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Investigation Of Noise Annoyance And Noise Sensitivity Among Miners In A Mechanized Underground Mining Operation

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Abstract

In the mining sector, which is classified as highly hazardous, the number of noise sources and consequently the noise level in the environment are increasing with the transition to mechanization. While mechanized vehicles have different noise levels, prolonged exposure to this noise can pose a direct risk to miners. Noise annoyance, associated with negative noise experiences is related to the amount of noise exposure. Noise sensitivity is a genetically inherited personality trait unrelated to exposure to noise. This research aims to determine whether the noise annoyance and sensitivity of miners differ from the general population and to examine their relationships with environmental and individual variables. This study is a cross-sectional, conducted on miners in a mechanized underground mine and male office workers with non-mining occupations. Volunteers who aged 20-60 years without any otological and neurological problems. Demographic information, noise annoyance, exposure data and the Weinstein Noise Sensitivity Scale results were analyzed. Analysis of the total sensitivity scale scores revealed a significant difference between the control and study groups. Miners had statistically significantly higher total sensitivity scores compared to those in the control group ($p=0.044$). Although not significantly different from the control group, the average score for miners with noise sensitivity is 90.05 ± 6.65. In conclusion, it is recommended to increase noise awareness among miners, provide appropriate job placement for individuals with noise sensitivity and implement other control measures.

Keywords

Noise annoyance,, Noise sensitivity, Occupational Noise Exposure, Underground mining, Occuppational healthy and safety, Weinstein's noise sensitivity scale

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Mekanize Bir Yeraltı Maden İşletmesinde Madencilerde Gürültüye Hassasiyetin ve Gürültüden Rahatsız Olma Durumlarının İncelenmesi

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Özet

Çok tehlikeli sınıfta yer alan madencilik sektöründe, mekanizasyona geçişle birlikte gürültü kaynaklarının sayısı ve dolayısıyla çevredeki gürültü seviyesi artmaktadır. Mekanize araçlardan kaynaklanan gürültüye maruz kalmak madenciler için doğrudan bir risk oluşturabilir. Genellikle olumsuz gürültü deneyimleriyle ilişkilendirilen gürültü rahatsızlığı, gürültüye maruz kalma miktarıyla ilgilidir. Gürültü hassasiyeti ise gürültüye maruz kalmayla ilgisi olmayan, genetik olarak kalıtılan bir kişilik özelliğidir. Bu araştırma, madencilerin gürültü rahatsızlığı, maruziyeti ve hassasiyetinin genel popülasyondan farklı olup olmadığını belirlemeyi ve bunların çevresel ve bireysel değişkenlerle ilişkilerini incelemeyi amaçlamaktadır. Bu çalışma, mekanize bir yeraltı madeninde çalışan madenciler ve madencilik dışı erkek ofis çalışanları üzerinde yapılan kesitsel bir çalışmadır. Çalışmaya, otolojik, nörootolojik veya nörolojik sorunları olmayan 20-60 yaş arası gönüllüler katılmıştır. Demografik veri formu, gürültüden rahatsız olma, gürültü maruziyeti, Weinstein Gürültü Hassasiyeti Ölçeği verileri çalışmaya dahil edilmiştir. Çalışma sonuçlarına göre toplam gürültü hassasiyeti puanları arasında anlamlı bir fark olduğu bulunmuştur (p=0.044). Bireysel gürültü hassasiyeti karşılaştırmasında kontrol grubuyla anlamlı bir fark olmamasına rağmen, gürültü hassasiyeti olan madencilerin ortalama puanı 90,05 ± 6,65'tir. Sonuç olarak, madenciler arasında gürültü farkındalığının artırılması, gürültü hassasiyeti olan bireyler için uygun iş yerleştirmelerinin sağlanması ve diğer kontrol önlemlerinin uygulanması önerilmektedir.

