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ASSESSMENT OF HEARING LOSS RISK DUE TO OCCUPATIONAL AND NON-OCCUPATIONAL EXPOSURE TO NOISE

PROCJENA RIZIKA OD GUBITKA SLUHA USLJED PROFESIONALNE I NEPROFESIONALNE IZLOŽENOSTI BUCI

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ABSTRACT

Loud noise in the workplace is a common occurrence in the labor market. Prolonged exposure to excessive noise can lead to hearing loss and the development of occupational disease. The aim of this study was to examine the impact of occupational noise exposure on the occurrence of hearing loss among workers exposed to hazardous noise levels in the workplace and to determine the extent to which non-occupational noise exposure contributes to overall exposure and the development of occupational hearing loss. Hearing assessment was performed using subjective audiological testing pure-tone audiometry, on a sample of 72 participants. The results revealed a significant risk of hearing loss among workers exposed to workplace noise (χ^2=72.688, df=10, p=0.000<0.001). It was found that the degree of hearing loss increased with the duration of work in noisy environments (t=14.449, df=70, p<0.001). No statistically significant association was found between non-occupational noise exposure and changes in the degree of hearing loss, indicating that noise outside the workplace does not represent a significant predictor of the occurrence or progression of hearing loss.

Key words: occupational noise, non-occupational noise, hearing loss.

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SAŽETAK

Glasna buka na radnom mjestu česta je pojava na tržištu rada. Dugotrajna izloženost prekomjernoj buci može dovesti do oštećenja sluha i razvoja profesionalnih oboljenja. Cilj ove studije bio je ispitati uticaj profesionalne izloženosti buci na pojavu gubitka sluha kod radnika izloženih opasnim nivoima buke na radnom mjestu, kao i utvrditi u kojoj mjeri neprofesionalna izloženost buci doprinosi ukupnoj izloženosti i razvoju profesionalnog gubitka sluha. Procjena sluha provedena je pomoću subjektivne audiološke metode – tonske audiometrije, na uzorku od 72 ispitanika. Rezultati su pokazali značajan rizik od gubitka sluha kod radnika izloženih buci na radnom mjestu ($\chi^2 = 72{,}688$; $df = 10$; $p = 0{,}000 < 0{,}001$). Utvrđeno je da se stepen gubitka sluha povećava s dužinom radnog staža provedenog u bučnom okruženju ($t = 14{,}449$; $df = 70$; $p < 0{,}001$). Nije utvrđena statistički značajna povezanost između neprofesionalne izloženosti buci i promjena u stepenu gubitka sluha, što ukazuje da buka izvan radnog mjesta ne predstavlja značajan prediktor pojave niti progresije oštećenja sluha.

Ključne riječi: profesionalna buka, neprofesionalna buka, gubitak sluha.

INTRODUCTION

Hearing loss, as the most common sensory deficit (Roccio et al., 2020), can lead to changes in an individual's family, social, and professional life (Barišić et al., 2004). Hearing loss and deafness are considered public health problems that occur in a large portion of the general population. The most common environmental factor leading to hearing loss is noise exposure. The development of technology and industry has resulted in increased sound intensity and the emergence of excessive levels of noise, which has become increasingly prevalent in the workplace. Exposure to excessive levels of noise can affect worker' health, reduce work performance, cause a higher number of errors and occupational injuries, and lead to decreased attention and missed information relevant to task completion. Today, there are almost no workplaces without noise. Noise is most commonly found in industry, transportation, and agriculture. Hearing loss due to occupational noise exposure is a significant health problem with economic consequences. The presence of noise directly affects work performance, as working in a noisy environment requires increased concentration, leading to faster fatigue and reduced work quality. The occurrence of occupational deafness is very complex and is associated with high-intensity noise, progressively increasing with the time spent in a noisy environment. Noise-induced hearing loss is a problem that should be considered from both social and health perspectives due to its continual rise. Nearly a quarter of self-reported hearing difficulties among workers can be attributed to their exposure to workplace noise (Tak & Calvert, 2008). The impairment can be bilateral, symmetrical, or unilateral, depending on the position of the ear relative to the sound source (Esquivel et al., 2018). Most cases of noise-induced hearing loss occur bilaterally. Recent studies (Le et al., 2017; Mirza et al., 2018) indicate the presence of unilateral hearing loss in 2–22% of cases, in situations where noise exposure is significantly louder in one ear than the other. Workers with noise-induced hearing loss are absent more often, may be at increased risk of occupational injuries, and are

