Hearing Loss and Contributing Factors Among Airport Workers in Malaysia

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SUMMARY

Sensorineural hearing loss is a common and important source of disability among the workers and often caused by occupational noise exposure. Aims of the study were to determine the prevalence and contributing factors of hearing loss among airport workers.

A cross-sectional study was carried out at an airport in Malaysia. This study used stratified sampling method that involved 358 workers who were working in 3 different units between November 2008 and March 2009. Data for this study were collected by using questionnaires eliciting socio-demographic, occupational exposure history (previous and present), life-style including smoking habits and health-related data. Otoscopic and pure-tone audiometric tests were conducted for hearing assessment. Noise exposure status was categorize by using a noise logging dosimeter to obtain 8-hour Time-Weighted Average (TWA). Data was analyzed by using SPSS version 12.0.1 and EpiInfo 6.04.The prevalence of hearing loss was 33.5%. Age >40 years old (aOR 4.3, 95%CI 2.2-8.3) is the main risk factors for hearing loss followed by duration of noise exposure >5years (aOR 2.5, 95%CI 1.4-4.7), smoking (aOR 2.1, 95%CI 1.2-3.4), duration of service >5 years (aOR 2.1, 95%CI 1.1-3.9), exposure to explosion (aOR 6.1, 95%CI 1.3-29.8), exposure to vibration (aOR 2.2, 95%CI 1.1-4.3) and working in engineering unit (aOR 5.9, 95%CI 1.1-30.9). The prevalence rate ratio of hearing loss for non-smokers aged 40 years old and younger, smokers aged 40 years old and younger, non-smokers older than 40 years old and smokers older than 40 years old was 1.0, 1.7, 2.8 and 4.6 respectively. This result contributes towards better understanding of risk factors for hearing loss, which is relatively common among Malaysian workers.

KEY WORDS:
Sensorineural high-frequency hearing loss, prevalence, cross-sectional studies, otoscopic, pure tone audiometric, 8-hour TWA

INTRODUCTION

Noisy environments are hazardous to the hearing. It is now well established that exposure to noise of sufficient intensity and duration damages the hearing of those exposed. Work-related hearing difficulties, particularly noise-induced hearing loss (NIHL) and impairment were highly prevalent among industrialized countries, and are considered the most common occupational disease in the world. Although counter measures have successfully reduced noise levels in many industries, noise is still a major occupational hazard. Some of the noises were unavoidable. Study by Malaysia Environment Department showed that most common sources of noise pollution were road traffic, industrial and building construction activity. Sound levels of less than 75dB(A) are unlikely to cause damage to hearing. However, sound levels of 85 dB(A) and above causes damage to hearing after many years of exposure. The unwanted increase in noise would lead to an epidemic of hearing loss which is incurable, but surely preventable.

Approximately 14% of industrial workers worldwide were exposed to noise more than 85 dB(A)[1]. Study conducted by Malaysia Institute for Public Health showed that 424,000 workers were identified to have hearing problems that were associated with noise exposure at working site[2]. In Britain, about 153 000 men and 26 000 women aged 35-64 years were estimated to have severe hearing difficulties attributed to noise at work[3]. Although NIHL is a highly potential preventable disease, it remains an important occupational health problem. Noise generated by aircraft and its effects on aviation workers who are unprotected for noise can lead to hearing loss[4].

MATERIALS AND METHODS

A cross-sectional study was carried out at an airports in Malaysia from November 2008 until March 2009. The sampling frame consisted of 2273 workers. Stratified sampling method was used that comprised of 3 different units namely engineering, aviation security and fire rescue unit. Simple random sampling was carried out to choose the workers by using staff numbers. The eligible population comprised all active male and female workers who were working for 1 year or more and had been chosen to participate in the hearing screening programme that was conducted by National Institute of Occupational and Safety Health (NIOSH) Malaysia.

Socio-demographic characteristics, occupational noise exposure history (previous and present), use of Hearing Protection Devices (HPDs), life-style including smoking status and health-related data were obtained using questionnaires administered by trained field workers in an isolated room. Individual noise exposure level was quantified by using personal noise dosimeter. Personal noise monitoring utilized by using Quest NoisePro DLX-1 Type 1 Noise Dosimeter data logging which was worn for an entire shift (8 hour). Dosimeters were calibrated before monitoring period. It was divided into 3 categories according to 8-hour TWA, i.e. <85

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(normal), 85-89 (action level) and ≥90 dBA (permissible exposure limit). History of head or ear injuries and operations, scuba diving activities, noisy activities during free time, experiencing tinnitus, consumption of ototoxic drugs, previous exposure to explosion and vibration was also inquired.

