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Investigation of Noise Exposure Levels in Furniture Industry: The Impact of Enterprise Scale and Machine Operational States

Istraživanje razina izloženosti buci u industriji namještaja: utjecaj veličine poduzeća i radnih stanja strojeva

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ABSTRACT • The furniture industry is characterized by the intensive use of cutting, shaping, and surface-treating machinery, which naturally generates high noise levels. This study aimed to assess noise exposure levels in furniture manufacturing facilities by examining the effects of enterprise scale, machine types, and working conditions (loaded and unloaded) on occupational health and safety (OHS). The study was conducted in a total of 30 enterprises, 10 at each enterprise scale level. Physical risk factor data for noise were recorded using on-site measurements for the machines and production lines used at each enterprise level, depending on various variables. ANOVA, T-test, and Correlation analyses were performed to determine the relationships between the variables. The results revealed that small-scale businesses were the riskiest group in terms of noise levels. Generally, although measured noise levels in workplaces remain below the highest exposure action value of 85 dB, critical levels have been detected under specific machinery and working conditions. In machine-based assessments, the critical machines exceeding the highest exposure value of 85 dB are: In small-scale businesses – planing machine (95.26 dB), circular saw (88.08 dB) and band saw (86.81 dB); in micro-scale businesses – CNC drilling machine (91.13 dB), CNC sizing machine (88.01 dB) and band saw (85.95 dB); and in medium-scale businesses – circular saw (85.24 dB). As a result of the study, it has been emphasized that long-term noise exposure poses a risk to employees' hearing health and that preventive measures are therefore mandatory.

KEYWORDS: noise pollution; furniture industry; machinery; occupational safety and health

SAŽETAK • Industriju namještaja obilježava intenzivna primjena strojeva za rezanje, oblikovanje i obradu površina drva, što posljedično uzrokuje visoke razine buke. Cilj ovog istraživanja bio je procijeniti razine izloženosti

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buci u pogonima za proizvodnju namještaja ispitivanjem utjecaja veličine poduzeća, vrste strojeva i radnih uvjeta (pod opterećenjem i bez njega) na zaštitu na radu. Istraživanje je provedeno u ukupno 30 poduzeća, odnosno u deset poduzeća za svaku kategoriju veličine poduzeća. Podatci o fizičkim čimbenicima rizika od buke prikupljeni su mjerenjem u blizini strojeva i proizvodnih linija u poduzećima različitih veličina, ovisno o različitim varijablama. Za utvrđivanje odnosa između varijabli provedeni su ANOVA, t-test i korelacijska analiza. Rezultati su pokazali da su mikropoduzeća i mala poduzeća rizičnije skupine s obzirom na razinu buke. Općenito, iako su izmjerene razine buke na radnim mjestima ispod gornje granične vrijednosti izloženosti od 85 dB, kritične razine zabilježene su za specifične strojeve i radne uvjete. Procjenama pojedinih strojeva ustanovljeno je da su kritični strojevi koji prelaze gornju graničnu vrijednost izloženosti od 85 dB sljedeći: u malim poduzećima blanjalica (95,26 dB), kružna pila (88,08 dB) i tračna pila (86,81 dB); u mikropoduzećima CNC bušilica (91,13 dB), CNC raskrajač (88,01 dB) i tračna pila (85,95 dB) te u srednje velikim poduzećima kružna pila (85,24 dB). Kao rezultat istraživanja naglašeno je da dugotrajna izloženost buci nosi rizik od oštećenja sluha radnika te da su stoga preventivne mjere obvezne.

KLJUČNE RIJEČI: onečišćenje bukom; industrija namještaja; strojevi; zaštita na radu

1 INTRODUCTION

1. UVOD

The furniture manufacturing sector holds an important position in national economies in terms of economic growth and employment potential (Grzegorzewska, 2020). However, the sector also involves significant hazards that directly affect employee health due to physical risk factors present in the working environment (Turan and Yıldız Töre, 2021; Özdemir and Albayrak, 2024). Among these physical risk factors, noise stands out as one of the most common and critical occupational health and safety (OHS) problems in the furniture industry (Yaşar *et al.*, 2024). Particularly in furniture production facilities where cutting, drilling, shaping, and surface-processing machines are intensively used, high levels of noise threaten workers' hearing health, hinder communication, cause distraction, and indirectly increase the risk of occupational accidents (Beljo Lučić and Goglia, 1995; Hasan *et al.*, 2024).

