

# Association between noise annoyance and hearing loss caused by chronic exposure to noise among the workers of an automotive industry

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## Abstract

**Background:** As a physical pollutant in the workplace, noise has physiological and psychological consequences for people.

**Objective:** The aim of this study was to investigate the relationship between annoyance and hearing loss in the people exposed to chronic noise in the automotive industry.

**Methods:** 250 workers exposed to sound pressure in the work environment were randomly selected. The DANPLEX-AS54 audiometry device was also used to measure the workers' hearing levels. Furthermore, an annoyance inventory containing questions numbered 1 to 11 to indicate the level of annoyance was used as well.

**Results:** using Pearson correlation coefficient to evaluate hearing levels and annoyance, we found out a significant positive relationship between annoyance and hearing level at frequencies of 2000, 4000 and 8000 in the left ear, and frequency of 6000 in the right ear ( $P < 0.001$ ). Also, there was a significant relationship between annoyance and NIHL (noise-induced hearing loss) in the left ear, and general conditions (both ears) ( $P < 0.001$ ).

**Conclusion:** The results of this study, showed that there was a significant positive relationship between noise annoyance and hearing loss among the workers, and the likelihood of noise annoyance increased with the incidence of hearing loss.

## Introduction

The advancement of technology, population growth, the use of vehicles and other issues of life all contribute to the annoyance of the modern men and depriving them of comfort by producing unpleasant noise [1]. Various studies have shown that unwanted noise can lead to hearing impairment, interruptions in speech, sleep disturbance, noise annoyance, and reduced performance of individuals and chronic physiological effects, including hypertension [2]. Negative effects of exposure to annoying noise not only affect hearing, but also lead to psychological and mental problems that may affect the lifestyle and work of the individuals [1,3]. Exposure to the noise pollution caused by industries and suffering from hearing loss resulted from it is one of the main problems of all industries [4]. Also, exposure to noise above the standard level can be a source of stress for workers, and reduce their level of comfort during work [5].

Continuous and prolonged exposures to 85 dB can cause temporary or permanent noise-induced hearing loss (NIHL), and this disorder can lead to interruptions in speech communication of individuals both quantitatively and qualitatively. Hence, the lack of proper and effective understanding will be followed by warning signs [6]. NIHL is today one of the problems of the world of advancement and industry, which affects all individuals regardless of age, gender and race [7,8]. NIHL is the most common cause of occupational

deafness, due to the destructive effect of noise on the inner hearing organ, called the Organ of Corti [9]. People with hearing impairment try harder than ordinary people to talk to others and understand them, as a result of which they will get tired quickly and making active and effective communication will be difficult for them. This will lead to their isolation. Hearing loss also has psychosocial consequences. Studies show that hearing impaired people tolerate more stress and are more isolated. They experience emotional instability, because hearing loss reduces friendly communications, self-confidence and personal autonomy. It may have a negative impact on the individuals' quality of life and cause psychological problems [10].

Annoyance is one of the harmful consequences of noise that is considered a mental problem of workers in the workplace. It is a negative

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mental attitude to the work environment, in which case the individual is totally reluctant to be present in a high -noise environment. Annoyance causes a fear of high-noise environments, anger and reduced accuracy in the workplace. Furthermore, sound intensity as well as exposure time and sound source are auditory factors affecting annoyance, and the feelings of fear and anger as well as cognitive impairment are among non-auditory factors that affect work activities. [11]. Studies on noise annoyance indicate a relationship between feeling annoyed and the sound level. However, other sound features, such as frequency, are also important in this relationship [12,13]. The aim of this study was to investigate the relationship between annoyance and hearing loss. Hearing loss has significant negative impacts on the social life and work environment of the individuals exposed to noise, and makes a negative attitude toward noise in the workplace. The impacts of hearing loss on workers and their attitude towards the work environment as well as their fear of exposure to noise, and ultimately noise annoyance are the issues discussed in this study. As there are few studies conducted on the relationship between annoyance and hearing loss, this study was carried out to investigate annoyance in people who have experienced hearing loss due to prolonged exposure to noise