Otoscopic assessment was carried out to check for impacted ear wax, discharge and infection. Workers who were found to have ear problems will be excluded from the study. Competent personnel from NIOSH Malaysia assessed hearing ability using standardized audiometric examination procedures assuring at least 14 hour of noise free period. Audiometric testing was conducted in a mobile, acoustically treated van room with a Siemens audiometer (Model SD 25). The testing was conducted about 3 km away from the aircraft runaway and 0.5 km from the road to minimize background sound pressure effect from the aircraft and road traffic. NIOSH Standard Operation Procedure (SOP) method was used to carry out air-conduction measurement. The hearing thresholds were measured at the octave frequencies of 0.5, 1, 2, 3, 4, 6, and 8 kHz for air-conduction respectively for both ears.

Hearing loss was defined based on hearing thresholds more than 25 dBA, at least in one of the following frequencies: 3, 4, 6 kHz, bilaterally. Factories and Machinery (Noise Exposure) Regulations 1989 defined hearing impairment as average hearing threshold for frequencies 0.5, 1, 2, 3 KHz equal or more than 25 dBA.

All statistical analyses were carried out using statistics software package 'SPSS for Windows' 12.0.1 and EpiInfo 6.04. Logistic regression was used to evaluate the odds of having hearing loss associated with contributing factors and other potential confounders. The Research Ethics Committee of the Medical Faculty, National University of Malaysia approved the study proposal.

RESULTS

A total of 378 airports workers were involved in this study. Twenty workers were excluded because they had ear problems such as bilateral wax, discharge and infection. Finally, only 358 respondents were incorporated in this study.

The study group comprised predominantly of males (69.0%) and Malay (98.3%) with ages ranging from 21 to 54 years (mean: 31.9 ± 9.9 years). Majority of the participants (77.9%) were 40 years old and below. The major group for this study came from aviation security unit which comprised of 316 (88.3%) participants followed by engineering (7.0%) and aviation fire rescue units (4.7%). The mean length of service in the company was 10.7± 9.6 years (1-34 years) and mean length of exposure to noise in the working environment was 6.8± 8.9 years (0-34 years). Majority of the workers have length of service (55.3%) and exposure to noise (69.0%) more than 5 years and within 5 years respectively. 8-hour TWA levels in this study varied considerably, ranging from 60.2 to 106.3 dBA (81.4± 6.1). Two hundred forty nine (69.5%) of them did not using HPDs at all through their working period. Among the workers, 132(36.9%) were smokers and majority of them were 40 years old and below.

The prevalence of hearing loss was 33.5% (120 workers) while hearing impairment was 8.1% (29 workers). In the bivariate analysis (Table I), there were 10 variables that showed significant association ($p<0.05$) with hearing loss which were age >40 years old, male , working in aviation fire rescue unit, service duration > 5 years, exposure duration to occupational noise >5 years, 8 hour time-weighted average (TWA) ≥ 90dBA, exposure to occupational noise, smoking, exposure to explosion and exposure to vibration.

The prevalence of hearing loss among cigarette smokers older than 40 years old was the highest (89.5%) as compared to non-smokers older than 40 years old (55.0%) and smokers aged 40 years old and younger (33.6%). For both smokers and non-smokers groups older than 40 years old, there was a significant association ($p<0.05$) between them with hearing loss (Table II). This study also showed that the prevalence ratio of hearing loss for non-smokers aged 40 years old and younger, smokers aged 40 years old and younger, non-smokers older than 40 years old and smokers older than 40 years old was 1.0, 1.7, 2.8 and 4.6 respectively (Table III).

Mean hearing level at each tested frequency was compared between occupational noise exposed and non exposed groups using Student t tests. There were a significant difference in the frequency 3 KHz (95%CI= 3.4-10.0), 4 KHz (95%CI= 3.0-12.5), 6 KHz (95%CI= 2.3-13.2) and 8 KHz (95%CI= 1.3-11.8) of right ear between the two groups. Unlike right ear, there was only a significant difference in the frequency 3 KHz (95%CI= 2.6-9.2) of left ear between the two groups. Among those who were in the non exposed group, mean hearing levels for each tested frequency in both ears better compared to expose group (Figure 1, 2) . It was also found that the higher the frequency, the greater the difference of mean in the hearing levels between both groups. The notch of frequency for both ears was at 6 KHz.

