand M, Haji-Miresmaeil SJ (2008). Noise Exposure and Risk of Hypertension: a Cross-Sectional Study. *Medical Journal of the Islamic Republic of Iran*, 22 (3): 141-144.
23. Safavi naeini SA, Fatholomi MR, Fattahi Bafghi A (2005). Evaluation of Workers Hearing Status in High Noise Workshops of Tehran Azmayesh Factory. *Shahid Beheshti University of Medical Sciences, Journal of Medical Faculty*, 29 (3): 239-243.
24. Golmohammadi R, Olieaei M, Samavat H, Motamedzadeh M (2008). Design and Build of Impedance Pipe to Determine the Materials noise Absorption Coefficient used in Noise

Control. *Journal of Hamadan University of Medical Sciences*, 15 (1): 55-61.
25. Monsefi M, Bahoddini A, Nazemi S, Dehghani G.A (2006). Effects of Noise Exposure on the Volume of Adrenal Gland and Serum Levels of Cortisol in Rat. *Iran J Med Sci,* 31 (1): 5-8.
26. Nassiri P, Azkhosh M, Mahmoodi A, Alimohammadi I, Zeraati H, Jafari Shalkouhi P, Bahrami P (2011). Assessment of Noise Induced Psychological Stresses on Printery Workers. *Int J Environ Sci Tech*, 8 (1): 169-176.
27. Monazzam MR, Golmohammadi R, Nourollahi M, Momen Bellah Fard S (2011). Assessment and Control Design for Steam Vent Noise in an Oil Refinery. *J Res Health Sci,* 11 (1): 14-19.
28. Golmohammadi R, Atari SQ, Arefian S, Golchobian R (2008). A Rapid Method for Estimating of Noise Exposure in Work-places. *J Res Health Sci*, 8 (2): 21-27.
29. Omidvari M, Mesgraf H, Rafiei Z (2003). Survey of Noise Pollution at Open Stone Mining of Hersin Area, Kermanshah. Proceedings of the fifth conference on mining safety, health and environment, Iran.
30. Jahangiri M, Adl J (2003). Survey of Human Errors Caused by Noise Interference in the Communication at Izomax Unit of Tehran Refinery. First National Conference of Noise, Health, Development. Mashhad-Iran.
31. Fazli m, Nassiri P, Hassani Z (2009). Effects of Workplace Noise on Zanjan Dentists Hearing Power. *Scientific- Research Journal of Zanjan University of Medical Sciences*, 17 (68): 65-74.
32. Roshani Z, Zkerian A (2004). Survey of hearing loss at assembly workers of Megamotor factory. Fourth congress of occupational health, Hamadan-Iran.
33. Rasoolzadeh Y, Gholamnia R, Koohi F, Jahanian S (2004). Survey of NIHL and hearing impairment at employees of a manufacturing company. Fourth congress of occupational health, Hamadan-Iran.
34. Golmohammadi R, Amjad H, Dormohammadi A, Musavi S (2012). Study of Occupational Noise Induced Hearing Loss in a Tractor Manufacturing Plant. *Occup Med Quarterly J*, 4 (2): 28-33.
35. Keshtkar AA, Kabir MJ, Asghari Sh, et al (2005). The Relationship between Hearing Loss and Noise Exposure Among Cultivated Plants Workers. *Iran J Epidemiol,* 1 (2): 59-64.
36. Abedi K, Zare M, Rahimi nejad M, et al. (2009). Hearing Loss among Isfahan Shahid Beheshti Airport. *Scientific Journal of Gorgan University of Medical Sciences,* 11 (4): 57-63.
37. Labbafinejad Y, Attarchi MS, Mohammadi S (2000). Effect of Smoking and High Noise Exposure on Hearing. *Journal of Azad University of Medical Sciences*, 20 (2): 113-117.
38. Aghilinejad M, Alimohammadi I, Mohammadi S, Fallahi M (2007). Assessment of the Effect of Occupational Noise on Workers Hearing in Small Scale Industries in Tehran. *Journal of Army University of Medical Sciences,* 5 (3): 1305-1311.
39. Mirmohammadi S, Baba haji meibodi F, Noorani F (2008). Assessment of Hearing Threshold at Meibod Tile Workers. *Journal of Yazd University of Medical Sciences*, 16 (1): 8-13.
40. Mahram M, Soghli A, Niknam M, et al. (2004). Survey of Hearing Loss at Workers of Highly Noised Industrial Units, Zanjan. *Journal of Zanjan University of Medical Sciences*, 49: 44-49.
41. Golmohammadi R, Zamanparvar A, Khalili SA (2001). Relationship Between Noise and Hearing Loss Among Rolling Workshop of Steel Industry, 8 (1): 35-38.
42. Arghami Sh (1997). Assessment of Cooper Smith Hearing Loss, Zanjan City. *Journal of Zanjan University of Medical Sciences*, 20: 18-22.
43. Ghorbani Shahna F (2006). Noise Induced Hearing Loss and its Relationship With Dose and Exposure Length. *Journal of Qazvin University of Medical Sciences*, 10 (1) :84-88.
44. Shahraki S, Mohammad alizadeh S, Hosein rezaei H (2005). Hearing Reduction at Workers of Kerman Coal Washing Plant and Coal Mines. *Medical Journal of Hormozgan University of Medical Sciences,* 9 (4): 271-278.
45. Poorabdian S, Ghotbi M, Yousefi HA, Habibi E, Zare M (2009). The Epidemiologic Study on Hearing Standard Threshold Shift Using Audiometric Data and Noise Level Among Workers of Isfahan Metal Industry. *Journal of Semnan University of Medical Sciences*, 10 (4): 31-38.
46. Mohammadi S, Labbafinejad Y, Attarchi M (2010). Combined Effects of Ototoxic Solvents and Noise on Hearing in Automobile Plant Workers in Iran, *Arch Indust Hyg Toxicol*, 61 (3): 267-274.
47. Emami F (2003). Evaluation of Influencing Factors on Hearing Protection Workers of Hamadan Large Industries. *Journal of Hamadan University of Medical Sciences*, 10 (4): 55-58.

48. Ahmadi S, Karbord AA, Inanloo M, Ayubi zadeh H, Zarei M (2010). Occupational Noise Exposure and Hearing Loss Among Car Smoothers in Qazvin. Iran. *J Health & Environ*, 3 (4): 85-91.
49. Jafari MJ, Karimi A, Haghshenas M (2010). Extrapolation of Experimental Field Study to a National Occupational Noise Exposure Standard. *Int J Occup Hyg*, 2 (2): 63-68.
50. Ketabi D, Barkhordari A (2010). Noise Induced Hearing Loss Among Workers of an Iranian Axial Parts Factory. *Int J Occup Hyg*, 2 (2): 69-73.
51. Tajic R, Ghadami A, Ghamari F (2008). The effects of Noise Pollution and Hearing of metal Workers in Arak. *Tabib Shargh*, 10 (4): 291-299.
52. WHO (1997). *Prevention of Noise Induced Hearing Loss*. Report of World Health Organization. Geneva.