Archives of Occupational Health | Volume 3 | Issue 3 | July 2019 | 400-8.

Original

Association between Noise Exposure and Sensitivity and Psychological Distress

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Abstract

Background: Noise pollution is considered as a major threat to human society that may affect life quality, efficiency, physical and mental health. Therefore, the present study was aimed to investigate the effects of noise exposure and noise sensitivity on psychological distress in an automobile parts manufacturer's employees. **Methods:** In this descriptive-analytical study, 325 employees of an automobile parts manufacturer who were exposed to different noise levels in seven groups were investigated. Daily personal noise exposure for each group was measured using calibrated sound level meter (SVANTEK-971) based on ISO-9612 standards. Then employees' mental disorder and noise sensitivity were determined using Kessler Psychological Distress Scale and Weinstein's Noise Sensitivity Scale (WNSS), respectively, and data was analyzed using SPSS v. 23. **Results:** Mean psychological distress was significantly different between noise sensitivity and noise exposure groups (*P*-value <0.05). Based on the results of multiple regression analysis among four variables including age, work experience, noise exposure and noise sensitivity, noise exposure and noise sensitivity had significant effect on psychological distress and could explain 0.36 and 0.25 of variance of response variable, respectively. Age and work experience at the level of 5% error had no significant effect on psychological distress status.

Conclusion: It can be argued that the worsening of psychological distress in these employees is often due to noise exposure and noise sensitivity. As an individual variable, noise exposure has the greatest effect on increase of psychological distress compared to noise sensitivity level and demographic characteristics studied.

Keywords: Noise Sensitivity; Noise exposure; Psychological distress; Automotive industry employees

Introduction

Exposure to high levels of the environmental noise is considered as one of the causes of physical and mental illnesses in society.[1-3] This factor affects millions of workers worldwide every year.[4] Noise exposure causes fatigue in mental and physical tasks that have different cognitive and physical workloads in workers. It also affects the mental states of individuals and disrupts their adaptation to the work

Citation: Mousavi Kordmiri SH, Monazzam MR, Abbasi M, kamali S, Mousavi Kordmiri SA. **Association between Noise Exposure and Sensitivity and Psychological Distress.** Archives of Occupational Health. 2019; 3(3): 400-8.
Article History: Received: 5 May 2019; Revised: 6 June 2019; Accepted: 1 July2019

environment and even the environment of the family and society, resulting in reduced Work efficiency.[2, 5, 6] There are studies to show that noise exposure can lead to an increase of error rates and accidents and a decrease of productivity.[4, 7] One of the basic hypotheses about how this factor affects is that the noise exerts its effects through certain mediators, including psychological variables such as noise sensitivity and noise annoyance.[8-11]

Monazzam et al. have argued that noise sensitivity is a major predictor of the degree of noise annoyance and acts as a mediator for the effects of noise on the psychological aspects of human health.[12] Noise sensitive individuals are more vulnerable to noise compared to non-noise sensitive ones, and therefore when exposed to noise, they display more emotional responses and hardly adapt to noise.[13-15] Psychological distress is a general term to refer to unpleasant feelings or emotions that affect the level of performance of individuals.[16] Mental impairment is associated with flexible and creative thinking and good social behavior and physical health, so that the deficiency in each of the above factors causes mental disorders at varying degrees.[17]

In one study by Rostami et al. (2015) on the effect of noise exposure on the general health of workers in the steel industry, it was shown that workers exposed to noise had significantly different levels of depression compared to the control group, so that 36% of workers exposed to noise suffered from at least one mental disorder. The results of that study showed that noise could be considered as a risk factor for mental disorders.[18] Although noise-induced discomfort is recognized as an important stressor in the environment and working environment, its association with mental health has been studied less frequently.

Further, most of the previous studies have addressed noise pollution caused by traffic and flights, and people who work in industries with far higher levels of occupational noise have been mostly neglected. Meanwhile, the automotive and automobile parts manufacturing industries are among the industries in which, due to their nature, exposure to noise caused by certain machinery equipment such as cutting, pressing, welding and milling is particularly important.[19-21] Therefore, the present study was aimed to investigate the relationship of noise exposure and noise sensitivity to psychological distress among different occupational groups in an automobile parts manufacturing industry.

Methods

This cross-sectional, descriptive-analytical study was carried out in an automobile parts manufacturing industry in 2018. In this study, the inclusion criteria were having at least two years of work experience and history of taking anti-depressant drugs. The individuals with hearing impairments were excluded from the study. The study population consisted of all employees of the industrial group under study (n = 650). Given $\alpha = 0.05$ and $\beta = 0.8$, the minimum sample size was determined at 242 using the Cochran formula. Eventually, 325 employees of the industrial group from six manufacturing units and one administrative unit with different levels of noise exposures were included. The noise exposure level was measured in terms of the equivalent level in each occupational group using calibrated sound level meter (SVANTEK-971) equipped with analyzer based on ISO-9612 standards. All measurements were performed in the A network and in SLOW mode.

