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Effect of Smoking on Hearing Thresholds among Automobile Industry Workers

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Abstract: Smoking is the inhalation of smoke of burning tobacco encased in cigarettes, pipes and cigars. Smoking is a modifiable risk factor of hearing loss. The aim of this study was to explore mean hearing thresholds among smokers and non-smokers in an automobile industry. In this cross-sectional study, 203 participants from an automobile industry were exposed to noise levels above the action level of 85 dBA where permissible exposure limits was 90 dBA. Universal sampling was adopted. Smoking history was obtained from a questionnaire. Noise level of the industry was measured using personal exposure noise dosimeter and sound level meter. Data on hearing threshold levels were measured using manual audiometer. The mean hearing threshold level on right ear of participants at 2000 Hz was statistically significantly higher among smokers compared to non-smokers (2.97 (95% CI, 0.41-5.53) dBA, $t(201) = 2.29$, $p = 0.023$, effect size = 0.38). The mean hearing threshold levels on left ear at 2000 and 3000 Hz were also statistically significantly higher among smokers compared to non-smokers (1.88 (95% CI, 0.01-3.75) dBA, $t(201) = 1.99$, $p = 0.048$, effect size = 0.31) and (3.18 (95% CI, 1.05-5.31) dBA, $t(201) = 2.94$, $p = 0.004$, effect size = 0.46). Hence, smokers showed worsening of hearing thresholds at 2000 (both ears) and 3000 Hz (left ear) in a noisy industry. Therefore, the industries should review their policy by banning smoking in the premise which may lower the risk of noise-induced hearing loss.

Key words: Hearing loss, occupational noise, smoking, smokers, cigarettes

INTRODUCTION

Smoking is the inhalation of smoke of burning tobacco encased in cigarettes, pipes and cigars. Many health experts now regard habitual smoking, as a psychological addiction and one with serious health consequences (Olson and Kutner, 2000). Smoking is a modifiable risk factor of hearing loss. Chemicals released from smoking such as toluene, xylene, lead and carbon monoxide are hazardous to hearing loss (Ferrite and Santana, 2005). Smoking may cause ischemia to the cochlear since carboxyhemoglobin concentration in blood is increased and constriction of vessels ensues. Moreover, blood viscosity is increased among the smokers (Sung *et al*., 2013) and there is only a single vessel supplying blood to the cochlear. According to a health interview study, smoking at least 2 packs a day is likely to lead to hearing loss among smokers (NCHS, 1967).

Cigarette smoking is associated with poorer hearing thresholds (Sung *et al*., 2013) and has synergistic effect with noise exposure (Carmelo *et al*., 2010). In 2010, a total of 663 cases of occupational diseases were investigated in Malaysia. From this total, around 70% of them were diagnosed to have noise-induced hearing loss, making it as the most common occupational disease (DOSHM, 2013). The present study is conducted with the aim of exploring, the meanhearing threshold levels among smokers and non-smokers in a noisy industry. It is of utmost importance to determine scientifically as to ban smoking in industries, since it will impose cost and enforcement issues.

MATERIALS AND METHODS

Study design and population: This is a cross-sectional study comparing smokers (ever smoked) and non-smokers on mean hearing threshold levels. Upon enrolment in the present study, hearing threshold levels were measured before the participants began to work; they should not be exposed to noise levels beyond 80 dBA for a period of 14 h (LoM, 2010).

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Recruitment of study area was initiated through online requests to safety and health officers. The details of study information were explained to the safety and health officers and human resource managers. Upon approval to conduct this study in the industry, information about this study was disseminated to the participants and written consent was obtained. The participation of employees was voluntary.

All subjects in the industry recruited into the study were exposed to noise level above action level, i.e., 85 dBA (LoM, 2010). One of the exclusion criteria was subjects who refused to participate. Contract workers were not included since they were not permanently employed and lorry drivers were excluded since they were not stationed in the industry. Those suffering from diseases of the ear, such as chronic suppurative otitis media or malignancy, employees who had experienced physical trauma to the ear due to penetrating injury or fall and also those who had undergone ear surgery were not included in this study. This information was obtained from a questionnaire.