Machines commonly used in furniture production processes – such as circular saws, milling machines, CNC units, sanding lines, air compressors, and various assembly machines – generate high noise levels due to their operating principles (Owoyemi *et al.*, 2016; Serin *et al.*, 2017). The level of noise emitted from these machines may vary depending on several factors, including machine type, maintenance condition, production line layout, the worker's proximity to the machine, and production intensity (Serin *et al.*, 2013; Dimou, 2014). Previous studies have shown that noise levels in carpentry lines and high-speed cutting machines often exceed 85 dB(A), and in some enterprises this level may rise to 95–100 dB(A) (Rathipe and Raphela, 2022), which indicates that legal limits are exceeded (MLSS, 2013). According to OHS regulations, exposure above 85 dB(A) requires employees to use hearing protection, while exposure above 87 dB obliges employers to implement technical and organizational improvements (Directive 2003/10/EC, 2003; MLSS, 2013; Official Gazette, 2013).

Noise is also known to affect more than just hearing health. Long-term exposure to high noise levels can lead to stress, sleep disorders, fatigue, decreased performance, concentration problems, and communication difficulties (Mehrotra *et al.*, 2024). Furthermore, noise can increase the likelihood of accidents by making it more difficult for workers to hear emergency warnings (Diviani *et al.*, 2019).

Across Türkiye, the distribution of enterprise scales in furniture manufacturing is as follows: 23,372 micro-scale enterprises (86 %), 3,238 small-scale enterprises (11 %), and 490 medium-scale enterprises (1.8 %). In terms of total employment in the sector, 32 % (62,859 workers) are employed in small-scale enterprises, 33 % (65,449 workers) in medium-scale enterprises, and 23 % (44,363 workers) in micro-scale enterprises (SSI, 2022).

This study aims to analyze noise, a physical risk factor, in the furniture industry, which, due to its small-scale business structure and location far from industrial zones, has a high risk of occupational accidents and diseases. Within this scope, the study identifies and compares noise levels among different sizes of businesses in the furniture sector, at varying levels of machinery and equipment, and in terms of operational activities. Based on the data obtained, improvement suggestions have been developed for different variables.

Studies on noise exposure in the furniture industry in the literature have generally focused either on specific machine types or on general operational data. However, this study differs from previous literature and the authors' past works by combining and analyzing the scale of the operation (micro, small, medium), machine operating conditions (loaded/unloaded), and measurement locations (operator location/environment) within the same dataset. This multivariate approach offers a unique contribution not only by identifying noise risk through measurement but also by holistically revealing how this risk interacts with the business structure and operational dynamics.

2 MATERIALS AND METHODS

2. MATERIJALI I METODE

This study aimed to examine noise pollution in furniture manufacturing firms operating in the central district of Bursa across different enterprise scales (small, medium, and large). The research was conducted as a field study in furniture production facilities. For this work, the enterprise scale classification of the Small and Medium Enterprises Development Organization (SMEDSA) for the year 2023, which is based on the number of employees, was adopted. Accordingly, companies with less than 10 employees are defined as micro-sized, companies with 10-50 employees are defined as small-sized, and companies with 50-250 employees are defined as medium-sized (SMEDSA, 2023).

To ensure reliable results in the variance analyses applied to the data obtained from this study, it was essential that sample sizes across groups were not significantly different. For this reason, a minimum of 10 enterprises per scale group (small, medium, and large) was targeted, and measurements were conducted in at least 30 enterprises in total. Enterprises were selected using a convenience sampling method based on their accessibility, availability, and ability to reflect industry activity.

Noise measurements were conducted using a digital sound level meter (brand: EXTECH, model: EN300-5). This device is an “Integrated Mean Field Sound Level Meter” conforming to IEC 61672-1 Class 2 standards. The measurement process was carried out in accordance with the device measurement sensitivity of 1.5 dB(A). The sound level meter is also capable of performing frequency analysis, allowing the frequency range of each decibel value to be determined.

Noise measurements of workers operating in indoor environments in furniture manufacturing enterprises were carried out using a digital sound level me-

ter, as illustrated in the noise measurement algorithm shown in Figure 1. In this study, the noise measurement device was calibrated to 104 dB(A) prior to measurements. Noise measurements were performed using A-weighting and slow response mode, at the workers’ ear level (160 cm). Measurements were conducted on workers operating different machines in each enterprise, with approximately 10 minutes of measurement duration and three repetitions per measurement. All measurements were taken during day shifts and while the facility was in active production.