Anahtar kelimeler

Gürültüden rahatsız olma,
Gürültü hassasiyeti,
Mesleki gürültü maruziyeti,
Yeraltı madenciliği,
İş sağlığı ve güvenliği,
Weinstein gürültü hassasiyet ölçeği

1. INTRODUCTION

Noise is one of the most common environmental exposures in modern working life, such as air pollution and environmental disturbances, and is considered a significant occupational risk factor, especially for individuals working in industrial sectors [1-4].

Noise is emerging as a significant health and safety issue [5]. So that, long-term noise exposure is not limited to auditory effects such as hearing loss; it is also associated with a variety of non-auditory health consequences, including stress, sleep disturbances, cardiovascular effects, and decreased quality of life [1]. The mining sector stands out as one of the work environments where high levels of continuous and impulsive noise exposure are observed. In the mining sector, which is classified as highly hazardous, the number of noise sources and, consequently, the noise level in the environment are increasing with the transition to mechanization [6]. Mechanized vehicles used for excavation, transportation, and support work have varying noise levels, but prolonged exposure to this noise can pose biopsychosocial risks to miners [7-10]. Erol et al. (2015), in their study measuring the noise levels of some mining machines working in a mechanized underground mine, reported that perforator machines exceeded the limit value of 87dBA, while other machines operated at the exposure action limit value of 85dBA [8]. There are studies that draw attention to the increase in noise and reverberation time caused by mining machinery [11]. A study conducted in South African mines also showed that engineering control measures reduced the noise intensity emitted by the machinery from the 93 dBA - 104 dBA range to the 90 dBA - 94 dBA range [12].
Considering the biopsychosocial effects of noise, it is known that it causes temporary or permanent hearing loss, affects workers psychologically and reduces the physical performance of the employee [13]. For this reason, it is recommended that noise levels be kept below the limit values for the health and safety of miners [7, 14]. With this, the masking effect of noise causes negative effects on the hearing system. When the signal-to-noise ratio exceeds 5-6dB, it may cause inadequacies in speech discrimination even in individuals between the ages of 30-40, may cause comprehension problems in educational environments. This masking effect of noise can turn into a significant environmental and personal risk at workplaces [13].

Exposure to noise or unwanted sounds has been proven to have many negative physical and psychological effects, including impaired communication, concentration, and daily functioning [15, 16]. Noise levels below those that can cause hearing damage have been reported to cause annoyance, sleep disturbances, cognitive impairment, physiological stress, endocrine disorders, and cardiovascular problems [15, 17].

Annoyance is just one of numerous health problems associated with noise exposure, affecting large populations worldwide. Noise annoyance, generally associated with negative noise experiences, is related to the amount of noise exposure [15]. According to the World Health Organization (WHO), people disturbed by noise may experience negative conditions such as depression, anxiety, or fatigue, and this increased stress is a risk factor for cardiovascular diseases [18]. However, the effects of noise on individuals cannot be explained solely by the level of exposure; inter-individual differences play a significant role. In this context, noise sensitivity is defined as an important individual characteristic reflecting the psychological and physiological responses of individuals to environmental sound stimuli. It is reported that individuals with high noise sensitivity experience more intense effects such as noise-related discomfort, stress, and distraction [19].

Noise Sensitivity; it refers to an internal state that increases the intensity of an individual's general response to noise and is associated with being annoyed by noise.

Measurements of noise sensitivity do not provide information about individuals' hearing levels [20, 21]. It has been reported that individuals sensitive to noise experience significant impairments in their quality of life, particularly in terms of mental health. For people living in noisy environments, noise level may not be the primary factor in determining their response to noise, and individuals may exhibit different reactions under the same acoustic conditions [22]. In this context, the presence of noise sensitivity becomes a significant public health issue due to its impact on quality of life and work performance [23].

Although occupational noise exposure and noise-induced hearing loss among miners have been widely investigated, research examining noise sensitivity in this occupational group remains limited. Understanding noise sensitivity among miners may provide valuable insight into individual variability in responses to occupational noise exposure and contribute to more effective occupational health interventions.
The use of noise sensitivity questionnaires is recommended to determine the professional competence and productivity of professionals working in environments exposed to noise. This research aimed to determine whether the levels of noise annoyance and noise sensitivity among miners differed from those in the general population, and to examine the relationships between these levels and environmental and individual variables, using the Weinstein Noise Sensitivity Scale [24, 25].