Participants of this study were from an automobile industry. A total of 260 workers from the industry were exposed to noise levels above the action level. Of the eligible participants, 203 of them participated in this study. The nonrespondents were those who were involved in busy work procedures and who had the predilection not to participate in the study. Universal sampling was adopted in the study. Participationin the study was stimulated by communicating with the employees through phone calls and provided them with incentives (food) to participate.

Measures

Noise area and personal exposure noise measurement: Noise area measurement was measured using sound level meters (LoM, 2010), calibrated and approved by the Department of Occupational Safety and Health (DOSH) (Larson Davis, model Spark 706 RC and Spark 703+). Noise exposure among employees was measured using personal exposure noise dosimeter (LoM, 2010), calibrated and approved by the DOSH (Larson Davis, model Spark 706 RC and Spark 703+). The measurement was done in each job area, exceeding action level of the industry. One employee represented a group of employees from the same job area (LoM, 2010). The noise dosimeters were worn by the participants for the entire shift while at work and were switched off during breaks. The average noise exposure was taken and recorded. The exchange rate of 5 dB was applied during measurement of noise in both study locations. The dosimeters were calibrated just before and after noise measurement.

Hearing threshold level: A manual audiometer was used to collect data on hearing threshold levels of the participants from the automobile industry, calibrated and approved by the DOSH (model asi 17 equipped with TDH-39 headphones). This audiometer was placed in a sound-proof booth, calibrated according to the factories and machinery (noise exposure) regulations 1989 (LoM, 2010). The test frequencies measured were 500, 1000, 2000, 3000, 4000, 6000 and 8000 for both ears of the participants. To increase the reliability of measurements, 2 similar readings were taken before entering in the audiogram. Hearing protection devices (LoM, 2010) were used to reduce noise exposure levels among participants to levels ranged between permissible exposure limit (90 dBA) and action level (85 dBA).

Compliance: The continuous use of ear plugs among participants was ensured by providing checklists to supervisors of the 2 factories for monitoring purpose. Researchers also monitored by regular spot checks in these factories on the use of these hearing protection devices.

Statistical analyses: The data analyses were performed using SPSS version 20 for Windows. An independent t-test was used to analyze the difference in means for continuous characteristics, such as age and duration of employment variables. The independent t-test was also used to analyze the difference in means of hearing threshold levels at various frequencies of both ears between smokers and non-smokers. A Chi-square test was used to detect differences among smokers and non-smokers in the frequencies of categorical characteristics such as exposure to hand-arm vibration, alcohol consumption and medication with an increased risk of hearingvariables. Fischer's exact test was used, if the assumptions of the Chi-square test were not met. A p-value of <0.05 was considered statistically significant.

Ethical considerations: Written authorization was obtained from the relevant personnel to conduct this study in the automobile industry. Ethical approval was then obtained from the Research and Ethics Committee, University of Malaya (MEC Ref. No: 848.37). Participant information sheets were distributed to the participants, the objectives were specified and maintenance of confidentiality was provided for and that the participants were assured that they were free to opt out at any time during the study. The contact details were given in the event the participants intend to clarify any doubts pertaining to the study. The written informed consents were collected before participants were allowed to take part in this study.

RESULTS AND DISCUSSION

With reference to Table 1 mean age of the participants was 27.1±6.56 years. The majority of the participants are males and Malays accounted for >90% of the participants in this study. Most of these workers are single and >60% have ever smoked and hardly 3% of them ever consumed alcohol. More than two third of these employees have only secondary or primary school education and hence, most of them earned <RM 3000; low income payees earn below RM 3000 a month in Malaysia (Mohd, 2009). The mean duration of employment of the participants in the automobile industry was 2.4±2.05 years more than two third has been exposed to hand-arm vibration. Employees worked in the Production Control (PC) press, Quality Control (QC) press, welding and maintenance departments and also in the PC resin, QC resin, kaizen and painting departments. There are more than a fifth of subjects in each department.