## Methods

### Participants and setting

This descriptive-analytical research was carried out in 2017 to investigate the relationship between annoyance and hearing loss in automotive industry workers. The tools used to conduct the study included an annoyance inventory and an audiometer. The number of workers in the automotive industry was 600, of whom 300 were randomly selected based on statistical relations. After studying their medical records to know about the history of organic diseases of the hearing system, we excluded 50 individuals due to hearing impairment, and the other 250 ones were divided in two groups. The first group included 106 individuals exposed to the sound pressure levels below 85 dB, and the second included 144 people exposed to higher-than 85 dB sound pressure levels. They were all subjected to an audiometric test using the DANPLEX-AS54 audiometer (which was previously calibrated). The tonal audiometric test (air conduction) was also used to assess the workers' hearing loss. Prior to entering the workplace and starting the shift work, the subjects were examined in an acoustic room with 8 standard frequencies of 250, 500, 2000, 3000, 4000, 6000 and 8000. In this study, the data derived from the audiograms for the left and right ears of the individuals in the exposure group were calculated and recorded at all frequencies. Besides, the mean hearing thresholds at low frequency (HTL-L) and high frequency (HTL-H) were measured and recorded as well. Measuring the level of sound pressure in the workplace using the Testo device (model CEL-815) based on the ISO 9612: 2009 standard showed that the individuals' exposure level was

81 to 89 dB. The data were then analyzed using the SPSS statistical software, and were compared to the base frequency (25 dB), which was considered a measure for hearing loss. The hearing threshold over 25 dB indicated hearing loss at that frequency [14]. The relationship between hearing loss and the age and work experience of the workers was statistically analyzed using the SPSS software and the t-test. Moreover, the degrees of hearing loss obtained from the subjects exposed to noise were compared based on the classification by the American National Standards Institute and the Academy of Otolaryngology. The noise-induced annoyance was also measured using a questionnaire containing a numerical question. The question was numbered 1 to 11, the highest of which indicated the highest degree of annoyance [15]. Besides, the subjects' demographic information was investigated using a general questionnaire.

### Data analysis

The statistical tests used in this study included descriptive and analytical ones. The former included central tendency and dispersion, and in the latter, the data were analyzed through Pearson correlation coefficient, independent t-test and repeated measures. The statistical analysis was done through the use of SPSS 22 software, and the significance level in all tests was considered lower than 0.05.

## Results

In this study, the mean ages of the subjects in the two groups were  $36.33 \pm 3.81$  and  $35.73 \pm 3.44$  years, respectively, and no significant relationship was observed between the two groups in terms of age ( $P=0.201$ ). Also, the mean work experiences in the two groups were 14.94 and 14.92 years, respectively, which showed no statistically significant difference ( $P=0.939$ ). There was no significant relationship between educational levels, either ( $P=0.549$ ). Regarding marital status, most of the subjects were married and there was no significant relationship between the two groups ( $P=0.235$ ). Table 1 shows the demographic data of the subjects in terms of the received sound pressure level within 8 hours.

Using the independent T-test to examine the hearing degrees of right and left ears at a frequency of 250 to 8000 based on the received sound pressure showed that there was a significant relationship in the left ear at frequencies of 500 and 2000, and in the right ear at frequencies of 500, 250, 2000, 3000, 4000, and 6000. Furthermore, there was a significant relationship between the overall hearing loss in the left and right ears, and in general, the received sound pressure level (Table 2).