Noise level measurements in the furniture manufacturing facility were conducted in accordance with the ‘Task-Based Measurement Strategy’ outlined in the ISO 9612 standard. To satisfy and exceed the minimum duration requirements specified by the standard, three independent measurement repetitions (samples) were recorded for each task, with each sampling period lasting 10 minutes. The measurements were converted to an eight-hour working period using Equation 1. Using Equation 2, the maximum allowable working durations for workers were calculated (Directive 2003/10/EC, 2003; Noise Regulation, 2003).

$$L_{ED,d} = L_{eq} + 10 \cdot \log(t/8)$$

$$L_{ED,d} = L_{eq} + 10 \cdot \log(0.5/8) \quad (1)$$

L_{eq} – noise level, t – measurement duration (hours).

$$L_{ED,d} = 10 \cdot \log_{10} \left(\frac{t_1 \cdot 10^{\frac{L_1}{10}}}{8} \right) \quad (2)$$

L_1 – noise level at time t_1 , t_1 – exposure duration, $L_{ED,d}$ – hazard limit.

The measurements to be conducted in the enterprises were evaluated within the scope of continuous noise exposure. Measurements were carried out along the furniture production line, primarily at the workers’ operating positions and movement routes, in a manner

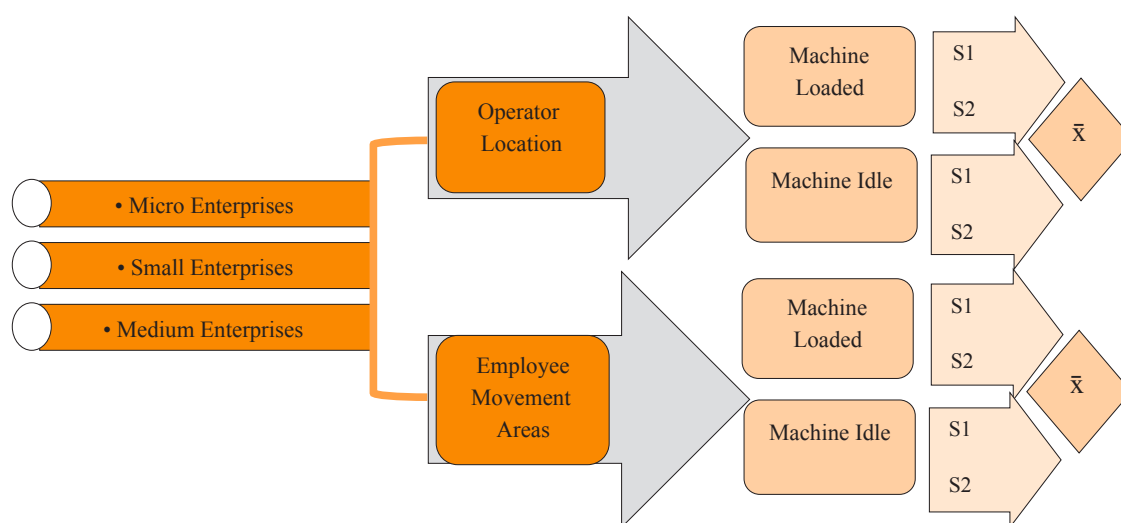


Figure 1 Noise measurement algorithm
Slika 1. Algoritam za mjerenje buke

that covered the entire working environment. The noise levels transmitted from the machines to the workers were compared among enterprises in accordance with the relevant regulations (ILO, 1993). The aim of these measurements was to determine the personal noise exposure of furniture industry workers.

Descriptive statistical values for the dust data were calculated, and summary tables and graphs were prepared for each enterprise and machine type. To determine whether there were statistically significant differences among dust measurement data from different enterprises and machines, variance analysis (ANOVA) was performed. The collected data were analyzed using statistical methods, and all analyses were conducted with the SPSS (Statistical Package for the Social Sciences) software, after which the results were interpreted.

3 RESULTS AND DISCUSSION

3. REZULTATI I RASPRAVA

In the study, three different measurements were conducted for each variable in the enterprises within the measurement scope. The reliability (internal consistency) of the data obtained from the measurements was calculated using the Cronbach's Alpha Reliability Coefficient (α) as 0.716. The fact that the reliability coefficient satisfied the condition of $0.60 < \alpha < 0.80$ indicated that the data were reliable (Kalaycı, 2010; Yıldız and Uzunsakal, 2018). The Kolmogorov-Smirnov test was applied to the data, and it was determined that the data showed a normal distribution. Therefore, parametric tests were used in the analyses.

Data obtained from micro, small, and medium-sized enterprises where noise levels were measured were subjected to a general evaluation (using a One-Sample T-Test) according to the highest exposure ac-

tion value of 85 dB (Directive 2003/10/EC, 2003; MLSS, 2013; Official Gazette, 2013). The findings revealed that the measured values showed statistically significant differences ($p < 0.05$) from the determined limit value. It was determined that the average noise level in the businesses was 3.949 dB below the specified limit value (Table 1). In a general evaluation conducted in small and medium-sized furniture businesses, it was determined that the average noise level was below 85 dB (Yaşar *et al.*, 2024). However, another study reported that the highest exposure action value of 85 dB was exceeded in 70 % of the enterprises (Hasan *et al.*, 2024). The high noise risk in small-scale enterprises is driven by cumulative noise from closely spaced, older machinery, poor building acoustics, and low PPE compliance.