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more likely to be underemployed or unemployed (Dzhambov & Dimitrova, 2017; Neitzel et al., 2017). Noise exposure does not occur exclusively in the workplace but also outside of work in everyday life. Common sources of noise include traffic, household appliances, hospitality venues, music events, and frequent use of headphones. Prolonged exposure to these noise sources can have a cumulative effect, worsen existing hearing loss, or increase the risk of its development.

The aim of this study was to examine the impact of noise on the development of hearing loss among workers exposed to noise in the workplace and to determine the extent to which noise exposure outside the workplace contributes to overall exposure and the development of occupational hearing loss.

MATERIAL AND METHODS

Sample of participant

The sample of participants was divided into two subsamples. The first, a control subsample, consisted of workers (36) who were not exposed to noise in the workplace during workday. The second subsample (36) consisted of workers who were exposed to noise levels above 85 dB during workday.

Method of conducting research

The study was conducted at the Otorhinolaryngology Department in the audiology clinic. Participants' hearing was assessed in the morning to prevent fatigue from noise exposure. Audiometric testing was performed at least 18 hours after the last noise exposure to allow recovery from any temporary threshold shifts.

Measuring instruments

Hearing loss in participants was assessed using subjective audiological examination with pure-tone audiometry. For this purpose, a Madsen Xeta audiometer was used. The audiometer, through its computer software, allows for monitoring test results, storing, exporting, and printing data.

Data processing methods

The research results were processed using descriptive analysis. To assess the risk of hearing loss among workers exposed to noise in the workplace, the chi-square test was used. Regression analysis was applied to test the relationship between noise exposure outside of work, total exposure, and the development of occupational hearing loss. Statistical analysis was performed using SPSS version 24.0.

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RESULTS AND DISCUSSION

Table 1 shows the distribution of participants according to the degree of hearing loss. Among workers not exposed to workplace noise, no hearing loss was detected, while among those exposed to workplace noise, 47.2% had mild hearing loss, 30.6% moderate, and 11.1% severe hearing loss or deafness. The mean (M=3.02) and standard deviation (SD=1.14) indicate that, on average, the degree of hearing loss ranges between mild and moderate, with moderate variability among participants. The largest proportion of workers were exposed to noise for 8 hours per day (61.1%), followed by 10 hours (25%) and 12 hours (13.9%). The mean (M=1.52) and standard deviation (SD=0.70) indicate that participants were, on average, exposed to noise between 8 and 10 hours per day, with small individual differences. The highest proportion of workers had been exposed to noise for up to 5 years (30.6%), followed by 6–10 years (19.4%), 11–15 years (11.1%), 16–20 years (16.7%), and over 20 years (22.2%). The mean (M=2.98) and standard deviation (SD= 1.51) indicate that workers are, on average, exposed to long-term noise, with individual differences in both duration and intensity of exposure, which is reflected in the observed degree of hearing loss.