Using the repeated measures test, we investigated the process of hearing changes at frequencies of 250 to 8000, the results of which are shown in Figures 1 and 2. As shown in Figure 1 (right ear), there was no significant difference between the two groups in terms of hearing loss ( $P=0.241$ ), but a significant difference was found between the degree

**Table 1.** Relationship between demographic information and received sound pressure level in the studied groups

		$L_{f_{pd}}$		Total Mean±Sd	t	P value
		≤85 Mean±Sd	>85 Mean±Sd			
Age(year)		35.73±3.44	36.33±3.81	36.07±3.66	1.28	0.201
Experience(year)		14.92±1.89	14.94±2.15	14.94±2.04	0.076	0.939
		Number (%)	Number (%)	Total Number (%)	X <sup>2</sup>	P value
Education	Diploma	58 (54.7%)	69 (47.9%)	127 (50.8%)	1.198	0.549
	Associate degree	27 (25.5%)	44 (30.6%)	71 (28.4)		
	Bachelor's degree and more	21 (19.8%)	31 (21.5%)	52 (20.8%)		
marriage status	single	11 (10.4%)	9 (6.3%)	20 (8%)	1.413	0.235
	married	95 (89.6%)	135 (93.8%)	230 (92%)		

of hearing and the frequencies in general ( $P < 0.001$ ). In Figure 2 (left ear), there was no significant difference between the two groups in terms of hearing loss ( $P = 0.452$ ), either, but the degree of hearing had a significant relationship with the frequencies in general ( $P < 0.001$ ).

Investigating the relationship between the hearing level and annoyance through the use of Pearson correlation coefficient showed a significant relationship in the left ear at frequencies 2000, 4000, and 8000, and in the right ear at frequency 6000. In addition, there was a significant relationship between annoyance and NIHL (noise-induced hearing loss) in the left ear and general conditions (both ears) (Table 3).

**Table 2.** Evaluation of hearing loss in different frequencies based on the received sound pressure level using the independent t-test

	Sound Frequency	$L_{Epd}$		P value	t
		$\leq 85$ Mean $\pm$ Sd	$> 85$ Mean $\pm$ Sd		
Left ear	250	12.22 $\pm$ 2.49	11.77 $\pm$ 2.40	0.157	1.42
	500	18.25 $\pm$ 4.68	21.53 $\pm$ 4.51	$< 0.001^{**}$	5.54
	1000	25 $\pm$ 0.75	25.4 $\pm$ 0.64	0.632	0.479
	2000	27.74 $\pm$ 4.42	29.51 $\pm$ 4.02	0.01*	3.26
	3000	29.58 $\pm$ 7.71	29.69 $\pm$ 7.93	0.911	0.112
	4000	37.50 $\pm$ 4.79	38.02 $\pm$ 6.42	0.464	0.734
	6000	31.32 $\pm$ 9.44	29.44 $\pm$ 10.84	0.146	1.45
	8000	24.95 $\pm$ 9.19	26.56 $\pm$ 9.74	0.184	1.33
	NIHL	28.55 $\pm$ 3.29	27.12 $\pm$ 2.62	$< 0.001^{**}$	3.70
Right ear	250	13.54 $\pm$ 2.58	12.22 $\pm$ 3.22	$< 0.001^{**}$	3.58
	500	19.01 $\pm$ 2.71	20.35 $\pm$ 3.95	0.02*	3.17
	1000	28.68 $\pm$ 2.21	28.61 $\pm$ 2.24	0.811	0.239
	2000	32.50 $\pm$ 4.64	35.38 $\pm$ 7.62	$< 0.001^{**}$	3.70
	3000	30.57 $\pm$ 10.49	27.74 $\pm$ 6.94	0.017*	2.40
	4000	42.31 $\pm$ 4.88	44.20 $\pm$ 8.90	0.033*	2.14
	6000	28.44 $\pm$ 8.90	33.58 $\pm$ 12.78	$< 0.001^{**}$	3.74
	8000	26.89 $\pm$ 10.61	24.51 $\pm$ 11.47	0.093	1.68
	NIHL	30.62 $\pm$ 3.47	32.23 $\pm$ 5.02	0.003*	2.98
Total	NIHL	27.85 $\pm$ 2.48	29.19 $\pm$ 1.97	$< 0.001^{**}$	4.57