2. MATERIAL AND METHOD

2.1. Study Design and Area

This study is cross-sectional research conducted on miners (excavation, support, transportation and repair and maintenance) working in a mechanized underground mine and on male employees with non-mining occupations (office clerks/workers) for comparison with the general population in the same

province (control group). Permission for the research was obtained from the Recep Tayyip Erdoğan University Social and Human Sciences Ethics Committee with meeting decision number 2023/348 dated 22/11/2023.

In this context, the research was conducted on volunteers who read and agreed to participate in Scientific Research. The research was conducted between November and December 2023. Volunteers aged 20-60 with at least one year of work experience and no otological, neuro-otological or neurological problems were included. Individuals who did not fully answer the scales or who reported a diagnosis of hearing loss from a physician were excluded from the study. We continued working with those who did not report any hearing loss or hearing-related problems.

2.2. Materials and Procedures

The study employed a quantitative research method, specifically the survey method. Demographic information form, the Weinstein Noise Sensitivity Scale and noise annoyance data were analyzed.

2.2.1. Questionnaire for assessment

The assessment questionnaire was created by compiling the Weinstein Noise Sensitivity Scale questions into a single form, along with demographic information (age, marital status, smoking, education level, presence of systemic diseases), medical history (hearing loss, ear discharge, balance disorders, dizziness, tinnitus, ear surgery and history of noise exposure) and two questions covering the level of annoyance caused by noise which one of these asking about the level of annoyance experienced at home and at work over the past 12 months and the other one is about annoyance level according to Visual Anolog Scale (VAS) between 0 and 10. The survey was conducted face-to-face at the workplace using printed materials. Mining operations were not disrupted during this process.

Weinstein Noise Sensitivity Scale (WNSS); noise sensitivity is also considered to be an individual's response to noise. Since no correlation has been found between hearing acuity and noise sensitivity, it is known that individuals with normal hearing have different levels of noise sensitivity. Developed by Weinstein in 1978, the "Weinstein Noise Sensitivity Scale" is a scale used to determine individual noise sensitivity [25]. This scale consists of 21 items and assesses individuals who report more discomfort than the general population to a specific noise source and everyday environmental sounds. The scale is Likert-type, with ‘Agree/Disagree’ responses rated from 1 to 6. Participants are asked to indicate the number that best reflects their degree of agreement or disagreement with the item they have read. The responses are totaled to obtain a WNSS score. The high score obtained indicates a high degree of sensitivity. The highest possible noise sensitivity score is 126. The scale was adapted into Turkish by Keskin Yıldız et al. in 2015. The Turkish version of WNSS (Tr-WNSS) was used in this study with their permission [24]. According to the Tr-WNSS, scores of 84 and below indicates no noise sensitivity, while scores of 97 and above indicate noise sensitivity. These values were used in Tr-WNNS study [24]. Individuals with high sensitivity respond more negatively to noise than those with low sensitivity [26]. Both the original and translated versions of WNSS have shown comparable reliability estimates. Weinstein reported an acceptable reliability using the Kuder-Richardson formula (r = 0.83) in his study [27].

2.3. Statistical Analysis

All statistical analyses were performed using SPSS 25.0 [IBM SPSS Statistics 25 software (Armonk, NY: IBM Corp)]. Continuous variables were defined by the mean ± standard deviation; median (IQR: 25th-75th percentiles) and categorical variables were defined by number and percent. Kolmogorov smirnov test was used for determination of normal distribution. For independent groups comparisons, Inpendent samples t test was used when parametric test assumptions were provided and Mann Whitney U test was used when parametric test assumptions were not provided. Difference between categorical variables were analyzed with Chi Square test and Fisher Exact test. Logistic regression analysis was used to examine the factors affecting dependent variable. Statistical significance was determined as $p<0,05$.