Table 1: Participants sociodemographic characteristics

Socio demographic variables	Frequency (%) n = 203
Gender	
Male	193 (95.1)
Female	10 (4.9)
Age	
Mean (SD) years	27.12 (6.56)
Median	25.78
Range	17.59-54.46
Race	
Malay	198 (97.5)
Non-Malay	5 (2.5)
Religion	
Islam	200 (98.5)
Non-Islam	3 (1.5)
Marital status	
Single	125 (61.6)
Ever married	78 (38.4)
Education level	
Primary and Secondary school	137 (67.5)
Form six, certificate, college and university	66 (32.5)
Income	
<3000	184 (90.6)
3000 and above	19 (9.4)
Smoking	
No smoking	65 (32.0)
Ever smoked	138 (68.0)
Alcohol consumption	
Not consuming alcohol	196 (96.6)
Ever consuming alcohol	7 (3.4)
Duration of work	
Mean (SD) years	2.41±2.05
Median	2.00
Range	0.08-11
Exposure to hand-arm vibration	
Exposed	149 (73.4)
Not exposed	54 (26.6)
Surgery to ear	
Yes	0 (0.0)
No	203 (100.0)
Medication with an increased risk of hearing loss	
Yes	2 (1.0)
No	201 (99.0)

The basic sociodemographic characteristics and risk factors of hearing loss were compared between smokers and non-smokers as shown in Table 2. All the independent variables between them were not statistically significant different, except the variable of alcohol consumption. Almost all the smokers never consumed alcohol.

The mean noise exposure of participants from each department is shown in Table 3. There was no difference between smokers and non-smokersamong the departments from the industry (0.23 (95% CI, -0.46 to 0.93) dBA, t (201) = 0.67, p = 0.504).

The mean hearing threshold level on right ear of participants at 2000 Hz was statistically significantly higher among smokers compared to non-smokers (2.97 (95% CI, 0.41-5.53) dBA, t (201) = 2.29, p = 0.023, effect size = 0.3) as shown in Table 4. According to Cohen (1988), the effect size was moderate. The mean hearing threshold levels on left ear at 2000 and 3000 Hz were also statistically significantly higher among smokers compared to non-smokers (1.88 (95% CI, 0.01-3.75) dBA, t (201) = 1.99, p = 0.048, effect size = 0.31), the effect size was moderate and (3.18 (95% CI, 1.05-5.31) dBA, t (201) = 2.94, p = 0.004, effect size = 0.46) the effect size was moderate to large as displayed in Table 4. Hence, smokers showed worsening of hearing thresholds at 2000

Table 2: Comparison of independent variables between smokers and non-smokers

Characteristics/ Risk factors	Smokers (n = 138) Frequency (%)	Non-smokers (n = 65) Frequency (%)	p-value
Age			
Mean (SD)	26.98 (6.99)[a]	27.41(5.58)[a]	0.670[b]
Alcohol consumption			
Ever consumed alcohol	1 (0.7)	6 (9.2)	0.005[c]
Not consumed alcohol	137 (99.3)	59 (90.8)	
Duration of work			
Mean (SD)	2.38 (2.12)	2.49 (1.92)	0.726[b]
Exposure to hand-arm vibration			
Exposed	100 (72.5)	49 (75.4)	0.660[d]
Not Exposed	38 (27.5)	16 (24.6)	
Medication with an increased risk of hearing loss			
Yes	2 (1.4)	0 (0.0)	1.000[c]
No	136 (98.6)	65 (100.0)	

[a]Data represents mean (SD); [b]Statistical significance is based on independent t-test; [c]Statistical significance is based on Fisher's exact test; [d]Statistical significance is based on Chi-square test for independence frequency

Table 3: Comparison of noise exposure between participants from various departments

Departments	Frequency (%) n = 203	Mean (SD) dBA
PC and QC press	41 (20.2)	90.8 (0.75)
Welding and maintenance	65 (32.0)	87.2 (1.60)
PC and QC resin	44 (21.7)	88.6 (1.62)
Kaizen and painting	53 (26.1)	90.1 (2.50)

Table 4: Comparison of mean hearing threshold levels between smokers and non-smokers

