



Correlation between Noise Exposure and Mental Health Components among Iranian Steel Workers, 2021

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Citation: Fallah Madvari R, Tahmasbi Abdar F, Halvani GH, Sefidkar R, Mohammadi M, Sojoudi S, Jafari Nodoushan M. Correlation between Noise Exposure and Mental Health Components among Iranian Steel Workers, 2021. *J Occup Health Epidemiol.* 2022;11(2):148-56.

Article Info

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Article history

Received: Nov 2021
Accepted: Apr 2022

 10.52547/johe.11.2.148

Print ISSN: 2251-8096
Online ISSN: 2252-0902

Peer review under
responsibility of Journal of
Occupational Health and
Epidemiology

Abstract

Background: Noise is an important occupational safety and health issue in many workplaces. Noise annoyance is a strong measurable mental response. It is a reaction that a person expresses to the noise exposure. Thus, this study investigates the correlation between noise exposure and its annoyance in terms of mental health components.

Materials and Methods: This was a correlational descriptive study conducted on 100 workers. Respondents were recruited by a simple random sampling method. The equivalent sound level (LeqA) was determined using dosimetry. The numerical scale of ISO/TS 15666:2003 was used to measure noise annoyance. Mental health components were determined using the SCL-90 mental health questionnaire. Data analysis was performed in SPSS software (version 22) using Mann-Whitney, Kruskal-Wallis, and correlation tests.

Results: The median of mental health and noise annoyance were 38 and 6.5, respectively. A positive correlation was observed between equivalent sound level (LeqA) and noise annoyance score ($P < 0.001$, $r = 0.92$). A significant correlation was found between mental health components (depression, anxiety, self-morbidity, obsession and compulsion, aggression, morbid fear, paranoid thoughts, psychosis, and sensitivity in interpersonal relationships) and equivalent sound level ($P < 0.001$). Also, a significant correlation was observed between noise annoyance score and mental health components ($P < 0.001$).

Conclusion: We concluded that in order to enhance the mental health of employees and increment efficiency and performance, it is recommended that appropriate control methods should be applied.

Keywords: Noise-Induced, Hearing Protective Device, Mental Health, Depression, Anxiety, Industry, Aggression, Psychotic Disorders

Introduction

Today, noise is considered an important occupational safety and health issue in many

industrial complexes. In recent years, with the expansion of various equipment and machinery in industries, noise has become a health concern [1]. Noise annoyance is a reaction that a person

expresses to noise exposure. This reaction can take many forms, including dissatisfaction, harassment, and disruption [2]. Most studies of workplace noise show the noise level to be higher than allowed [3]. Recent estimates show that 7% of the world's population is exposed to inappropriate workplace noise [4]. Statistics also indicate that about 600 million workers globally are exposed to workplace noise [5]. According to studies in the United States and Europe, about 50-60 million of the workforce is exposed to dangerous noise [6]. Statistics from the Ministry of Health of Iran show that about 2 million employees are exposed to impermissible noise (85 dB) [7].

The noise effects are very diverse. Auditory effects include temporary hearing loss or deafness and tinnitus [8]. While hearing impairment is a major concern in dealing with noise, its other physical and psychological effects should not be overlooked. Exposure to unauthorized noise can, in addition to causing auditory effects, lead to non-auditory impacts such as psychological disorders in individuals [9]. The psychological effects often appear gradually in people, and in the long run, it has consequences such as sleep disorders, distraction, stress, and mental fatigue [10]. Noise can also affect mood by affecting the endocrine glands [11]. Broucek et al. showed a significant relationship between exposure to noise and verbal anger [12]. Studies also show that about 63% of people exposed to noise suffer from anger and rage [10]. Various studies indicate that people's exposure to noise has a positive and significant relationship with noise annoyance [13]. In the study of Abbasi et al., performed on the Manjil wind power plant employees, a significant relationship was found between noise level and noise annoyance [14]. Also, a significant relationship is observed between air traffic noise and noise annoyance [15]. Noise annoyance can harm sleep quality and psychological distress [16]. Van den Berg states that noise annoyance is highly correlated with sleep disorders. He believes noise annoyance is a better predictor of sleep disorders than the noise itself [17]. In addition, Fallah et al. showed that noise annoyance could also affect burnout [4].