Table 1. Distribution of participants according to the degree of hearing loss and daily and yearly exposure to workplace noise

Variables		Presence of occupational noise			
		f	%	M	SD
Degree of hearing loss	Mild hearing loss	17	47.2	3.02	1.14
	Moderate hearing loss	11	30.6		
	Severe hearing loss	4	11.1		
	Deafness	4	11.1		
Daily noise exposure in hours	8 hours	22	61.1	1.51	.70
	10 hours	9	25.0		
	12 hours	5	13.9		
Yearly noise exposure	0 to 5 years	11	30.6	2.97	1.51
	6 to 10 years	7	19.4		
	11 to 15 years	4	11.1		
	16 to 20 years	6	16.7		
	Over 20 years	8	22.2		

Audiometric characteristics of noise-induced hearing loss are reflected by a drop in the hearing threshold between 3 and 6 kHz. Noise-induced hearing loss is irreversible and manifests at frequencies of 3 kHz, 4 kHz, and 6 kHz. Prolonged exposure leads to a decrease in hearing sensitivity at 0.25 kHz, 0.5 kHz, 1 kHz, 2 kHz, and 8 kHz. After cessation of noise exposure, no further hearing loss occurs (Lie et al., 2016). In cases of noise-induced hearing

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loss, hearing sensitivity assessed via audiometric methods shows a characteristic and recognizable pattern, as well as a specific progression. The longer the exposure to noise, the more profound and widespread the hearing loss becomes, although sensitivity in the social communication range (500–3000 Hz) remains preserved for an extended period (Metiadieri et al., 2013; Stucken & Hong, 2015). To determine the risk of hearing loss among workers exposed to noise in the workplace, it was examined whether occupational noise exposure contributes to the development of hearing loss. Tests of normality, including p-values for the Kolmogorov-Smirnov and Shapiro-Wilk tests, indicated that the data were not normally distributed; therefore, the χ^2 test was used for further analysis. Regarding the time when participants first noticed a decrease in hearing and their self-assessment of hearing in both ears, the largest proportion of participants (27.8%) reported noticing reduced hearing 5 to 10 years ago, 15.3% indicated difficulties occurring 2 to 4 years ago, and 5.6% noticed hearing loss more than 10 years ago. The smallest proportion of participants (1.4%) reported difficulties within the past year. It is important to note that participants were able to evaluate their hearing in the left and right ears separately; however, their responses indicate a roughly similar level of hearing loss in both ears. Subjective assessment of hearing among participants showed that those not working in noisy environments reported excellent (41.7%) or good hearing (58.3%). In contrast, all participants exposed to occupational noise reported reduced hearing.

Table 2. Participants' Subjective Self-Assessment of Hearing

Variables		Presence of occupational noise		No noisy environment	
		f	%	f	%
Subjective hearing assessment	My hearing is excellent	-	-	15	41.7
	My hearing is good	-	-	21	58.3
	My hearing is not good	36	100	36	100
Hearing drop	Not reported	-	-	36	100
	Past year		1.4	-	-
	Past 2 to 4 years		15.3	-	-
	Past 5 to 10 years		27.8	-	-
	>10 years		5.6	-	

The results of the Chi-square test show a statistically significant association between workplace noise exposure and hearing loss among participants (χ^2=72.688, df =10, p=0.000<0.001).

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Table 3. Association between workplace noise exposure and the risk of hearing loss in workers

Test of association	Value	df	p
Pearson's Chi-square	72.688	10	.000
Model probability ratio	98.821	10	.000
Linear-by-linear association	66.402	1	.000

