

Hearing impairment due to cigarette smoking and simultaneous exposure to occupational noise

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Abstract

Background: Noise is the most common hazard in the workplace and noise induced hearing loss considered to be the most common occupational disease as well. Cigarette smoking, in some studies, has been known to induce hearing loss. The purpose of this study was to evaluate the effect of contemporary exposure to occupational noise and cigarette smoking on hearing.

Methods: 478 assembly workers of an automobile plant which were exposed to the noise more than TLV (threshold limit value) level included in this study. After considering the exclusion criteria, all participants according to the smoking status were divided in smoker and nonsmoker groups and compared for hearing impairment. Hearing impairment in this study was assessed with the offered method of American Academy of Otolaryngology (AAO).

Results: Of 478 assembly workers, 225 persons were smokers and others non smokers. Prevalence of hearing impairment in smokers was significantly higher ($p < 0.001$). Hearing impairment had a significant relation with smoking status even after adjusting for cofounders like age and duration of work (OR=8.23, 95% CI=3.63-18.66).

Conclusion: The results of this study suggested that cigarette smokers had more hearing impairment than non smokers. According to these results we concluded that in working environments, especially in noisy ones, workers must be encouraged to quit smoking and regular audiometric tests, especially for smokers, must be applied. We must consider not only the noise, but indeed all effective elements of hearing impairment in working environment that could compromise the hearing.

Keywords: hearing impairment, cigarette smoking, noise.

Introduction

Noise has been known as one of the most common occupational hazards [1-4] and many studies show that more than six hundred million workers throughout the world are subjected to

the occupational noise [5] in which nine million of them are American [6].

Noise induced hearing loss is one of the oldest and principal of occupational diseases, caused by long time exposure to occupational noise greater than 85 dB A [7,8]. This is not only

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predictable but also rigorously disabling and unrelapsing disease [1]. According to the related studies, in England, 153/000 men and 26/000 women are exposed to occupational noise that could lead to severe hearing loss [7,9].

The other noteworthy point of these assessments is that almost 1.3 billion people throughout the world are smokers. In recent years there are many objectives showing harmful effects of smoking on hearing in not only working but also general population [12-22], however in one study smoking was described to have a protective effect [1,23] and in some studies no association between smoking and hearing loss was found [2,9,17-19,22,24-26]. Smoking causes hypoxic damage to hair cells and hearing loss via different ischemic mechanisms including increased blood viscosity and reduced available oxygen and consequently decreased cochlear blood supply [1,10,11,15,17,27-36]. Inner ear cochlear basal cells which are responsible for higher frequencies are located at the end of arteries and are highly sensitive to changes of blood supply and so easily damaged due to ischemic mechanisms [1,2,33]. Experimental studies have shown direct ototoxic effects of nicotine on hair cell function via nicotinic like receptors on hair cells [2,37]. Ototoxic agents in the smoke of cigarette (toluene, lead, mercury and carbon monoxide), although in low concentration, can interfere with noise or age and intensify hearing loss [1,38-41]. Carbon monoxide in the cigarette smoke can amplify the ototoxic effects of chemicals via increasing accessibility of these agents to the cochlear region due to increasing blood supply and vascular permeability [1,30]. Some studies have shown that noise and smoking cause hearing loss via a common pathway namely decreased cochlear blood supply [1]. On the basis of the study of Mizoue et al, factory workers in comparison with office workers are exposed to higher risk of hearing loss due to higher rate of smoking and exposure to noise [2].

Hearing loss compensation can be determined with assessing hearing loss rate and its associated impairment. According to the US statistics in 1999 and 2000, 6745 individuals requested hearing loss compensation which exceeded 39,907,386 USD in which 8,982,139 of them were for medical charges [42]. One of the hearing loss consequences is disturbing social communications that can be nearly determined with calculation of hearing loss impairment. There are not any similar studies assessing hearing impairment caused by smoking and noise exposure. In this study, smoking and contemporary noise exposure effects on hearing impairment of assembly workers was assessed in an automobile plant.

Methods

A descriptive-analytic study was designed to evaluate the effect of smoking and simultaneous exposure to noise on hearing capability in a large Iranian automobile manufacturing company in Tehran in 2008. All the male employees of the assembly department with at least one accomplished audiometry were entered the study via census method. The exclusion criteria included: history for systemic diseases like diabetes mellitus and thyroid dysfunction, ototoxic drug use, severe or frequent ear infections, severe head trauma, exposure to noise in second or previous jobs and hobbies (such as active military services, hunting or listening to amplified music). Unilateral or conductive hearing loss in pure tone audiometry (PTA) was also purposed as exclusion criteria. Samples were stratified into smokers and controls (nonsmokers).