3. RESULTS

After excluding those who reported having hearing problems, the individuals who volunteered for the study were selected.

3.1 Demographic Variables

The distribution of demographic variables among the groups is given in Table 1. No statistically significant differences were found between the groups in the analyses conducted according to age and marital status variables. Analysis based on educational attainment revealed statistically significant differences between the control and study groups. The control group had a higher proportion of individuals with higher education, while the study group had a higher proportion of individuals with only a high school education or lower. Examinations regarding smoking habits also revealed statistically significant differences between the control and study groups. The study group had a higher smoking rate compared to the control group.

Table 1. Distribution of demographic variables across groups

Variable		Group		
		Control	Miners	p
Age	Mean ± S.D	38.16 ± 7.95	37.43 ± 6.24	0.586 (t=0.546)
	Med (IQR)	38 (32 - 43)	37.5 (32 - 41)	
	min - max	22 - 58	25 - 53	
Marital Status	Married	41 (%70.7)	48 (%82.8)	0.124 (cs=2.365)
	Others	17 (%29.3)	10 (%17.2)	
Education	Literate	0 (%0)	2 (%3.4)	0.0001* (cs=44.382)
	Primary School	0 (%0)	5 (%8.6)	
	Secondary School	0 (%0)	11 (%19)	
	High School	20 (%34.5)	30 (%51.7)	
	College and Above	38 (%65.5)	10 (%17.2)	
Smoking	Sigara içiyor	28 (%48.3)	37 (%63.8)	0.011* (cs=8.970)
	İçtim bıraktım	8 (%13.8)	13 (%22.4)	
	Hiç içmedim	22 (%37.9)	8 (%13.8)	

*p<0.05 statistically significant; Med (IQR): Median (25th – 75th percentiles), t: Independent samples t test; cs: Chi-square test; γ: Fisher exact test

3.2 Noise Annoyance (NA) and Noise Exposure Variables

According to Visual Anolog Scale (VAS), no statistically significant difference was found between the groups in terms of NA VAS level and NA variables based on the last 12 months. Analysis based on the noise exposure variable revealed statistically significant differences between the control and study groups. The rate at which individuals in the control group indicated "no" was statistically significantly higher than those in the study group while the rate at which individuals in the study group indicated "I constantly work/live in a noisy environment" was statistically significantly higher than those in the control group (Table 2).

Table 2. Examining the levels of 'Noise Annoyance' and 'Noise Exposure' among groups

Variables		Group		
		Control	Miners	p
Noise Annoyance VAS level	Mean ± S.D	3.41 ± 2.51	3.9 ± 2.36	0.252 (z=-1.145)
	Med (IQR)	3 (1.75 - 5.25)	4 (2 - 6)	
	min - max	0 - 8	0 - 8.5	
Noise Annoyance last 12 months	Not at all	18 (%31)	11 (%19)	0.429 (cs=2.769)
	Slightly	20 (%34.5)	20 (%34.5)	
	Middle	16 (%27.6)	22 (%37.9)	
	A lot	4 (%6.9)	5 (%8.6)	
Noise Exposure	No	19 (%32.8)	4 (%6.9)	0.0001* (cs=37.895)
	Only once	6 (%10.3)	1 (%1.7)	
	I was exposed for a certain period of time	26 (%44.8)	17 (%29.3)	
	I work/live in a constantly noisy place	7 (%12.1)	36 (%62.1)	

*p<0.05 statistically significant; Med (IQR): Median (25th – 75th percentiles), z: Mann Whitney U test; cs: Chi-square test

3.3 Noise Sensitivity Variables

Analysis based on the total WNSS score revealed a significant difference between the control and study groups. Miners had statistically significantly higher total WNSS scores compared to those in the control group (Table 3). According to the classification using Weinstein scale, no statistically significant difference was found between the groups in terms of individual noise sensitivity (p>0.05). However, it was observed that the control group was more inclined towards the lower 1/3 class (those without sensitivity), while the study group was more inclined towards the upper 1/3 class those with sensitivity (Table 4).