Frequency (ear)	Smoker (n = 138) Mean (SD)	Non-smoker (n = 65) Mean (SD)	Mean difference (95% CI)	t statistic (df)	p-value*
500 (right)	23.22 (9.41)	21.54 (5.65)	-1.69 (-4.18 to 0.81)	-1.33 (201)	0.184
500 (left)	19.46 (5.79)	17.92 (5.51)	-1.53 (-3.22 to 0.16)	-1.79 (201)	0.075
1000 (right)	20.54 (9.87)	19.00 (5.09)	-1.54(-4.11 to 1.02)	-1.19 (201)	0.236
1000 (left)	18.91 (6.21)	17.38 (5.80)	-1.53 (-3.33 to 0.277)	-1.67 (201)	0.097
2000 (right)	19.89 (9.54)	16.92 (6.23)	-2.97 (-5.53 to -0.41)	-2.29 (201)	0.023
2000 (left)	18.19 (6.70)	16.31 (5.32)	-1.88 (-3.75 to -0.01)	-1.99 (201)	0.048
3000 (right)	19.71 (10.75)	17.08 (7.90)	-2.63 (-5.58 to 0.31)	-1.76 (201)	0.080
3000 (left)	18.95 (7.65)	15.77 (6.07)	-3.18 (-5.31 to -1.05)	-2.94 (201)	0.004
4000 (right)	20.91 (11.14)	17.92 (10.53)	-2.98 (-6.23 to 0.27)	-1.81 (201)	0.072
4000 (left)	19.13 (8.43)	17.62 (8.30)	-1.52 (-4.00 to 0.97)	-1.20 (201)	0.974
6000 (right)	27.10 (13.48)	28.00 (18.28)	0.90 (-3.60 to 5.40)	0.39 (201)	0.694
6000 (left)	23.77 (10.43)	25.08 (14.91)	1.31 (-2.76 to 5.38)	0.64 (95)	0.525
8000 (right)	15.80 (12.81)	17.31 (17.92)	1.51 (-3.40 to 6.43)	0.61 (96)	0.543
8000 (left)	15.14 (10.36)	16.62 (15.24)	1.47 (-2.13 to 5.07)	0.81 (201)	0.421

*Statistical significance is based on independent t-test

(both ears) and 3000 Hz (left ear) in a noisy industry. The findings were consistent with an epidemiology study conducted in the US where the risks of current smokers to have hearing loss were higher than non-smokers (Cruickshanks *et al*., 1998). Mizoue *et al*. (2003) had concluded that hearing loss was more among smokers but not increased when exposed to noise where smoking was associated with high frequency hearing loss. A cross-sectional study (Carmelo *et al*., 2010) was conducted in Italy showed that smoking had effect on hearing loss and associated with number of cigarettes smoked per day (Mizoue *et al*., 2003). Smoking works synergistically with noise on hearing loss (Carmelo *et al*., 2010). A meta-analysis showed that there were vulnerabilities to hearing loss among smokers, more among current smokers compared to past smokers (Nomura *et al*., 2005).

Alcohol consumption was associated with hearing loss (Kumar and Patrick, 2011). In this study, more non-smokers consumed alcohol but mean hearing threshold levels were higher among smokers, showing detrimental effect of smoking on hearing threshold levels.

Sound waves from external sources are heard through air conduction and bone conduction (Henry and Letowski, 2007). In air conduction, these sound waves travel via external auditory canal. Air conduction is affected once there is damage either in outer or middle ear. In bone conduction, the sound waves are transmitted directly to the cochlea through skull bones. Therefore, if there is any damage to inner ear or auditory nerve, the bone conduction is affected. Bone conduction is used to distinguish sensorineural from conductive hearing loss (Gelfand, 2009). Only air conduction was used to measure hearing threshold levels in this study. To ensure no damage to the outer or middle ear, ear assessment was performed on all the participants. The assessment was done using otoscopy examination. Only participants who have no damage to ear were allowed to undergo audiometry assessment.

There were no differences on possible confounding factors between smokers and non-smokers on consumption of alcohol (Upile *et al*., 2007) and exposure to hand-arm vibration (Pettersson, 2013) variables. There was also no significant difference among the 2 groups in terms of age and employment duration.

Noise level is measured using sound level meter and noise dosimeter. The former measured noise at the point of time whereas the latter measures average exposure of an employee to noise in the job area (Levey *et al*., 2012).