Demographic data, medical and occupational history like age and working history, smoking habits and exclusion criteria were gathered through interview recorded in a designed questionnaire. All workers participated voluntarily in this study and an informed consent was given to each individual.

521 employees were engaged in assembly

Table 1. Comparison of mean age, work history and binaural hearing impairment between smokers and non smokers.

Variable	Smoker (225 persons)		Nonsmoker (253 persons)		P value
	Mean	SD	Mean	SD	
Age (year)	34.50	4.47	35.27	6.78	0.137
Work history (year)	8.50	3.63	8.17	3.69	0.322
Hearing impairment (percent)	2.39	4.43	0.5	3.79	<0.001

department but after considering the including and excluding criteria, 225 smokers and 253 controls (nonsmoker employees) were entered to the study.

In order to evaluate the sound pressure level in assembly section, a team of occupational hygienists monitored the noise via a CEL-440 sound level meter. The results of this monitoring, indicated the sound level was between 87 and 94 dB A and every body were exposed to impermissible level of noise for 8 hours in a working day shift.

Hearing threshold was measured by an audiologist applying an acoustic chamber meeting the ANSI S3.1-1991 standards with a standard audiometer, model AD 229b, inter acoustic Denmark Co. Ltd, at 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz for air and bone conduction assuring of noise avoidance not less than 14 h. Results were gathered in a specific questionnaire.

Hearing impairment was determined through a common method recommended by American Academy of Otolaryngology (AAO) [43] which is supported by American Medical Association [44]. Based on this method the binaural hearing impairment was determined as follows:

- 1- The average hearing threshold level for each

- ear was calculated at 500, 1000, 2000 and 3000 Hz.
- 2- The percentage of the impairment for each ear was calculated by multiplying the amount by which the above average exceeding 25 by 1.5.
- 3- The hearing handicap (binaural assessment) was then calculated by multiplying the smaller percentage (better ear) by 5, adding this figure to the larger percentage (poorer ear), and dividing the total by 6.

Percentage of unilateral impairment = (Average dB at 500, 1000, 2000, 3000Hz) - 25 dB (low fence) × 1.5%

Percentage of bilateral impairment = (Percentage of unilateral impairment in better ear × 5) + (Percentage of unilateral impairment in poorer ear) ÷ 6

In this study t-test were used for quantitative comparison and chi square analysis for qualitative variables. Logistic regression analysis was performed to adjust the effect of confounders and precisely evaluating the relation between smoking and hearing impairment. All of the calculations were statistically analyzed using the Statistical Package for Social Sciences (SPSS) software ver. 15.

Results

Based on inclusion and exclusion criteria, 478 employees of assembly department in an

Table 2. Binaural hearing impairment between smokers and nonsmokers.

Variable	Smoker (225 persons)		Nonsmoker (253 persons)		OR	CI	P value
	No.	percent	No.	percent			
Without hearing impairment	156	69.33	242	95.65	9.73	4.99-18.96	<0.001
With hearing impairment	69	30.67	11	4.35			

P<0.001 by chi square test

Table 3. Relationship among BHI and age, duration of exposure to noise and cigarette smoking by logistic regression analysis.

Variable	β	Standard error	P value	Odds ratio (95% CI)
Constant coefficient	- 5.615	0.610	<0.001	—
Age (year)				
≤33 (n=237)				1.00
>33 (n=241)	2.524	0.55	<0.001	12.47 (4.24-36.70)
Duration of exposure (year)				
≤7 (n=253)				1.00
>7 (n=225)	1.133	0.353	0.001	3.10 (1.55-6.20)
Smoking (pack-year)				
Non-smoker(n=253)				1.00
≤8 (n=115)	2.109	0.417	<0.001	8.23 (3.63-18.66)
>8 (n=110)	2.157	0.389	<0.001	8.64 (4.03-18.53)

automobile industry were entered in this study. All subjects were male with mean age of 34.91 years (SD=5.82) and minimum of 23 years and maximum of 55 years. The mean for working history was 8.33 years (SD=3.66) which ranged between 1 to 25 years. 225 persons (%47.1) were smoker and 253 persons (%52.9) did not smoke anywhere. The binaural hearing impairment was calculated for all and the results were between %0 to %45 with mean of %1.39 (SD= %4.2). Mean of age, working history and binaural hearing impairment were compared using t-test between two groups of smokers and non smokers which are presented in Table 1. There was no significant difference between two groups of smokers and non smokers at the view of mean age and working history, but smokers had a statistically significant higher hearing impairment ($p<0.001$).