Table 3. Comparison of Total Noise Sensitivity Scores (Tr-WNSS) by Group Based

Variables		Group		
		Control	Miners	p
Tr-WNSS Total Score	Mean ± S.D	69.28 ± 17.12	75.09 ± 13.43	0.044*(t=-2.033)
	Med (IQR)	68.5 (58 – 83)	75 (65 – 87)	
	min – max	28 – 106	51 – 103	

*p<0.05 statistically significant; Med (IQR): Median (25th – 75th percentiles), t: Independent samples t test

Table 4. Comparison of Sensitivity Levels by Groups According to Scale Scores

	Variables	Score range	Total	Control		Miners		Group		
				Mean ± SD	Med (IQR)	Mean ± SD	Med (IQR)	Control	Miners	p
Weinstein	No Sensitive	28 - 65	39 (%33,6)	54,12 ± 10,25	57 (53 - 59,5)	58,07 ± 4,68	58 (54,75 - 62)	25 (%43,1)	14 (%24,1)	
	Middle Class	65 - 79	39 (%33,6)	70,6 ± 4,03	70 (68 - 75)	72,54 ± 4,5	73 (68 - 77)	15 (%25,9)	24 (%41,4)	0,071 (cs=5,285)
	Sensitive	80 - 106	38 (%32,8)	89,22 ± 7,8	86 (83 - 94,25)	90,05 ± 6,65	88,5 (84,75 - 95,5)	18 (%31)	20 (%34,5)	

SD: Standard deviation; Med (IQR): Median (25th – 75th percentiles); *p<0.05 statistically significant; cs: Chi-square test

3.4 Examining the Relationship Between Demographic Variables and Noise Sensitivity

According to Table 5, in the control group, smoking, NA within the last 12 months, VAS noise annoyance level, and noise exposure variables did not have a statistically significant effect on the presence of noise sensitivity.
Age was found to have a statistically significant effect on the presence of noise sensitivity. Increasing age was found to be a significantly decreasing factor in the presence of noise sensitivity (OR=0.868). Marital status was found to have a statistically significant effect on the presence of noise sensitivity. Being single was found to be a significantly increasing factor compared to being married (OR=5.040). Education was found to have a statistically significant effect on the presence of noise sensitivity. Increasing education level was found to be a significantly decreasing factor in the presence of noise sensitivity (OR=0.105).

The results obtained from the miners are as follows: Age, marital status, education, smoking, noise annoyance in the last 12 months, and VAS noise annoyance level variables did not have a statistically significant effect on the presence of noise sensitivity. However, the high noise exposure variable was found to have a statistically significant effect on the presence of noise sensitivity. Increased high noise exposure was found to be a significantly reducing factor in the presence of noise sensitivity (OR=0.479).

Table 5. Examining the Relationship Between Demographic Variables and Noise Sensitivity in Groups

Variables	Control				Miners			
	Wald	p	O.R.	%95 C.I Lower - Upper	Wald	p	O.R.	%95 C.I Lower - Upper
Age	6.961	0.008*	0.868	0.782 - 0.964	3.230	0.072	1.095	0.992 - 1.21
Marital_status (Single; reference: Married)	5.558	0.018*	5.040	1.314 - 19.337	0.343	0.558	0.607	0.114 - 3.225
Education	9.026	0.003*	0.105	0.024 - 0.456	0.263	0.608	1.176	0.632 - 2.188
Smoking (No smoking; reference: Smokes)	0.606	0.436	1.667	0.461 - 6.03	0.234	0.628	1.354	0.397 - 4.618
Noise Annoyance last 12 months	1.265	0.261	0.654	0.312 - 1.371	0.353	0.553	0.820	0.426 - 1.579
Noise Annoyance VAS level	1.596	0.206	0.838	0.637 - 1.102	1.974	0.160	0.833	0.645 - 1.075
Noise Exposure	0.168	0.682	0.883	0.486 - 1.604	4.367	0.037	0.479	0.24 - 0.955