Universal sampling was adopted in this industry. Findings in this study are arrived at based on data collected in the automobile industry and thus should not be generalized. More studies in future are required to be conducted on different types of industries to confirm the findings. The study design was cross-sectional and hence, there was no evidence on temporal relationship between the exposure and the outcomes. To reduce measurement bias 2 similar readings were taken before entering in the audiogram.

CONCLUSION

This study concludes that smoking had detrimental effect on hearing threshold levels in a noisy industry. Consequently, the industries should review their policy by prohibiting smoking in the premise, reducing the risk of noise-induced hearing loss.

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REFERENCES

Carmelo, A., G. Concetto, Z. Agata, T.M. Antonietta and D.A. Graziella *et al*., 2010. Effects of cigarette smoking on the evolution of hearing loss caused by industrial noise. Health, 2: 1163-1169.

Cohen, J., 1988. Statistical Power Analysis for the Behavioral Sciences. L. Erlbaum Associates, New Jersey, USA., ISBN-13: 9780805802832, Pages: 567.

Cruickshanks, K.J., R. Klein, B.E. Klein, T.L. Wiley, D.M. Nondahl and T.S. Tweed, 1998. Cigarette smoking and hearing loss: The epidemiology of hearing loss study. J. Am. Med. Assoc., 279: 1715-1719.

DOSHM, 2013. Occupational diseases and poisoning investigation. Department of Occupational Safety and Health Malaysia (DOSHM). http://www.dosh.gov.my/index.php?option=com_content&view=article&id=392:occupational-diseases-and-poisoning-investigation&catid=349&Itemid=760&lang=en.

Ferrite, S. and V. Santana, 2005. Joint effects of smoking, noise exposure and age on hearing loss. Occup. Med., 55: 48-53.

Gelfand, S.A., 2009. Essentials of Audiology. In: Thieme, Hiscock, T. (Ed.). Medical Publishers Inc., New York, USA.

Henry, P. and T.R. Letowski, 2007. Bone conduction: Anatomy, physiology and communication. Army Research Laboratory, May 2007, pp: 1-192.

Kumar, K.A. and R. Patrick, 2011. Hearing in alcoholics-a case control study. J. Clin. Diagn. Res., 5: 85-87.

Levey, S., B.J. Fligor, C. Ginocchi and L. Kagimbi, 2012. The effects of noise-induced hearing loss on children and young adults. Contemp. Issues Commun. Sci. Disorders, 39: 76-83.

LoM, 2010. Factories and Machinery Act 1967 (Act 139) and Regulations and Rules. International Law Book Services, Malaysia.

Mizoue, T., T. Miyamoto and T. Shimizu, 2003. Combined effect of smoking and occupational exposure to noise on hearing loss in steel factory workers. Occup. Environ. Med., 60: 56-59.

Mohd, S., 2009. Social protection in Malaysia. Economic and Social Commission for Western Asia (ESCWA), Arab Forum on Social Policy, Beirut, October 2009, pp: 1-13.

NCHS, 1967. Cigarette smoking and health characteristics: United States-July 1964-June 1965. National Center for Health Statistics, Series 10, No. 34, May 1967, U.S. Department of Health, Education and Welfare, Washington, DC., USA., pp: 1-64.

Nomura, K., M. Nakao and T. Morimoto, 2005. Effect of smoking on hearing loss: Quality assessment and meta-analysis. Prev. Med., 40: 138-144.

Olson, C.K. and L. Kutner, 2000. A Comparison of the Health Effects of Alcohol Consumption and Tobacco Use in America. American Council on Science and Health, New York, NY., USA., Pages: 47.

Pettersson, H., 2013. Risk of hearing loss from combined exposure to hand-arm vibrations and noise. Ph.D. Thesis, Experimental Study, Umea University, Sweden.

Sung, J.H., C.S. Sim, C.R. Lee, C.I. Yoo, H. Lee, Y. Kim and J. Lee, 2013. Relationship of cigarette smoking and hearing loss in workers exposed to occupational noise. Ann. Occup. Environ. Med., 25: 1-10.

Upile, T., F. Sipaul, W. Jerjes, S. Singh and S.A.R. Nouraei *et al*., 2007. The acute effects of alcohol on auditory thresholds. BMC Ear Nose Throat Disord, Vol. 7. 10.1186/1472-6815-7-4.