In the next session, we divided the sample size into two groups based on hearing impairment. The first group had no impairment but the second had some extent. Relationship between binaural hearing impairment with smoking was surveyed via chi square analysis shown in Table 2. This table addresses smokers with significantly higher hearing impairment ($p<0.001$).

Finally, for precisely surveying the relation

between smoking and hearing impairment and adjustment of confounding variables such as age and working history, we used logistic regression analysis which results are seen in table 3. In this study we grouped the variables, hence workers were divided into two age groups (≤ 33 years and >33 years), working history or noise exposure history into two groups (≤ 7 years and >7 years) and their cigarette smoking habit was calculated based on the number of pack per year, and then these were divided into three groups (non smokers, ≤ 8 and >8 pack years). Table 3 showed that smokers had more hearing impairment even after adjustment of age and working history and the impairment was statistically significant ($p<0.001$). Although there were no significant odds ratio between two groups of less and more than 8 pack year. Age and working history had also a significant relation with hearing impairment.

Discussion

According to the results, cigarette smokers have more hearing impairment than nonsmokers and it was statistically significant even after adjustment for age and duration of work ($p<0.001$). All employees had noise exposure but exposure to other ototoxic materials includ-

ing ototoxic drugs and solvents were ruled out. the noise with higher has greater impact and therefore hearing impairment due to smoking and noise exposure in this study were surveyed in lower frequencies as well. Other studies predominantly focused on the effects of smoking on higher frequencies and there are too little studies about the lower one.

There are little surveys about the effects of contemporary exposure to noise and smoking on hearing loss. Whereas in some studies including Framingham, after audiometric evaluations, there was no relationship between hearing status and smoking or number of cigarettes smoked [9,19,22], in other studies cigarette introduced as the agent of hearing loss even in the absence of exposure to noise and the relationship stayed significant even after adjustment of other variables [1,9,17]. In a survey conducted in USA, men which smoked two packs or more in a day had more complaint of hearing impairment [9,21]. In other cross sectional study in US, 25 dB hearing loss in worse ear in smokers than the persons never smoked was 1.7 times more common even after adjustment of other variables [9,16]. In a survey conducted on non-smokers, little increase in hearing loss (OR=1.3) in accordance to exposure to ETS (environmental tobacco smoke) was seen [9,45]. In other study in Japan, which was on the persons working in silent areas (white collars), more hearing loss were seen in smokers than non smokers and a dose response relationship between cigarette smoking in current smokers and hearing loss was seen which was more obvious in higher frequencies than the lower one [1,2,9,12,15]. In the study of Mizoue et al. smoking was related significantly to the risk of hearing loss in higher frequencies and there was no relationship with low frequencies. In this study cigarette was introduced as an independent risk factor of high frequency hearing loss and 4 KHz hearing loss among smokers who not exposed to noise was comparable with hearing loss in non smokers who have exposed

to noise [2].

Although in one study a protective effect against noise induced hearing loss has been observed for cigarette [1,23], another studies discovered a synergistic or simple additive effect between cigarette and noise [1,2,9,46]. None of the cigarette, noise and age does not have protective effect for hearing and each of them can impair hearing even alone [1,47]. Also a multiplicative effect has been seen between age and smoking in one study [1,48]. Smoking does not intensify the effect of noise on hearing rather act independently [2]. Prevalence of hearing impairment and tinnitus increases not only with increasing the exposure time to noise even after adjustment for age, but also with age [7]. Age related degenerative changes commonly affect high frequency related regions [1,49]. Due to common pathogenic pathway, cigar, noise and age have synergistic effect in genesis of hearing impairment [1]. Also it must be considered that studies survey contemporary exposure, if cross sectional, have limitations in causality [1,2].

Conclusion

Although it is not necessary to restrict engagement of smokers in areas with high level of noise exposure [1,9], according to the results of this study and similar studies concluded that employees especially in areas with high level of noise must be encouraged to quit smoking and exposure to noise must be reduced as much as possible. Periodic exams especially audiometric evaluations must be considered. We must consider not only the noise but also the other agents causing hearing impairment in occupational compensations. Also it is better to design prospective studies for determining contemporary exposure effects.