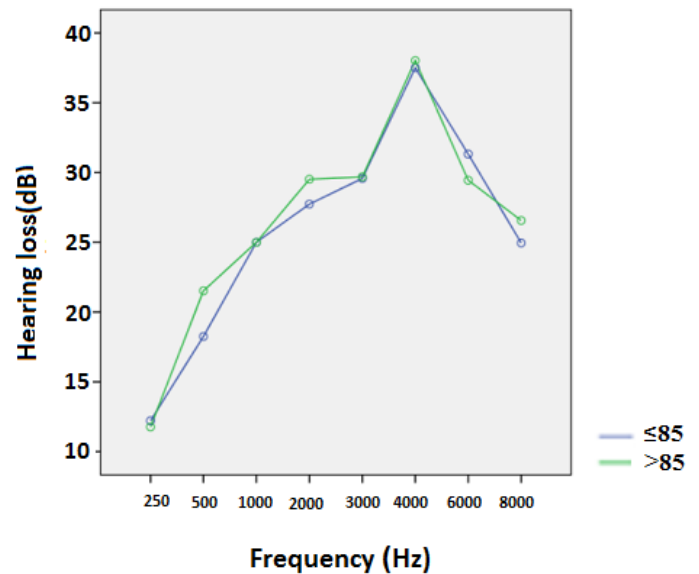
\*Statistically significant less than  $< 0.05$

\*\*Statistically significant less than  $< 0.01$

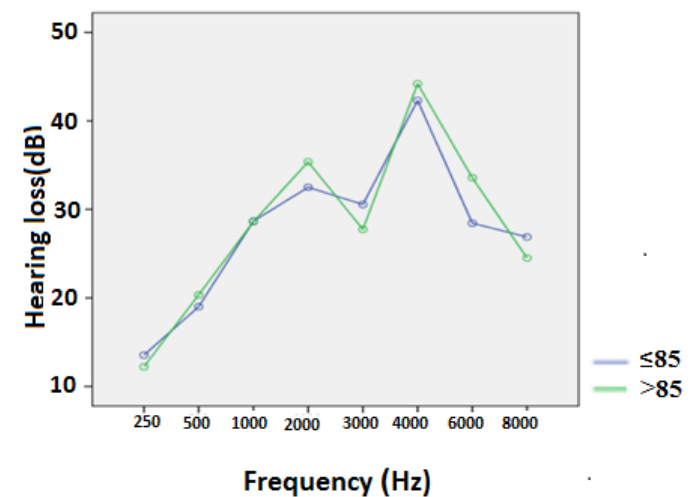
**Table 3.** Relation between annoyance and hearing level at different frequencies using Pearson correlation coefficient

	Sound Frequency	Mean $\pm$ Sd	Pearson Correlation	P value
Left ear	250	11.96 $\pm$ 2.44	0.026	0.684
	500	20.14 $\pm$ 4.85	0.044	0.484
	1000	25.02 $\pm$ 0.71	-0.116	0.068
	2000	28.76 $\pm$ 4.28	0.184	0.003
	3000	29.64 $\pm$ 7.83	0.003	0.957
	4000	37.80 $\pm$ 5.78	0.213	0.001*
	6000	30.24 $\pm$ 10.29	-0.084	0.185
	8000	25.88 $\pm$ 9.52	-0.151	0.017
	NIHL	27.95 $\pm$ 3.00	0.185	0.003*
Right ear	250	12.78 $\pm$ 3.03	-0.016	0.796
	500	19.78 $\pm$ 3.53	-0.089	0.161
	1000	28.64 $\pm$ 2.22	-0.121	0.055
	2000	34.16 $\pm$ 6.66	-0.034	0.591
	3000	28.94 $\pm$ 8.72	-0.004	0.955
	4000	43.40 $\pm$ 7.51	0.053	0.405
	6000	31.40 $\pm$ 11.56	-0.134	0.035*
	8000	25.52 $\pm$ 11.15	-0.049	0.438
	NIHL	31.55 $\pm$ 4.49	-0.025	0.694
Total	NIHL	28.62 $\pm$ 2.29	0.137	0.031*

\*Statistically significant less than  $< 0.05$



**Figure 2.** Hearing level in the left ear



**Figure 1.** Hearing level in the right ear

## Discussion

The results of this study, which aimed to investigate the relationship between annoyance and hearing loss in the workers exposed to chronic noise, showed a significant positive relationship between the degree of annoyance and the workers' hearing loss. In other words, being exposed to noise in the work environment increased the chance of hearing impairment, such as hearing loss and its consequences including the development of a negative attitude toward noise in the workers exposed to chronic noise, fear of sound, and reluctance to attend the environments with loud noise and noise pollution. That is to say, hearing loss increased noise annoyance, and this is consistent with the results of other related studies [16-18].