The instrument was calibrated before each measurement. Eventually, the equivalent level of the daily personal noise exposure (LEP,d) (dBA) during eight working hours was measured. In generalizing the results regarding noise exposure, the similarity of the work process in different occupations was taken into account, and measurements were performed on one person representing one occupation. Besides, in places with the highest sound level where people spent most of their working time, frequency analysis was performed at octave band frequencies to obtain information about the frequency spectrum of the

noise in these places. After determining the level of noise exposure for participants, a demographic information questionnaire, Kessler Psychological Distress Scale[22] and Weinstein's Noise Sensitivity Scale (WNSS)[20] were completed by them as the researcher was present. Kessler Psychological Distress Scale was developed by Kessler et al. in 2002 to detect mental disorders in the general population. This scale has two versions, 10-item (K10) and 6-item (K6). The items in both versions are rated on a 5-point Likert scale from "never" to "always" and scored 1-5. Therefore the maximum attainable score on K10 is 50. The greater the score on this scale is, the more severe psychological distress will be.[22, 23]

In this study, the K10 was used. The Persian version of the K10 was investigated by Yaghubi (2015) and its construct validity and correlation were confirmed.[24] Finally, participants were ranked according to their scores. To this end, participants attaining scores below 20 were considered to be good and healthy, scores 20-24 to have a mild mental disorder, scores 25-29 to have a moderate mental disorder, and scores 30-50 to have a severe mental disorder. The WNSS is used to determine the degree of noise sensitivity and vulnerability of individuals. The validity and reliability of the scale have been approved.[25] The participants were divided into three categories, ie, low sensitivity [≤62], moderate sensitivity [62< sensitivity score ≤88] and high sensitivity [>88], according to their scores on noise sensitivity.

The data was analyzed using the SPSS version 23. In order to compare the mean scores on mental distress and noise sensitivity among different levels of exposure to the noise of devices, age groups and work experience, one-way ANOVA was used because data were normally distributed. Besides that, two independent samples T test was used to compare psychological distress among different education levels. Pearson correlation coefficient was also used to investigate the relationship of psychological distress to the noise exposure and noise sensitivity levels, age and work experience. The Separate effect of each of the independent variables (noise exposure, noise sensitivity, age and work experience) on the severity of psychological distress was investigated using simple linear regression model. Multiple regression analysis was used to study the simultaneous effect of the four independent variables age, work experience, noise sensitivity and noise exposure on the dependent variable mental disorder.

Results

Of the 650 employees in the studied industrial group, 325 volunteered to participate in the study, all of whom were male and permanent daily workers. Forty-four (13.5%) of participants were occupied in the administrative unit, 57 (17.5%) in the pressing unit, 49 (15%) in the cutting unit, 42 (13%) in the assembly unit, 36 (11%) in the bolts manufacturing unit, 45 (14%) in the molding unit and 52 (16%) in the Metallurgical unit (die cast and casting). The mean age and work experience of participants were 36.46 (7.18) and 13.26 (5.15) years, respectively. 118 (36.2%) had an education level of lower than high school diploma and 207 (63.8%) had high school diploma and higher education levels. The results of the sound level meter and frequency analysis in different occupational groups are presented in Table 1 and Figure 1, respectively.

Table 1. Descriptive data on occupational groups and daily personal noise exposure

Occupational group	Number(%)	(SD) Daily Personal Noise Exposure(dBA)
Administrative	44(13.50)	54.3 (1.3)
Assembly	42(13.00)	78.8 (1.6)
Metallurgical unit (die cast and casting)	52(16.00)	82.5 (1.5)
Molding	45(14.00)	84.0 (3.2)
Pressing	57(17.50)	90.5 (8.2)
Cutting	49(15.00)	89.3 (7.7)
Bolts Manufacturing unit	36(11.00)	88.5 (4.5)