Maintaining and promoting the health of employees is important. Employee health levels can affect organizational productivity and job performance [18]. Health is defined as complete well-being in four dimensions: physical, mental, spiritual, and social [19]. The World Health Organization emphasizes that neither of these dimensions is superior to the other [20]. Mental health is vital in all aspects of life. Therefore, it is necessary to identify the factors affecting mental

health [21]. Numerous factors, such as stress, can affect mental health [22]. One of them is the job of individuals [23]. Some environmental factors in workplaces can lead to mental disorders. Studies show that noise exposure can affect mental health [25]. Masoudzadeh et al. reported that the mental health status of low-noise areas is better than that of high-noise areas [26].

Moreover, Thomas Münzel et al. showed that noise exposure at low levels could lead to sleep and communication disorders. In addition, they showed that people exposed to noise exhibit emotional reactions such as stress and anxiety [27]. Hammersen et al. investigated the relationship between noise annoyance and mental health in German adults. They indicated noise annoyance to be associated with mental disorders; further, they showed that with the increase of annoyance caused by ambient noise sources, mental disorders also increased [28].

In the steel industry, sound pressure is above the permissible level. Equipment such as pumps and furnaces are sources of noise production. The studies conducted in the steel industry show that the noise produced is above the permissible level (85 dBA) [29]. Hence, it is predicted that mental health is high among workers in the industry. Today, the steel industry is significantly expanded, thus employing many workers. Therefore, inattention to the noise in this industry can threaten the health of many workers. This study investigates the association of noise exposure and its annoyance with mental health components.

Materials and Methods

This cross-sectional study was conducted in 2021 in the steel Industry. The participants were male workers selected by a simple random sampling method. All workers were randomly selected from noisy sections. Inclusion criteria included being male, age under 50 years due to the removal of age-related confounders, and work experience of more than six months due to the presence of a worker in the workplace for a significant period. Also, people with a history of taking antidepressants and psychotropic drugs and hearing problems were excluded from the study. Since the aim was to study the correlation between variables, the sample size was determined using formula 1 [30].

Formula 1.

$$n = \left(\frac{Z_{1-\frac{\alpha}{2}} + Z_{1-\beta}}{0.5 \ln\left(\frac{1+r}{1-r}\right)} \right)^2 + 3$$

α , β , and r coefficients were determined by reviewing similar studies and the opinion of the

researcher [31, 32]. Considering $\alpha = 0.05$, $\beta = 0.2$, and $r = 0.29$, the sample size was equal to 91. Taking a 10% loss into account, the final sample size was 100. After the oral and written explanation of the details of the study and the completion and confirmation of informed consent by each individual, the mental health and noise annoyance questionnaires were provided to them. Individuals were also assured that their information and details would remain confidential. The study protocol was confirmed by Shahid Sadoughi University of Medical Sciences (IR.SSU.SPH.REC.1399.212).

In this study, frequency, percentage frequency, and mean and standard deviation were used to describe the information. Mann-Whitney, Kruskal-Wallis and correlation tests were also used for statistical analysis. To check the normality of the data, the Kolmogorov-Smirnov test was used. In the case of non-normal data, median and Interquartile Range indices were used to express centrality and dispersion. Data analysis was performed in version 22 of SPSS software.

Noise Exposure: Noise measurement was performed using the dosimetry method. It was under the ISO 9612:2009 standard [33]. The equivalent sound level (Leq) was measured using a dosimeter model TES-1354 in Taiwan. Before measurement, the device was calibrated with a

TES-1356 calibrator (made in Taiwan) to obtain accurate results. The dosimeter was set up for the worker. The microphone of the dosimeter was set up at a standard distance from the ear canal (10 to 30 cm). Workers were requested to bring the device with them until the end of the shift work. The shift was eight hours. Finally, the equivalent sound level was calculated using formula 2 [4].