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References

1. Ferrite S, Santana V. Joint effects of smoking, noise exposure and age on hearing loss. *Occupational Medicine* 2005; 55: 48-53.
2. Mizoue T, Miyamoto T. Combined effect of smoking and occupational exposure to noise on hearing loss in steel factory workers. *Occup Environ Med* 2003; 60: 56-59.
3. Koh D, Jeyaratnam J. Occupational health in Singapore. *Int Arch Occup Environ Health* 1998; 71: 295-301.
4. Uimonen S, Maki-Torkko E, Sorri M. Hearing and occupation. *Int J Circumpolar Health* 1998; 57: 156-61.
5. Alberti PW. Noise-the most ubiquitous pollutant. *Noise Health* 1998; 1: 3-5.
6. Rabinowitz P, Thomas S. Occupational hearing loss. In: Rosenstock L, editor. *Text book of Clinical occupational and environmental medicine*. China: Elsevier; 2005. pp. 426.
7. Palmer KT, Griffin MJ. Occupational exposure to noise and the attributable burden of hearing difficulties in Great Britain. *Occup Environ Med* 2002; 59: 634-639.
8. Johnson J, Robinson S. Hearing Loss. In: Ladou J, editor. *Current occupational and environmental medicine*. USA: McGraw-Hill; 2007. pp. 104.
9. Palmer KT, Griffin MJ. Cigarette smoking, occupational exposure to noise and self reported hearing difficulties. *Occup Environ Med* 2004; 61: 340-344.
10. Shafey O, Dolwick S, Guindon GE. *Tobacco control country profiles*. Atlanta: American Cancer Society; 2003. pp. 234.
11. Lowe GD, Drummond MM, Forbes CD, Barbenel JC. The effects of age and cigarette smoking on blood and plasma viscosity in men. *Scott Med J* 1980; 25: 13-17.
12. Virokannas H, Anttonen H. Dose-response relationship between smoking and impairment of hearing acuity in workers exposed to noise. *Scand Audiol* 1995; 24: 211-16.
13. Fuortes LJ, Tang S, Pomrehn P. Prospective evaluation of associations between hearing sensitivity and selected cardiovascular risk factors. *Am J Ind Med* 1995; 28: 275-80.
14. Starck J, Toppila E, Pyykkö I. Smoking as a risk factor in sensory neural hearing loss among workers exposed to occupational noise. *Acta Otolaryngol* 1999; 119: 302-5.
15. Nakanishi N, Okamoto M, Nakamura K. Cigarette smoking and risk for hearing impairment: a longitudinal study in Japanese male office workers. *J Occup Environ Med* 2000; 42: 1045-9.
16. Cruickshanks K, Klein R, Klein B, et al. Cigarette smoking and hearing loss: the epidemiology of hearing loss study. *JAMA* 1998; 279: 1715-19.
17. Barone J, Peters J, Garabrant D. Smoking as a risk factor in noise-induced hearing loss. *J Occup Med* 1987; 29: 741-5.
18. Brant L, Gordon S, Pearson J. Risk factors related to age-associated hearing loss in the speech frequencies. *J Am Acad Audiol* 1996; 7: 152-60.
19. Karlsmose B, Lauritzen T, Engberg M. A five-year longitudinal study of hearing in a Danish rural population aged 31-50 years. *Br J Audiol* 2000; 24: 47-55.
20. Thomas G, Williams G, Hoger N. Some non-auditory correlates of the hearing threshold levels of an aviation noise exposed population. *Aviat Space Environ Med* 1981; 52: 531-6.
21. National Center for Health Statistics. Data from the National Health Survey: cigarette smoking and health characteristics, July 1964-June 1965. *Vital Health Statistics* 1967; 34: 11-14.
22. Gates G, Cobb J, D'Agostino R. The relation of hearing in the elderly to the presence of cardiovascular disease and cardiovascular risk factors. *Arch Otolaryngol Head Neck Surg* 1993; 119: 156-61.
23. Dengerink HA, Lindgren FL, Axelsson A. The interaction of smoking and noise on temporary threshold shifts. *Acta Otolaryngol* 1992; 112: 932-938.
24. Friedman GD, Siegeland AB, Seltzer CC. Cigarette smoking and exposure to occupational hazards. *Am J Epidemiol* 1969; 98: 175-83.
25. Drettner B, Hedstrand H, Klockhoff I, et al. Cardiovascular risk factors and hearing loss. *Acta Otolaryngol* 1975; 79: 366-71.
26. Pyykkö I, Koskimies K, Starck J, et al. Risk factors in the genesis of sensorineural hearing loss in Finnish forestry workers. *Br J Ind Med* 1989; 46: 439-46.
27. Chung D, Wilson G, Gannon P, et al. Individual susceptibility to noise. In: Hamernik R, Henderson D, Salvi R, eds. *New perspectives on noise-induced hearing loss*. New York: Raven Press 1982; 4: 511-19.
28. Hawkins JE. The role of vasoconstriction in noise-induced hearing loss. *Ann Otolaryngol* 1971; 80: 903-13.
29. Hultcrantz E, Hillerdahl M, Angelborg C. Effect of nicotinic acid on cochlear blood flow. *Arch Otolaryngol* 1982; 234: 151-5.
30. Fechter L, Thorne P, Nuttall A. Effects of carbon monoxide on cochlear electrophysiology and blood flow. *Hear Res* 1987; 27: 37-45.
31. Cocchiarella LA, Sharp S, Persky VW. Hearing threshold shifts, white-cell count and smoking status in working men. *Occup Med* 1995; 45: 179-85.
32. Rubinstein M, Hildesheimer M, Muchnik C. Chronic labyrinthine ischemia. *J Laryngol Otol* 1988; 102: 496-9.
33. Browning GG, Gatehouse S, Lowe GD. Blood viscosity as a factor in sensory neural hearing impairment.