Various studies have investigated the negative outcomes of hearing loss in the work environment and social life, and the noise annoyance caused by it. In this regard, the results indicated a relationship between the feeling of annoyance and the sound levels, and the role of other contributing factors such as frequency in the workers' feeling of annoyance caused by hearing loss was important. The results

of other studies also indicated a dose-response relationship between the sound levels and the annoyance induced by hearing loss [13,19]. Besides, low-frequency noise (LFN) that has high penetration and is very hard to control may cause more distress and annoyance than high-frequency noise (HFN). In addition, personal differences affect the individuals' responses to sound. Some people have a special hearing sensitivity and are not tolerant to common sounds [20,21]. The results of the present study showed that in sound pressure levels lower and higher than 85 dB, hearing loss had a significant difference at various frequencies. In low frequencies, the incidence rate of hearing loss was higher than in high frequencies, which was consistent with the results of other studies [22,23].

In the study by Holly Reed on the psychological effects of hearing loss in adults, it was well documented that hearing loss caused psychosocial changes such as mental and cognitive ones as well as the changes in the individuals' quality of life and daily life. In other words, hearing loss decreased social roles and activities, and caused stress, unpleasant feelings towards noise, and reluctance to attend noisy environments. This confirms the results of our study on the effect of hearing loss caused by chronic exposure to noise on the individuals' annoyance [24].

Ray Moon *et al.* also found that hearing loss had an impact on the incidence of noise annoyance. They concluded that the co-occurrence of hearing loss and occupational anxiety could be accompanied by noise annoyance which is followed by reduced accuracy and concentration at work and increased human errors [25]. This is consistent with the results of our study. In their research, Wagner-Hartl *et al.* clearly stated that age was interrelated with hearing loss as well as quality and duration of work. It was also related to concentration and accuracy at work [23]. Peterson *et al.* provided evidence of the relationship between the workers' annoyance and the hearing loss caused by exposure to traffic noise. They identified that the men with hearing loss were suffering from a higher degree of annoyance than those without hearing loss. Although the present research was not carried out on two groups with and without hearing loss, the results were generally consistent with those of the study by Peterson *et al.* [26]. Another study by Moghadam *et al.* clearly showed that hearing-impaired people had lower general health status and lower social function than those without hearing impairment, and the subjects with hearing loss were suffering from limitations in playing their roles, as a result of emotional-psychological problems and psychiatric disorders [27]. Even Gharashi *et al.* made it clear that psychological treatments to reduce noise annoyance caused by hearing loss in children could well reduce depression and anxiety resulted from hearing loss [18]. According to the study by Nachtegaal, hearing loss had psychosocial impacts such as decreased communication, daily disorders, loneliness, depression, reduced social functions, and anxiety [28]. Another study by Denmark found that people with hearing impairment had lower physical health than normal individuals, due to the stress caused by hearing impairment that increased the amount of stress hormones and also increased the risk of diseases. Finally, it caused negative psychooogical effects, including fear of being in noisy environments, and ultimately, hearing impairment. This is consistent with the findings of the present study [29].

The lack of examining the annoyance caused by noise-induced hearing loss in different sexes is one of the limitations of this study. Also, given that this is a cross-sectional study on the impact of hearing loss on the incidence of annoyance in people exposed to chronic noise in the workplace, generalization of the results to normal populations should be done with caution. Besides, longitudinal studies in this area

can help to further clarify the impact of hearing loss on the annoyance caused by it. In general, the researchers concluded that there was a significant relationship between annoyance and hearing loss in the individuals exposed to chronic noise.

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## Conflict of interest

All authors have no potential conflict of interest pertaining to this journal submission.

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