Formula 2.

$$Leq_{8hr} = 10 \log \left(\frac{D \times T}{100 \times t} \right) + SPL$$

D = Noise dose

T = Duration of work shift = 8 hour

t = Exposure time = 8 hour

SPL = Standard sound pressure level = 85 dBA

Noise Annoyance Questionnaire: The noise annoyance of the workers was assessed by the numerical scale of ISO/TS 15666:2003. This scale included 11 classes from zero to 10. Higher scores (near 10) indicated more annoyance (Fig. 1). Participants should choose their level of annoyance from zero to 10 [34]. The validity and reliability were evaluated by Alimohammadi et al. [35].

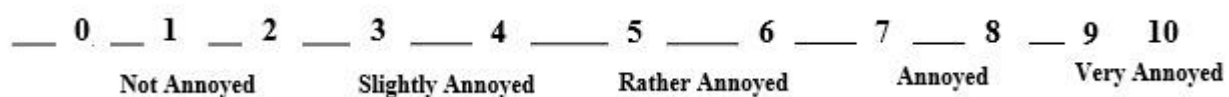


Fig. 1. Noise Annoyance Scale [36]

Mental Health Questionnaire (SCI-90): The questionnaire was designed in 1972 by Derogatis et al., but the final form was prepared in 1976. This questionnaire has 90 questions, with ten for each of the nine mental health symptoms, including depression, anxiety, self-morbidity, obsession and compulsion, sensitivity in interpersonal relationships, aggression, morbid fear, paranoid thoughts, and psychosis. This questionnaire is divided into a 5-point Likert scale (none = 0, strongly = 4). In this questionnaire, the minimum score is zero for each question, and the maximum score is four. Higher scores indicate a more severe mental disorder [37]. Various studies have confirmed its reliability. A study was conducted on 219 volunteers in the United States to assess their internal stability. In this study, Kuder-Richardson-20 and alpha coefficients were used. The results

obtained for the 9 dimensions were quite satisfactory. The lowest correlation was related to the dimension of psychosis (77%), and the highest correlation was related to depression (90%) [38]. According to Babaei et al., the total scale reliability coefficient by the Cronbach alpha method was 0.84 [39]. In Yazarloo et al., Cronbach's alpha coefficient for self-morbidity was 0.85, obsession and compulsion 0.80, sensitivity in interpersonal relationships 0.88, depression 0.92, morbid fear 0.79, paranoid thoughts 0.87, anxiety 0.77, aggression 0.83, and psychosis 0.87 [40].

Results

The mean age of the subjects was 37.68 ± 6.25 years. Also, their mean work experience was equal to 13.20 ± 4.60 years. Table 1 presents the demographic variables.

Table 1. Frequency distribution of demographic variables (n=100)

Variable	Grouping	Frequency	Percent
Education status	High school	15	15
	Diploma	59	59
	Above the diploma	26	26
Using earplugs and earmuff	Yes	89	89
	No	11	11
Smoking	Yes	17	17
	No	83	83
Number of children	0	19	19
	1-2	67	67
	3	14	14
Residence status	Native of Yazd	87	87
	Non-native	13	13
Shift work	One-shift	32	32
	Shift Work*	68	68

* Morning, Evening, Night

Most workers (89%) use a Hearing Protection Device (HPD) in the workplace, and 83% do not smoke. Table 2 also shows the association of the noise annoyance score and the mental health score with demographic variables. Since the results of the Kolmogorov-Smirnov test showed the

distribution of scores of mental health and noise annoyance was not normal ($P < 0.05$), median and Interquartile Range indices were reported.

The median and interquartile range of mental health, noise annoyance, and equivalent sound level are presented in Table 3.