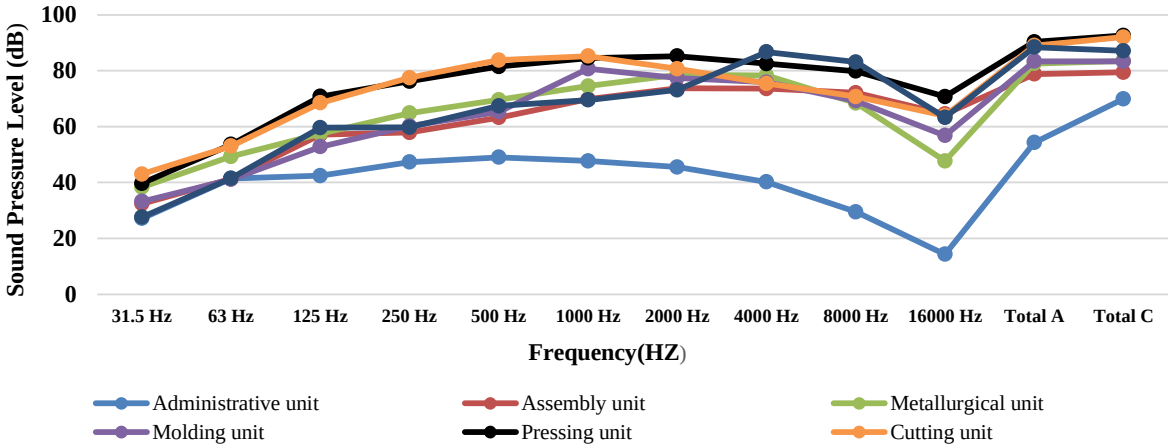

Figure 1. The results of frequency analysis of one octave band occupational groups

Table 2. Descriptive data on psychological distress according to noise sensitivity, occupational group, work experience and age group

			Mean Psychological distress (SD)	*p*-value
Psychological distress	**Mean Total Psychological distress**		23.46 (3.45)	
	Occupational group	Administrative	16.78 (3.22)	*<0.001
		Assembly	21.24 (2.58)	
		Molding	23.13 (2.61)	
		Die casting	23.76 (2.64)	
		Pressing	24.44 (2.82)	
		cutting	26.10 (3.44)	
		production unit Bolts	28.77 (2.74)	
	sensitivity†	Low	17.87 (3.67)	*<0.001
		Moderate	24.79 (1.94)	
		High	27.72 (2.09)	
	Age†	…< 35	18.44 (3.15)	*<0.015
		35-40	24.59 (1.78)	
		40 <…	27.35 (2.98)	
	Experience†	…<10	19.66 (3.24)	*<0.002
		10-20	23.08 (2.67)	
		20 <…	27.64 (1.52)	
	Education‡	…< Diploma	23.90 (2.59)	*<0.811
		Diploma ≤ …	23.02 (3.21)	

*Significant at the 0.05 level † One-way variance analysis ‡ Independent sample t-test

Employees in the pressing unit had the highest noise exposure [mean (SD): 90.5 (8.2)] Table 1. Furthermore, the noise exposure of employees in the cutting and Bolts manufacturing unit [mean (SD): 89.3 (7.7) and 88.5 (4.5), respectively] was higher than the permissible daily limits. Among the participants, the lowest noise exposure [mean (SD): 54.3 (1.3)] was observed in the employees of the administrative unit. It can be said that noise exposure at all octave frequencies was higher in the employees of the pressing unit than in the other occupational groups. Besides that, because the sound level at frequencies of 500-4000 Hz is almost higher than the other important frequencies for the auditory system, it can be acknowledged that the noise in these industries has a relatively high frequency. Mean noise sensitivity in our participants was 69.37 (9.14), with 38.2% (n: 124), 47.3% (n: 154) and 14.5% (n: 47) of them having mild, moderate and severe noise sensitivity, respectively.

The mean (SD) mental disorders in all employees was 23.46 (3.45), with the employees of the pressing and administrative units having the highest and lowest mental disorders (mean: 28.77 (2.74) and 16.78

(3.22), respectively. The descriptive data on the rates of mental disorders according to occupational group, noise sensitivity and demographic variables are shown in Table 2. One-way ANOVA and two independent samples T test were used to investigate the mean difference in noise-induced mental disorders among demographic variables and occupational groups Table 2.

Based on the results of analysis of variance, the mean psychological distress was different with respect to occupational group, age and work experience (*P*-value < 0.05). The two independent samples T test results showed that the education level had no significant relationship to psychological distress (*P*-value > 0.05). The results of the relationship of noise exposure and noise sensitivity to psychological distress are illustrated in Figures 2 and 3.

The results of Figures 2 and 3 show that with increasing daily personal noise exposure (dB) and noise sensitivity, the mean psychological distress in employees also increases. Multiple regression analysis with forward selection was used to investigate the effect of significant variables according to the analysis of variance and independent T test results such as age, work experience, noise sensitivity and daily personal noise exposure (LEP,d) on psychological distress. Based on the multiple regression results, the variables under study could explain 42% of changes in psychological distress. Although there are many factors affecting psychological distress, only four variables were comparatively investigated in this study.