*p<0.05 statistically significant effect; Wald: Logistic regression coefficient; O.R: Odds Ratio; C.I: Confidence Interval

4. DISCUSSION AND CONCLUSION

Today, noise is one of the significant risk factors affecting health [5, 28]. In the mining sector, which is classified as a very dangerous industry and is one of the driving forces of technological and economic progress, the transition to mechanization has led to noise posing a biopsychosocial danger and risk to the health and safety of miners [29-31]. Noise is an extremely important external factor for human health and it has been reported that an internal variable called noise sensitivity is also important in the biopsychosocial effects of noise [23, 24, 32]. In the study conducted by Onder et al. (2012), it was shown that among those working in mines, operators and demolition workers, who are exposed to approximately 90-99 dB(A) of noise daily, are most affected by noise and develop hearing loss in approximately 4-11 years. [33]. A study conducted in an underground coal mine in Turkey

examined the relationship between age, occupation, and duration of noise exposure of the worker group and noise-induced hearing loss using logistic regression. The study concluded that miners in operational groups and those with 10-14 years of noise exposure had a higher risk, while age did not significantly increase the probability of hearing loss [7]. Another study examined coal miners' attitudes towards noise-induced hearing loss, their hearing protection usage habits, and their education levels. Lack of awareness of hearing loss or difficulties in using protective equipment have been identified as factors that perpetuate the risk. [34]. When the literature is examined, in miners; although many studies have been found on noise exposure, noise-induced hearing loss, and noise control measures, the fact that no study examining noise sensitivity has been found makes our study unique. There are many studies on noise sensitivity in different sectors such as textile [35, 36]. The "Weinstein's Noise Sensitivity Scale" helps identify individuals who report more discomfort to a particular noise source than the general population. Since this scale is not a hearing test, it does not provide information about the hearing levels of individuals. It provides the opportunity to obtain information especially about individuals who are sensitive to noise without hearing loss [24, 27].

In this research, it was aimed to examine whether miners' noise annoyance and noise sensitivity differ from the general population and their relationship with environmental and individual variables. As presented in Table 1, the demographic characteristics of the participants were examined to assess the comparability of the study groups. No statistically significant differences were observed between miners (n=58) and the control group (n=58) in terms of age or marital status, suggesting that the groups were broadly comparable with respect to these basic demographic variables. However, significant differences were identified in education level (p= 0.0001) and smoking status (p=0.011). Participants in the control group demonstrated higher educational attainment, whereas smoking prevalence was greater among miners. Since these findings may reflect occupational and socioeconomic characteristics associated with the mining workforce, they were taken into account when interpreting the study results. The present study evaluated noise annoyance and occupational noise exposure among miners and individuals from the general population (table 2). As shown by the VAS-based assessments, no statistically significant differences were observed between the groups in terms of overall noise annoyance levels or noise annoyance variables reported over the previous 12 months. This results suggests that although miners are frequently exposed to high levels of occupational noise, their subjective annoyance responses may not necessarily differ from those of individuals in the general population. Previous research has highlighted that noise annoyance is a multidimensional construct influenced not only by objective noise exposure but also by individual, psychological, and contextual factors [1, 2]. Consequently, individuals exposed to chronic occupational noise may develop adaptive or habituation responses that attenuate subjective annoyance despite continued exposure. In contrast, the analysis of the noise exposure variable revealed a statistically significant difference between the groups. Individuals in the miner group reported substantially higher levels of continuous exposure to noisy environments compared with the control group. This finding is consistent with the well-documented acoustic characteristics of mining environments, where workers are frequently exposed to high-intensity noise generated by drilling, blasting, heavy machinery, and transport equipment [37]. Occupational noise exposure in mining has been repeatedly identified as one of the most prevalent environmental hazards in the sector and represents a major risk factor for both auditory and non-auditory health outcomes [38].