Table 2. The association of mental health and noise annoyance of individuals with demographic variables

Qualitative demographic variables	Noise annoyance			Mental health		
	Median	Interquartile range	P-value	Median	Interquartile range	P-value
Education status	High school	7	5	16	48	0.04
	Diploma	6.5	3	43	45.25	
	Above the diploma	5.5	3.25	33.50	39.50	
Using earplugs and earmuff	Yes	6	3	38.50	50.50	0.42
	No	7	2.5	34	89.50	
Smoking	Yes	6.5	4.75	60.50	67.25	0.02
	No	6.5	2.5	34	48	
Number of children	0	5	4	15	49	0.24
	1-2	7	3	39	43	
	3 \geq	5	3.5	52	61	
Residence status	Native of Yazd	6.5	3	36.5	46	0.88
	Non-native	5	3	40	74	
Shift work	One-shift	6.5	3	34	62	0.60
	Shift work	6.5	3	38.5	44	

According to Table 2, there was no significant relationship between noise annoyance score and smoking, residence status, the number of children, the use of HPD, education level, and shift work ($P > 0.05$). Unlike the noise annoyance score, a significant relationship was found between the worker's mental health score and smoking

($P = 0.02$). A significant relationship was found between workers' mental health scores and education ($P = 0.04$). No significant relationship was found between mental health score and residence status, the number of children, the use of HPD, and work shift ($P > 0.05$).

Table 3. Mental health, noise annoyance, and equivalent sound level

Variable	Median	Interquartile range
Mental health	38	49.50
Noise annoyance	6.5	3
Equivalent sound level	87.50	8

No significant relationship was found between age and noise annoyance score ($r=0.18$, $P=0.07$). A significant relationship was observed between noise annoyance score and work experience ($r=0.36$, $P<0.001$). Also, no significant relationship was observed between age and mental health score ($r=0.08$, $P=0.43$). A significant relationship was found between the mental health scores and

work experience ($r=0.28$, $P=0.006$). A significant relationship was found between equivalent sound level and noise annoyance ($P<0.001$, $r=0.92$). Spearman correlation test was used to investigate the association of equivalent sound level and noise annoyance with mental health components (Table 4).

Table 4. The association of equivalent sound level and noise annoyance with mental health components

Mental health components	Equivalent sound level		Noise annoyance	
	Correlation coefficient	P-value	Correlation coefficient	P-value
Depression	0.43	<0.001	0.37	<0.001
Anxiety	0.45	<0.001	0.44	<0.001
Self-morbidity	0.41	<0.001	0.39	<0.001
Obsession and compulsion	0.37	<0.001	0.35	<0.001
Sensitivity in interpersonal relationships	0.51	<0.001	0.51	<0.001
Aggression	0.36	<0.001	0.37	<0.001
Morbid fear	0.39	<0.001	0.36	<0.001
Paranoid thoughts	0.42	<0.001	0.41	<0.001
Psychosis	0.42	<0.001	0.42	<0.001
Total (Mental health)	0.46	<0.001	0.45	<0.001

Table 4, shows a relationship between equivalent sound level and mental health components ($P<0.001$). There was also a significant relationship between noise annoyance and mental health components, including depression, anxiety, self-morbidity, obsession and compulsion, sensitivity in interpersonal relationships, aggression, morbid fear, paranoid thoughts, and psychosis ($P<0.001$).

Discussion

The relationship between noise and mental health components was investigated. The median noise annoyance was 6.5, indicating moderate annoyance in the community. The results showed that noise annoyance was significantly related to work experience. The relationship between annoyance and work experience may be due to prolonged exposure to noise [41]. The median mental health was 38. The data analysis showed a significant association of mental health with work experience, education level, and smoking. Increasing the level of education can lead to a better job position and increased control over the job. The latter can reduce stress and improve mental health [42]. The median equivalent sound

level was 87.50, higher than the permissible limit of the ACGIH standard.