In Table 4, the statistical measures of association between the observed variables are presented. The Spearman correlation value ($r=0.917$; $p<0.001$) indicates an extremely strong positive linear relationship between occupational noise exposure and the risk of hearing loss among workers. Based on the analyzed results, it was determined that there is a statistically significant risk of hearing loss in workers exposed to noise at the workplace. These findings are consistent with the research of Rubak et al. (2006), who compared hearing status among workers in noisy environments with those not exposed to noise. They found that the risk of hearing loss >20 dB in the 2–4 kHz range tripled after more than 20 years of noise exposure. Ibrahimpašić et al. (2009) concluded that occupational noise exposure leads to hearing loss. These impairments are most pronounced in individuals aged 36 to 55 years, i.e., during the most productive years of life. The percentage and degree of noise-induced hearing loss increase with the length of exposure. The highest proportion of noise-induced hearing loss was observed after 4 to 6 years of occupational exposure. Seixas et al. (2012) studied the relationship between hearing loss and exposure duration. An increase in noise exposure of 10 dB led to a 2–3 dB hearing loss over 10 years at 3–6 kHz. Research involving workers exposed to noise levels of 88.59 dB for over 10 years showed the presence of occupational hearing loss in 21.6% of cases. This is due to the cumulative effect of noise on the human body (Berlianasyah & Kaman, 2017). Themann and Masterson (2019) reported that approximately 33% of working-age adults with a history of occupational noise exposure exhibited hearing loss during audiometric testing. Silva et al. (2021), in a sample of 748 metallurgical workers exposed to noise (mean 85.61 dB), found significant progressive deterioration of audiometric thresholds within the first 5 years of employment, with noticeable decline after 3 years.

Table 4. Association between occupational noise exposure and the risk of hearing loss in workers

Correlation	Value	ASE	Approximate T	p
Spearman's correlation	.917	.024	19.229	.000

To determine whether noise exposure outside the workplace significantly contributes to overall exposure and the development of occupational hearing loss, a linear regression analysis was conducted. Table 5 presents the F-value of 1.002 and a p-value of 0.320, indicating that no statistical significance was found at the conventional 0.05 significance

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level. The results show that there is no statistically significant linear relationship between noise exposure outside the workplace and changes in the degree of hearing loss, suggesting that non-occupational noise exposure does not contribute substantially to overall exposure or the development of occupational hearing loss.

Table 5. Impact of Noise Exposure Outside the Workplace – Regression Model

ANOVA					
Model	Sum of squares	p	Mean square	F	p
Regression	666.768	1	666.768	1,002	.320
Residual	46598.547	70	665.694		
Total	47265.315	71			

Further analysis of the regression model indicated that the unstandardized intercept coefficient was 44.239, suggesting that the expected average initial hearing loss is 44.239 when non-occupational noise exposure is zero. The unstandardized coefficient for non-occupational noise exposure was -5.223, implying that for each one-unit increase in non-occupational noise exposure, the average hearing loss is expected to decrease by 5.223 units. However, this effect was not statistically significant (p=0.320). The standardized coefficient for non-occupational noise exposure was -0.119, indicating a relatively small impact on initial hearing loss regardless of variable scaling. In this model, the intercept showed a statistically significant effect on initial hearing loss (p=0.030), whereas non-occupational noise exposure did not (p = 0.320), suggesting insufficient evidence for a significant linear relationship between non-occupational noise exposure and hearing loss. These findings are consistent with those of Neitzel et al. (2004), who reported that non-occupational noise exposure contributes minimally to total exposure among individuals working in high-noise environments. Similarly, Kock et al. (2004) found little impact of non-work-related noise on total exposure. In contrast, Flamme et al. (2012) suggested that noise exposure outside the workplace can, in some cases, be substantial and may significantly contribute to overall hearing loss (Abbate et al., 2005). Seixas et al. (2012) reported that noise exposure outside the workplace generally does not exert a significant influence on the development of occupational hearing loss.

Table 6. Linear Regression Analysis – Non-Occupational Noise Exposure and Hearing Loss

Model	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	Standard error	Beta		
Intercept	44.239	19,948		2.21	.030
Noise exposure outside the workplace	-5.223	5.219	-.119	-1.00	.320

CONCLUSION

A statistically significant association was found between workplace noise exposure and the risk of hearing loss. A statistically significant difference was observed in the average hearing loss between participants exposed to workplace noise and those in the unexposed group. Noise exposure outside the work environment does not contribute to overall exposure or the

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development of occupational hearing loss. The study results highlight the importance of implementing preventive measures to reduce the risk of hearing loss, as well as the need for regular audiometric testing of workers in high-noise conditions. Considering that occupational hearing damage is irreversible, it is necessary to improve guidelines regarding preventive measures.

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