Logistic regression demonstrated that age >40 years old is the most important risk factors for hearing loss among the workers followed by duration of noise exposure >5years, smoking, duration of service >5 years, exposure to explosion, exposure to vibration and working in engineering unit (Table IV).

DISCUSSION

Among the workers that involved in this study, 33.5% and 8.1% had hearing loss and impairment respectively. This finding can be correlates with noise level above 85 dB(A) that had been exposed to almost 38% of the workers within this study. This prevalence of hearing loss was less than two other studies done in an airport at East Asia which was about 40% for both studies[5,6]. Study conducted at Karachi airport showed a very high prevalence of hearing loss (86.4%)[7] likely to be cause by high 8 hour TWA (110 dBA) as compared to this study (81.4 dBA). Therefore Hearing Conservation Program (HCP) conducted in the airports should be reviewed for its effectiveness and usefulness.

Ageing appears to be the single most important variable that significantly associated with hearing loss in this study, given that the prevalence of such cases rise as the age group increased. The prevalence of hearing loss was around 4 times

Table I: Association between hearing loss and factors involved

Variables	Hearing loss		p value	Ods ratio (95%CI)
	Yes No. (%) n=120	No No. (%) n=238		
Age (years)				
≤40	70(25.1)	209(74.9)	<0.05*	1.0
>40	50(63.3)	29(36.7)		5.2(2.9-9.1)
Sex				
Woman	22(19.8)	89(80.2)	<0.05*	1.0
Man	98(39.7)	149(60.3)		2.7(1.5- 4.7)
Units				
Aviation security	96(30.4)	220(69.6)	<0.05*	1.0
Engineering	11(44.0)	14(56.0)		1.8(0.7-4.4)
Aviation fire rescue	13(76.5)	4(23.5)		7.4(2.2-27.8)
Service duration (years)				
≤5	33(20.6)	127(79.4)	<0.05*	1.0
>5	87(43.9)	111(56.1)		3.0(1.8-5.0)
Exposure duration (years)				
≤5	60(24.3)	187(75.7)	<0.05*	1.0
>5	60(54.1)	51(45.9)		3.7(2.2-6.1)
8 hour TWA (dBA)				
<85**	62(27.9)	160(72.1)	<0.05*	1.0
85-89	30(39.5)	46(60.5)		1.7(0.9-3.0)
≥90	28(46.7)	32(55.3)		2.3(1.2-4.2)
Exposure to noise				
Yes	108(36.9)	185(63.1)	<0.05*	2.6(1.3-5.0)
No**	12(18.5)	53(81.5)		
Smoking				
Yes	55(41.7)	77(58.3)	<0.05*	1.8(1.1-2.8)
No	65(28.8)	161(71.2)		
Exposure to explosion				
Yes	20(62.5)	12(37.5)	<0.05*	3.8(1.8-8.0)
No	100(30.7)	226(69.3)		
Exposure to vibration				
Yes	26(52.0)	24(48.0)	<0.05*	2.5(1.4-4.5)
No	94(30.5)	214(69.5)		

*Significant association (p<0.05), **Reference group

Table II: Association between smoking and age on hearing loss

Smoking and age (years old)	Hearing loss		p value	Ods ratio (95%CI)
	Yes No. (%) n=120	No No. (%) n=238		
Smoker				
≤40 years old**	38(33.6)	75(66.4)	<0.05*	1.0
>40 years old	17(89.5)	2(10.5)		16.8(3.4-111.2)
Non smoker				
≤40 years old**	32(19.3)	134(80.7)	<0.05*	1.0
>40 years old	33(55.0)	27(45.0)		5.1(2.6- 10.2)

*Significant association (p<0.05), **Reference group

Table III: Prevalence and prevalence ratios of hearing loss in smoker and non smoker by age groups

Age category (years old)	Non smoker			Smoker		
	Hearing loss	Prevalence (%)	Prevalence ratios	Hearing loss	Prevalence (%)	Prevalence ratios
≤40	32	19.3	1.0	38	33.6	1.7
>40	33	55	2.8	17	89.5	4.6