Lancet 1986; 9: 121-3.

34. Stewart RO. The effect of carbon monoxide on humans. *J Occup Med* 1976; 18: 304-9.

35. Maffei G, Miani P. Experimental tobacco poisoning. Resultant structural modifications of the cochlea and tuba acustica. *Arch Otolaryngol* 1962; 75: 386-396.

36. Chen GD. Effect of hypoxia on noise-induced auditory impairment. *Hear Res* 2002; 172: 186-195.

37. Blanchet C, Erostequi C, Sugasawa M, et al. Acetylcholine-induced potassium current of guinea pig outer hair cells: its dependence on a calcium influx through nicotinic-like receptors. *J Neurosci* 1996; 16: 2574-85.

38. Darral KG, Figgins JA, Brown RD, Phillips GS. Determination of benzene and associated volatile compounds in mainstream cigarette smoke. *Analyst* 1998; 123: 1095-1101.

39. Jacobsen P, Hein HO, Suadicani P, Parving A, Gyntelberg F. Mixed solvent exposure and hearing impairment: an epidemiological study of 3284 men. The Copenhagen male study. *Occup Med [Lond]* 1993; 43: 180-184.

40. Morata TC, Lemasters GK. Epidemiologic considerations in the evaluation of occupational hearing loss. *Occup Med* 1995; 10: 641-656.

41. Morata TC. Interaction between noise and asphyxiants: a concern for toxicology and occupational health. *Toxicol Sci* 2002; 66: 1-3.

42. Johnson J, Robinson S. Hearing Loss. In: Ladou J, editor. *Current occupational and environmental medicine*. USA: McGraw-Hill 2007; p: 121 .

43. Rabinowitz P, Thomas S. Occupational hearing loss. In: Rosenstock L, editor. *Text book of Clinical occupational and environmental medicine*. China: Elsevier; 2005. pp. 427.

44. Cocchiarella L, Andersson GB. *The Guides to the Evaluation of Permanent Impairment*. 5th ed. Chicago: American Medical Association 2001; 9: 247-251.

45. Iribarren C, Friedman GD, Klatsky AL, et al. Exposure to environmental tobacco smoke: association with personal characteristics and self reported health conditions. *J Epidemiol Community Health* 2001; 55: 721-8.

46. Prince M, Matanoski G. Problems in ascertaining the combined effects of exposures: results of an occupational cohort study of the joint effects of noise and smoking on hearing acuity. In: Fechter D, ed. *Proceedings of the 4th International Conference on the Combined Effects of Environmental Factors*. Baltimore: John Hopkins University 1991; 11: 87-91.

47. Rothman K, Greenland S, eds. *Modern epidemiology*. Philadelphia: Lippincott Williams and Wilkins; 1998. pp. 738.

48. Noorhassim I, Rampal KG. Multiplicative effect of

smoking and age on hearing impairment. *Am J Otolaryngol* 1998; 19: 240-243.

49. Rosenhall U, Pedersen KE. Presbycusis and occupational hearing loss. *Occup Med* 1995; 10: 593-607.