The regression results indicated that among independent variables such as age, work experience, noise exposure and noise sensitivity, noise exposure had the highest incremental effect (standardized regression coefficient: 0.36) on psychological distress followed by noise sensitivity, so that the psychological distress increased by 0.36 per 1-dB increase of noise exposure assuming that other variables entered into the model remained constant.

The results drawn from the model showed that although there was a significant difference in the mean psychological distress with respect to occupational group and work experience, these two variables did not have any significant effect on mental disorders in the presence of noise sensitivity and noise exposure. Among the independent variables studied, noise exposure had the greatest effect on mental disorders in terms of statistical significance.

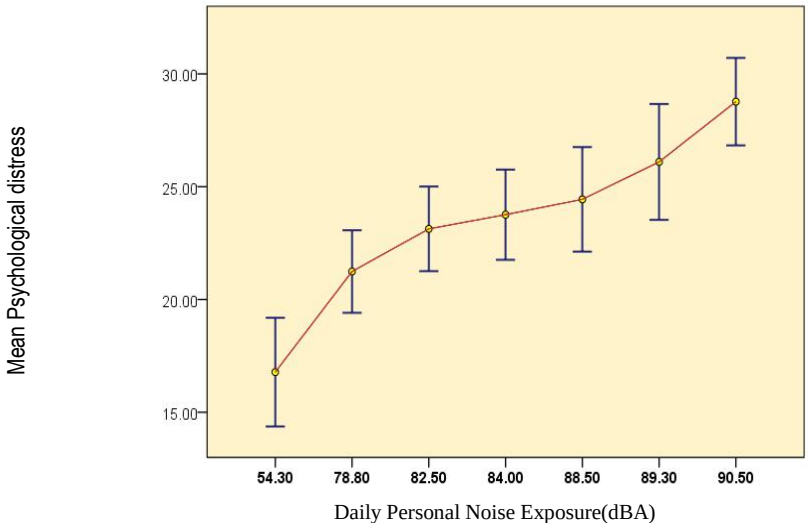

Figure 2. Comparison of psychological distress in different levels of exposure to devices' noise

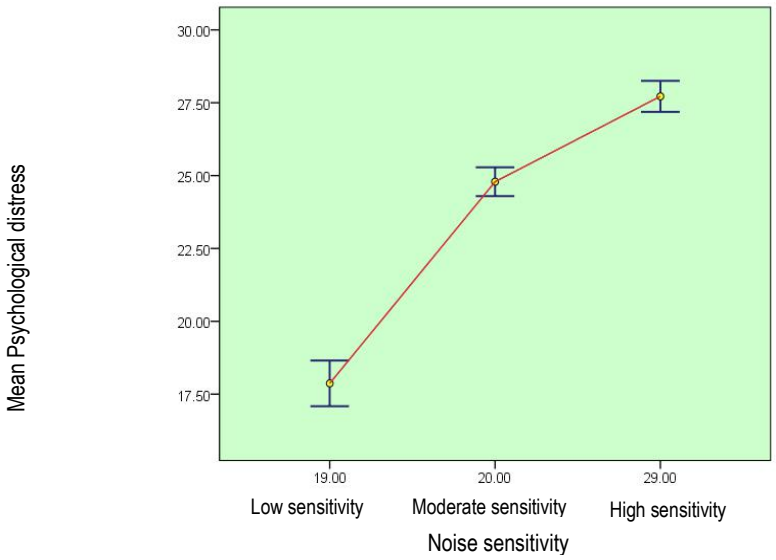

Figure 3. The rates of psychological distress of the employees according to the level of noise sensitivity

Discussion and conclusion

The aim of this study was to investigate the relationship of noise exposure and noise sensitivity to psychological distress among different occupational groups in an automobile parts manufacturing industry. The results showed that our participants had a mean noise sensitivity score of 69.37 (8.14) which may indicate a moderate noise sensitivity in the study population. The results of this study showed that there was a significant difference in the mean the psychological distress with respect to noise sensitivity, occupational group, age, work experience and noise exposure. Based on the results, the average score of mental disorders in the present study was obtained 23.46 (3.45). This indicates the likelihood of a mild mental disorder in all members of the study population. The results of one-way ANOVA showed that the psychological distress varied in different occupational groups, so that the psychological distress scores of employees in the cutting and pressing units were higher than those of the other occupational groups and the administrative staff had the lowest score of mental disorders. In this study, people with higher noise exposure attained higher mental disorder scores. Besides, the psychological distress scores were higher in the age group of over 40 years and employees with the work experience of over 20 years than in the other age groups and those with other work experience, indicating that mental health was comparatively lower in these two groups Table 2.