Table IV: Logistic regression model for hearing loss

Variables	β	S.E	Wald	p value	Adjusted odds ratio (95%CI)
Age (years)					
≤40**	1.46	0.33	19.36	<0.05*	4.3(2.2-8.3)
>40					
Type of jobs					
Aviation security**			4.90	0.09	
Engineering	1.78	0.84	4.49	<0.05*	5.9(1.1-30.9)
Aviation fire rescue	0.27	0.76	0.12	0.12	1.3(0.3-5.9)
Service duration (years)					
≤5**	0.74	0.32	5.42	<0.05*	2.1(1.1-3.9)
>5					
Exposure duration (years)					
≤5**	0.92	0.32	8.40	<0.05*	2.5(1.4-4.7)
>5					
Smoking					
Yes	0.72	0.26	7.82	<0.05*	2.1(1.2-3.4)
No**					
Exposure to explosion					
Yes	1.81	0.81	5.05	<0.05*	6.1(1.3-29.8)
No**					
Exposure to vibration					
Yes	0.78	0.35	4.90	<0.05*	2.2(1.1-4.3)
No**					
Constant	-3.32	0.81	16.69	<0.05*	0.04

*Significant association (p<0.05), **Reference group

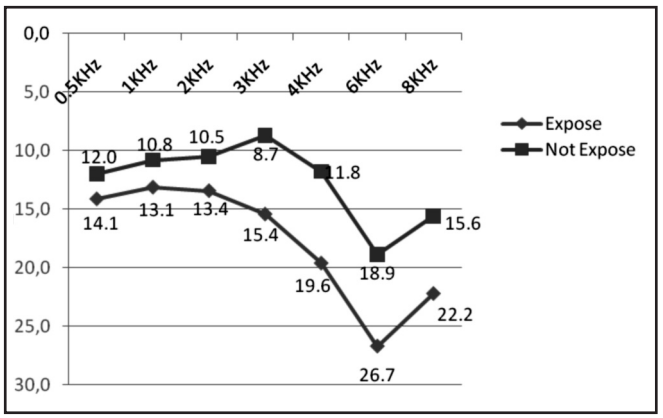

Fig. 1: Mean hearing level of right ear among noise exposed and non exposed groups.

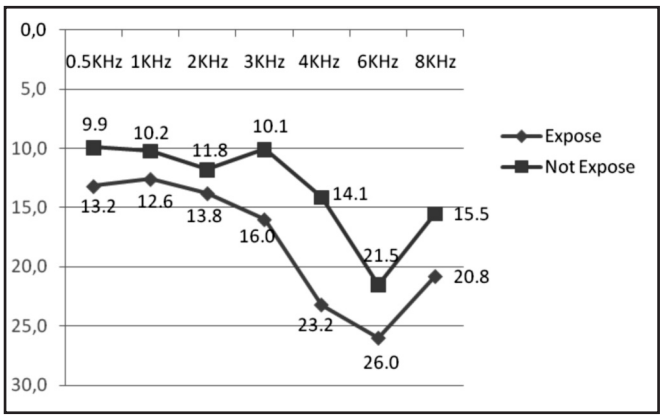

Fig. 2: Mean hearing level of left ear among noise exposed and non exposed groups.

greater among workers age older than 40 years old as compared to those in younger age groups. This finding is consistent with the data in the previous study that suggested those at extreme ages are more susceptible to noise than others[8]. Study also showed prevalence of NIHL for the workers age more than 40 years old was 40.3% in contrast with 11.3% for 40 years old and above[9]. Pyykko *et al.* (1987) found that ageing was the important cause for sensori-neural hearing loss among forest workers. Many other studies tried to locate the site of hearing loss as a result of aging process. The results are still controversial. Most of the studies indicate that change originates from the damage of cochlea. Hearing loss caused by aging process is gradual and forms a part of the progressive functional deterioration associated with the degeneration of sensory organs[11]. The degeneration process occurs more in the outer hair cells as compared to inner hair cells[12]. Age related degenerative changes may affect neural fibres and those parts of the cochlea, including vascular structures in which will affect most pronouncedly the high frequency[13].

Duration of noise exposure more than 5 years was shown to be the second most important variables that showed significant for hearing loss in this study, thereby indicating that the influence of this variables on hearing loss is very crucial. Workers who were exposed to noise for more than 5 years had 3 times risk of developing hearing loss. Generally, the rate of hearing loss is greatest during the first 10-15 years of exposure and decreases as the hearing threshold increases, unlike age-related hearing loss in which accelerates over time[14] but the vital causes is also depending on the dose (intensity) of exposure to the noise itself rather than duration only. Study among industrial workers in Brazil found that prevalence of hearing loss was high among workers who had

been exposed to noise for more than years[15]. Study at Korea airport also showed a significant association between hearing loss and duration of exposure to noise6. Long term exposure to noise can be hazardous because the consequences of noise can be accumulative over time[16].