Taken together, the findings indicate that while miners experience significantly greater environmental noise exposure, this increased exposure does not necessarily translate into higher levels of reported noise annoyance. This discrepancy may reflect the influence of occupational adaptation, individual tolerance, and contextual expectations associated with working in inherently noisy environments. Abadi et al. (2016) compared blue-collar production line workers and office workers in a steel factory in terms of 'noise annoyance'. It was found to be significantly higher in production line workers. My study does not support Abadi et al.'s study. In this context, when comparing occupational groups in different fields, the discomfort research question may differ; the fact that the sample group was selected from the same environment may cause this difference [39]. However, in a study conducted in Belgrade, a control area consisting of three streets with high traffic density and three streets in a relatively quiet part of the city were selected. A total of 413 people completed the WNSS. The results showed no significant difference in average noise sensitivity scores between those living in noisy and quiet urban areas. Consistent with the findings of Di Blasio et al (2019), occupational factors appear to play a significant role in shaping noise-related outcomes [40]. The use of hearing protection equipment, hearing training programs, and effective engineering and administrative control measures are necessary to reduce the negative effects of noise in underground mines. Further studies focusing on detailed organic hearing findings are recommended.

As presented Table 3, the analysis based on the total WNSS score demonstrated a statistically significant difference between the groups, with miners exhibiting higher overall noise sensitivity total scores compared with individuals in the control group (p=0.044). This finding suggests that individuals working in high-noise occupational environments may develop heightened perceptual or psychological responses to environmental noise. Previous research has identified noise sensitivity as a relatively stable personal trait that influences how individuals perceive and respond to environmental noise exposure [27, 41]. Studies have also shown that prolonged exposure to environmental or occupational noise may contribute to increased sensitivity through cumulative stress responses and heightened attentional processing of auditory stimuli [1].

With this, as presented at Table 4; when the cut-off values for evaluating individuals' sensitivity to noise, no significant difference was found between the control group and the miners in the intergroup comparison (p>0,005). This study found that 34.5% of miners were sensitive to noise with an average sensitivity score of 90.05 ± 6.65. The upper limit for the low sensitivity group is set at 65 points. Meanwhile, the lower limit for the high sensitivity group is set at 80 points. This analysis helps to categorize workers into different sensitivity groups based on their noise sensitivity levels. Similarly, a study conducted on farmers reported a significantly higher total noise score compared to the control group, but no significant difference was found in individual noise sensitivity. The insufficient sample size was highlighted as the reason for this in the study [42]. Another study found a significant difference between male and female genders, reporting that sensitivity is greater in women [43]. Since miners in Turkey are legally required to be male, this study focused on comparisons within the male gender category. Analyses can be conducted across different occupational groups using both genders. Individual noise sensitivity is a consistent personality behavior exhibited in response to a wide variety of environmental noises [44]. Several studies have shown whether environmental noise has an effect on noise sensitivity. Studies conducted around airports have indicated that, despite many individuals appearing almost unaware of the noise in areas exposed to the highest noise levels, there are people in areas far from the surveyed airport who find the sound of the aircraft extremely disturbing [45]. In another study, areas with sound levels exceeding 55 dB during the day and 45 dB at night were considered noisy streets, while areas with sound levels below 55 dB during the day and 45 dB at night were considered noise-free. In the study conducted, individuals living in noisy areas scored higher on Weinstein's noise scale [46]. In this study, statistically significant differences were found in the noise sensitivity scale results between underground miners working in a noisy environment and a control group working in a different area; however, no significant difference was found regarding the presence or absence of individual sensitivity.