Modarresi et al. showed no significant relationship between education level and mental health, inconsistent with the present study [43]. Nadri et al. found a significant relationship between education level and mental health. Their study also showed a significant relationship between age groups and mental health, inconsistent with the present study [44]. This result can be due to differences in work environments and personality traits of the subjects [45]. This study found a significant relationship between shift work and mental health. Shift work causes sleep disorders, and sleep disorders, in turn, can affect mental health [46]. Hoseini et al. showed smoking to be associated with mental health [47]. Smoking cessation programs can improve mental health and increase productivity [48]. Few researchers also believe that smoking is a way to deal with adverse conditions [49]. According to Fallah et al., noise annoyance and age were unrelated [50]. Another study, observed a positive and significant correlation between noise annoyance and age [51]. Contradictory results in studies can be due to different criteria for assessing noise annoyance and differences in the

threshold of this factor in the studied populations [52].

Ali found a significant and positive relationship between noise exposure and annoyance [53]. Pedersen et al. aimed to investigate the relationship between noise pollution and annoyance, emphasizing differences in the living environment; the results showed that an increase in the sound pressure level increased the noise annoyance [54]. Despite the differences in population and type of sound sources, studies show that sound pressure level significantly affects noise annoyance.

Based on Monazzam et al., noise exposure was associated with noise annoyance and psychosis. In their study, a significant relationship was found between age and psychosis. The authors conclude that this difference is due to work environment and study population differences. Also, a significant relationship was found between work experience and psychosis, consistent with the present study [2]. Prolonged exposure to harmful factors such as noise in the workplace can cause burnout and affect [2, 4]. Workers' mental health.

Shepherd believes noise annoyance is associated with mental conditions such as anxiety and can lead to mental health disorders [55]. Beutel et al. investigated the contribution of environmental and occupational noise resources to noise annoyance. This cohort study was performed on 15010 people from the general population of Germany. Based on its results, depression and anxiety had a positive and significant relationship with the rate of noise annoyance [56]. Hammersen et al. showed that noise annoyance and mental health differ for noise sources.

Further, the results showed that annoyance caused by road traffic could affect mental health. However, no significant relationship was found between noise annoyance caused by air traffic and mental health [28]. Various studies show that noise annoyance can be influenced by personality traits and noise frequency [57]. Jing et al. (2018) aimed to investigate the effect of noise on the mental health of 117 citizens (18-60 years old) in Beijing. This study showed that people with more noise exposure had poorer mental health [58]. Yoon et al. (2014) aimed to investigate the effect of noise exposure on the mental health of Korean employees. This study showed a positive and significant relationship between occupational exposure to noise and mental health [59]. In a study on Manjil wind power plant employees, noise annoyance and age were associated [14]. Jensen stated that people with a higher experience of noise annoyance had higher stress and poorer mental health [60]. Dzhambov showed that noise

annoyance could affect people's social cohesion and mental health. Individuals with more vocal disturbances report less social cohesion and worse mental health [61]. These effects can be attributed to stimulation of the Hypothalamic Pituitary Adrenal (HPA) axis by noise. This stimulation results in the secretion of cortisol (stress hormone). High secretion of this hormone due to noise exposure can lead to mental disorders [62].

Contradictory results in this area can be due to the type of jobs studied, different noise sources, and various working conditions. Limitations of this study that could affect the results included the impossibility of examining the trend of changes in the cross-sectional study.

Conclusion

The present study results show that noise and its annoyance can affect mental health. Indeed, workers exposed to higher noise and annoyance had poorer mental health. In order to maintain the mental health of employees and increment efficiency and performance, it is recommended to take measures such as implementing hearing protection programs and appropriate control methods. Researchers in the future could conduct similar studies with bigger sample sizes and more variables such as personality type and noise sensitivity. In addition to noise annoyance, other environmentally harmful factors of the workplace such as vibration, lighting, and heat stress can also be investigated.

Acknowledgement

This work was supported by the Shahid Sadoughi University of Medical Sciences [project code 8255]. The article's authors express their gratitude and thanks to the officials and esteemed employees of the Steel Industry for their sincere cooperation in implementing this project.

Conflict of interest: None declared.

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