Smoking was a well known cause of hearing loss and showed significant association with hearing loss in this study. Smoker showed 3 times greater risk in getting hearing loss as compared to non-smoker. Meta-analysis study which include 15 previous study regarding complication of smoking to workers hearing showed that smoking will cause hearing loss[17]. Hearing loss epidemiology study conducted in 1998 also showed that smoking had 1.69 times to cause hearing damage[18]. Furthermore, smoking increases the carboxyhemoglobin in the blood resulting in decrease in the amount of oxygen that will be used by cells. Smoking cessation and reduction of noise exposure may delay the onset of hearing loss. There are also suggested that inner ear cells responsible for high frequency hearing are more vulnerable to ischaemic damage, as they are located at the end of nutrient arteries[19].

Workers in this study were exposed to explosion while having shooting training especially for those in aviation security unit but this exercise did not involve all staff in the unit. This study showed that those who had history of exposure to explosion had 8 times higher risk in developing hearing loss as compared to non-expose workers. The immediate effects of exposure to high-intensity sound stimuli include elevation of hearing threshold, rupture of the eardrum and traumatic damage to the middle and inner ears (dislocation of ossicles, cochlear injury or fistulas). Study in Virginia that was conducted among workers that came to occupational health clinic found that exposure to explosion had prevalence ratio of 1.2 to develop hearing loss[20]. And study among recreational shooter found that there was a significant association between hearing loss and exposure to explosion with odds ratio of 1.6[21].

As expected, those engaged in engineering unit were the worst affected by noise where they had 6 times greater risk in developing hearing as compared to others unit. In this study, the location of working area for the engineering unit just beside the take off aircraft runaway and sometimes they have to work at the runaway itself, as compared to other units which majority of the time working in the building or at the main terminal building. This result was also consistent with previous study that was done at an airport in Korea that showed the incidence of NIHL were highest in the groups of maintenance workers (65.2%) and firemen (55.0%) as compared to policemen, airline ground staff and civil servants[5]. The different of mean for exposure duration to noise between these two groups was 4.0 years and it is statistically significant.

The final variable or factor that had significant impact on hearing function in this study was history of exposure to vibration while working especially among aviation fire rescue unit where 58.8% from them was exposed to vibration while working. There was twofold greater risk to develop hearing loss among those workers who were exposed to vibration as compared to non-expose workers. Sources of vibration came from fire rescue heavy vehicles and the equipment that they were using for rescue activity such as chain saws, blade saws and cutter. One study on tractor drivers showed more sensori-neural hearing loss than could be predicted on the basis of drivers' exposure to noise[22]. This was assumed to be the consequence of exposure to vibration.

Previous researchers had carried out few studies to distinguish the synergistic effect between smoking and aging on hearing loss or impairment. This study showed workers that smoke with aged more than 40 years old had 5 times risk to develop hearing loss as compared to non-smoker with the aged of 40 years old and younger. The prevalence ratio of hearing loss for non-smokers aged 40 years old and younger, smokers aged 40 years old and younger, non-smokers older than 40 years old and smokers older than 40 years old was 1.0, 1.7, 2.8 and 4.6 respectively. It showed that age and smoking have multiplicative effects on hearing loss. Previous study also reported that smoking and age have multiplicative adverse effects on hearing impairment[23]. However, when it came to combine effect of smoking and exposure to noise on hearing it was estimated to be additive[19].

This study was conducted in collaboration with NIOSH, Malaysia for this company's hearing screening programme. A large proportion of the information was obtained from the questionnaire drawn up for this program. Not all workers that had been chosen to be in this programme. There were choose among whom that not yet having their hearing check-up for the past 2 years. Thus, the survey had the burden of some limitations relating to the numbers of workers that had been chosen from each unit/department and the variation of age among the workers. Since the data collection was restricted among the workers that was selected by the company's administration, the study did not achieve 100% coverage over the period considered in its proposal for performing evaluations on all workers with potential exposure to noise in the working environment.