As presented at Table 5, it was stated that increasing age significantly decreased noise sensitivity in the control group (OR = 0.868). The relationship between age and noise sensitivity is complex in the literature; Some studies argue that sensitivity increases with age, some argue that it decreases, and some argue that there is no relationship at all [47]. Previous studies have similarly indicated that younger individuals tend to report higher levels of noise sensitivity and annoyance, potentially due to differences in lifestyle, expectations regarding environmental conditions, and psychological responses to environmental stressors [1, 2]. The decrease in sensitivity with age may be related to some kind of adaptation to noisy environments over time or to changing lifestyle priorities. The finding that being single increases sensitivity 5 times (OR = 5.040) compared to being married is remarkable. Although the effect of marital status as a direct moderator is not detailed in the sources, it is stated that noise sensitivity is related to personality traits such as social distrust and desire for privacy [47, 48] One of the important relationships in the control group is that noise sensitivity decreases as the education level increases (OR = 0.105). Higher educational attainment may contribute to greater environmental awareness and improved coping strategies in response to environmental stressors. For instance, Fallah Madvari et al. (2023) reported that noise sensitivity was not significantly associated with age, marital status, or occupational noise exposure among textile workers. However, a significant relationship was identified between noise sensitivity and education level, with workers who had lower levels of education reporting higher noise sensitivity scores. The authors suggested that educational background may influence individuals' perception and interpretation of environmental noise through differences in environmental awareness, coping strategies, and occupational health knowledge. In line with these findings, the present study also demonstrated that education level was a significant predictor of noise sensitivity in the control group, with higher education levels being associated with a lower likelihood of noise sensitivity. These results highlight the potential role of educational and cognitive factors in shaping individual responses to environmental noise [28]. Similarly, A study conducted in the textile industry found a negative correlation between workers' education levels and WSNN scores [35]. In contrast, none of the sociodemographic variables examined in the miner group including age, marital status, education level, and smoking status were significantly associated with the presence of noise sensitivity. It was found that noise sensitivity decreased (OR = 0.479) as the exposure to loud noise increased in miners. This situation can be explained by a kind of habituation or "desensitization" process that develops over time in individuals working in noisy workplaces [41, 49]. Noise sensitivity is a genetically inherited personality trait unrelated to noise exposure [21]. In their 2004 study, van Kamp et al. reported that there was no interaction between noise exposure and noise sensitivity [48]. Fallah Madvari et al. (2022), investigated the relationship between noise exposure and noise sensitivity in textile workers and found no relationship between exposure and noise sensitivity [28]. However, the literature notes that individuals with high noise sensitivity tend to make more mistakes in daily life than those with low precision scores [19, 35]. Given the existence of differing results in the literature and the organic and psychosocial effects of noise, the assessment of noise sensitivity and annoyance in miners is necessary for the management of occupational accidents and diseases.

Overall, the findings of this study provide important insights into the complex relationships between occupational noise exposure, noise annoyance, and noise sensitivity among miners compared with individuals from the general population. While miners reported significantly higher levels of environmental noise exposure, their subjective annoyance responses and the determinants of noise sensitivity differed from those observed in the control group. In the general population, sociodemographic factors such as age, marital status, and education level appeared to play a more prominent role in

shaping noise sensitivity. In contrast, among miners, occupational noise exposure emerged as the primary factor associated with noise sensitivity, potentially reflecting long-term behavioral adaptation or habituation to persistent workplace noise.

These findings highlight the importance of considering both individual characteristics and occupational context when evaluating the health impacts of environmental noise. From an occupational health perspective, the results emphasize the need for comprehensive noise management strategies in high-risk sectors such as mining, including regular noise monitoring, hearing conservation programs and educational interventions aimed at increasing awareness of the potential auditory and non-auditory effects of chronic noise exposure. Future research should further investigate the psychological and physiological mechanisms underlying noise sensitivity in occupational settings and explore longitudinal approaches to better understand how prolonged exposure influences individual responses to environmental noise.

This study has several strengths, including addressing the concept of noise sensitivity in miners and providing valuable insights into occupational noise exposure, such as a comparison between miners and a control group. However, the cross-sectional design limits causal interpretations. Future longitudinal studies are recommended to examine these relationships in more detail.

Consequently, the study provides valuable evidence regarding the interaction between occupational noise exposure and individual sensitivity responses, and it contributes to the growing body of literature addressing the non-auditory effects of environmental noise in occupational health settings.

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