These results are consistent with the study of Yoon et al. (2014) in various occupations in the United States. Yoon et al. reported a significant relationship of the discomfort caused by occupational noise to psychological symptoms.[26] Bakker (2012) showed a significant relationship between exposure to wind turbines noise and noise annoyance, mental disorder, and sleep disorder. This association was tested as a structural model whose results showed that exposure to wind turbines noise caused annoyance, sleep disorders and mental disorders. Furthermore, people who did not hear the noise of turbines did not have any symptoms of mental disorder, and the sound of turbines caused mental disorder indirectly through affecting annoyance.[27] In one study by Rostami et al. (2015) on the effect of noise exposure on the general health of workers in the steel industry, it was shown that workers exposed to noise had significantly different levels of depression compared to the control group, so that 36% of workers exposed to noise suffered from at least one mental disorder. The result of that study showed that noise could be considered as a risk factor for mental disorders.[19]

Although separate results regarding the effect of age and work experience revealed a significant difference in mental disorders with respect to age group and work experience, the regression results showed that work experience and age had no effect on mental distress in the presence of other variables. Although numerous factors contribute to the development and increase of mental disorders, which is not the subject of our study, the share of each of the factors that cause an effect will be determined in regression models. In the present study, noise exposure and sensitivity were able to justify 42% of changes in psychological distress. In other words, noise exposure and noise sensitivity is a major contributor to psychological distress in comparison with age and work experience, as well as constant consideration of all intervening variables. Therefore, it can be argued that the worsening of the mental health of the employees in the studied industrial group is often due to their noise exposure and noise sensitivity. Beutel et al. conducted a cohort study on 15010 individuals from general population in Germany in 2016, and examined the contribution of diverse environmental and occupational resources to noise annoyance, and argued that depression and anxiety were associated with total noise annoyance so that they further intensified with increase of noise annoyance.[2]

A study on Austrian schoolchildren aged 8 to 11 showed that there was a dose-response relationship between noise exposure and self-reported psychiatric disorders.[28] Because noise sensitivity is one of the attitudinal factors for noise-induced discomfort, it can be claimed according to this study that the physiological characteristics of the people are not the same and that different individuals are not equally affected by noise from psychological and neurological perspective, so that one noise can be tolerable for some people but annoying for others.As a result, our study suggests that noise sensitivity is a personal trait that increases the individual's vulnerability to noise. Therefore, it can be argued that noise exposure affects the psychological conditions of individuals both directly and indirectly through noise sensitivity.

Previous studies have shown that those who have noise sensitivity have a lower threshold for psychological responses and therefore perceive the noise as louder, which can lead to psychological and physiological health problems such as stress.[29-31] Studies show that given psychiatry-dependent variables, people with high noise sensitivity are more likely to experience discomfort and mental disorders than those with mild noise sensitivity, and negative emotions such as depression, anxiety, anger, tension and disability have been reported to be higher in people with high noise sensitivity irrespective of the level of the sound.[32-34] Schreckenberg et al. (2010) found that noise sensitivity was correlated with reported health but not mental health.[35] However, in a longitudinal study by Stansfeld et al. (2015), noise sensitivity, even when no primary and baseline psychological distress was considered, was found to serve as a predictor of depression and psychological distress. The study of Stansfeld et al. showed that noise sensitivity was associated with a low level of health-related quality of life due to the symptoms of depression.[36] These results support the findings of our study.

Given that the present study was a cross-sectional study and data was collected using subjective instruments, the results undoubtedly suffer from a certain level of bias. Therefore, it is suggested that more objective investigations with follow-up examinations be conducted in additional studies to obtain more reliable findings.

Overall, the results of this study indicate that there is a significant relationship of noise exposure and noise sensitivity to psychological distress so that people with higher noise exposure or higher noise sensitivity have more severe psychological distress. Therefore, given the results of this study and the unacceptable noise exposure levels in the employees of this industrial group, the implementation of a hearing conservation

program and the adoption of engineering-technical and managerial measures and methods seem necessary to control noise in some units so that physical and mental consequences of noise could be prevented in their employees.Furthermore, given the important role of noise sensitivity in creating psychological distress, it is possible to identify individuals with severe noise sensitivity and avoid hiring them in sensitive situations so that the rates of psychological complications and damages could be reduced.

Acknowledgment

This article was obtained from a Master's thesis supported by Tehran University of Medical Sciences (code: 97-02-27-38718). We hereby acknowledge the cooperation of the University and the authorities of the studied automobile parts manufacturing industry.

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