CONCLUSION

NIHL is a condition that has multifactorial synergistic causes and it can be either additive or multiplicative. Even with all the limitations discussed, this study has enabled better comprehension of principal characteristics that are related to NIHL, in a particular situation of industrial environment. Every approach undertaken must always be placed within its context because of the diversity of occupational health issues in Malaysia and other countries. Such studies not only involve various problems of a technical nature, but also financial interests and significant legal implications.

REFERENCES

1. WHO. 1995. Occupational and Community Noise. World Health Organization.
2. Bernama. 2008. 22 Julai.
3. Palmer KT, Griffin MJ, Syddall HE, Davis A, Pannett B & Coggon D 2002. Occupational Exposure to Noise and the Attributable Burden of Hearing Difficulties in Great Britain. Occupational and Environmental Medicine. 59: 634-9.
4. Fitzpatrick DT 1988. An Analysis of Noise-Induced Hearing Loss in Army Helicopter Pilots. Aviation, Space, and Environmental Medicine.

5. Chen TJ, Chiang HC & Chen SS 1992. Effects of Aircraft Noise on Hearing and Auditory Pathway Function of Airport Employees. Journal of Occupational and Environmental Medicine.
6. Hong OS & Kim MJ 2001. Factors Associated with Hearing Loss among Workers of the Airline Industry in Korea. ORL Head Neck Nurs. 19(1): 7-13.
7. Imtiaz AS & Riaz AS 2008. The Effect of Excessive Noise Exposure on the Hearing Thresholds of Aviation Workers in Karachi. Pak J Med Sci. 24(4): 525-30.
8. Kjellberg A 2001. Noise. Occupational Health Practice. 241-56.
9. Ferrite S & Santana V 2005. Joint Effects of Smoking, Noise Exposure and Age on Hearing Loss. Occupational Medicine. 55: 48-53.
10. Pyykko I, Pekkarinen J & Starck J 1987. Sensory-neural Hearing Loss during Combined Noise and Vibration Exposure. Int Arch Occup Environ Health. 59: 439-54.
11. Schuknecht HF. 1974. Pathology of the Ear. Cambridge, M.A., Harvard University Press.
12. Soucek S & Michael S. 1990. Hearing Loss in Elderly. London, Springer-Verlag.
13. Rosenhall U & Pedersen KE. 1995. Presbycusis and Occupational Hearing Loss. Occup Med. 10: 593-607.
14. ACOEM Evidence-based statement. 2003. Noise-induced Hearing Loss. Journal of Occup Environ Med. 45(6): 579-81.
15. Gueera MR, Lourenco PMC, Bustamante-Teixeira MT & Alves MJM. 2005. Prevalence of Noise-induced Hearing Loss in Metallurgical Company. Saude Publication. 39: 2.
16. McFadden SL & Henderso, D. 1999. Recent Advances in Understanding and Preventing Noise-induced Hearing Loss. Curr Opin Otolaryngol Head Neck Surg. 7(5): 266-73.
17. Nomura K, Nakao M & Yano E. 2005. Hearing Loss Associated with Smoking and Occupational Noise Exposure in a Japanese Metal Working Company. International Archives of Occupational and Environmental Health.78: 178-184.
18. Cruikshanks K, Klein R, Klein B, Wiley T, Nondahl D & Tweed T. 1998. Cigarette Smoking and Hearing Loss. The epidemiology of hearing loss study. JAMA. 279(21): 1715-9.
19. Mizoue T, Miyamoto R & Shimizu T. 2003. Combined Effect of Smoking and Occupational Exposure to Noise on Hearing Loss in Steel Factory Workers. BMJ Occupational and Environmental Med. (10): 56-9.
20. Darlene WO, Adera T & Andriano J. 2006. Association Between Smoking, Chemical Exposure and Hearing Loss in an Occupational Setting. Virginia Commonwealth University Richmond, Virginia.
21. David M, Nondahl MS, Karen J, Cruickshanks, Terry L, Wiley, Klein R, Barbara E, Klein K, Ted S & Tweed MS. 2000. Arch Fam Med. 9: 352-3.
22. Pinter I. 1973. Hearing Loss of Forest Workers and of Tractor Operators (interaction of noise with vibration). In: Proceedings of the International Congress on Noise as a Public Health Problem. Washington. The USA Environmental Protection Agency, Office of Noise Abatement and Control. 315-27.
23. Noorhassim I & Rampal KG 1998. Multiplicative Effect of Smoking and Age on Hearing Impairment. American Journal of Otolaryngology. (1): 240-3.