The results of the variance analysis showed statistically significant differences ($p < 0.05$) among the measured noise levels according to the enterprise scale variable (Table 2). This difference was found to be between small-scale and medium-scale enterprises. In a study conducted in the woodworking and furniture sector, it was reported that the development of OHS culture in small and medium-sized enterprises was insufficient (Komut *et al.*, 2023). In another study focusing on the furniture industry, it was determined that noise levels remained below the highest exposure action value 85 dB. (Taşdemir *et al.*, 2024). General assessments in the furniture sector indicate that OHS measures in the sector are insufficient (Yaşar and Komut, 2018; Taşdemir *et al.*, 2024).

The relationship between the measured average noise levels and enterprise scale and measurement location was examined through correlation analysis. The Pearson correlation coefficient was calculated as -0.110 for the business scale and -0.259 for the measurement

Table 1 One-sample *t*-test results for noise data

Tablica 1. Rezultati *t*-testa za podatke o buci

Enterprise scale <i>Veličina poduzeća</i>	<i>N</i>	Mean, dB <i>Srednja vrijednost, dB</i>	Standard deviation <i>Standardna devijacija</i>	<i>t</i>	Degrees of freedom <i>Stupnjevi slobode</i>	Mean differences <i>Razlike srednjih vrijednosti</i>	Sig. (2-tailed) <i>Značajnost (dvosmjerna)</i>
Whole / <i>sve veličine</i>	828	81.051	14.223	-7.990	827	-3.949	0.000*
Micro / <i>mikro</i>	148	82.062	9.236	-3.870	147	-2.938	0.000*
Small / <i>mala</i>	232	84.036	22.864	-0.643	231	-0.964	0.521
Medium / <i>srednja</i>	448	79.171	8.220	-15.009	447	-5.829	0.000*

* $p < 0.05$

Table 2 One-way ANOVA test results for noise data according to the enterprise scale variable

Tablica 2. Rezultati jednosmjernje analize varijance (ANOVA) za podatke o buci prema varijabli veličine poduzeća

Variation source <i>Izvor varijacije</i>	Sum of squares <i>Suma kvadrata</i>	Degrees of freedom <i>Stupnjevi slobode</i>	Mean of squares <i>Srednji kvadrat</i>	<i>F</i> -value <i>F-vrijednost</i>	Sig. (2-tailed) <i>Značajnost (dvosmjerna)</i>
Between groups / <i>među skupinama</i>	3800.909	2	1900.455	9.589	0.000*
Within groups / <i>unutar skupina</i>	163499.982	825	198.182		
Total / <i>ukupno</i>	167300.892	827			

* $p < 0.05$

Table 3 *T*-test results for noise data according to the measurement location variable**Tablica 3.** Rezultati *t*-testa za podatke o buci prema varijabli mjernog mjesta

Enterprise scale <i>Veličina poduzeća</i>	Location <i>Lokacija</i>	<i>N</i>	Mean, dB <i>Srednja vrijednost, dB</i>	Standard deviation <i>Standardna devijacija</i>	<i>F</i>	<i>t</i>	<i>df</i>	Mean differences <i>Razlike srednjih vrijednosti</i>	Sig. (2-tailed) <i>Značajnost (dvosmjerna)</i>
Whole <i>sve veličine</i>	Operator Position <i>položaj operatora</i>	414	84.734	17.880	5.214	7.710	826	7.366	0.000*
	Movement Area <i>područje kretanja</i>	414	77.368	7.628					
Micro <i>mikro</i>	Operator Position <i>položaj operatora</i>	74	83.184	9.319	0.593	1.484	146	2.245	0.140
	Movement Area <i>područje kretanja</i>	74	80.940	9.077					
Small <i>mala</i>	Operator Position <i>položaj operatora</i>	116	89.861	30.352	2.376	4.006	230	11.652	0.000*
	Movement Area <i>područje kretanja</i>	116	78.210	7.766					
Medium <i>srednja</i>	Operator Position <i>položaj operatora</i>	224	82.591	8.336	8.660	9.674	446	6.839	0.000*
	Movement Area <i>područje kretanja</i>	224	75.752	6.517					

* $p < 0.05$

location. In the analysis, the Sig. (2-tailed) value was calculated as 0.020 for the business scale and 0.000 for the measurement location. The results showed that the average measured noise level decreased as the enterprise scale increased.

Statistically significant differences were detected between the position where the machine operator controls the machine and the operator's movement area. For all three enterprise scale groups, the average noise level at the operator's position was 84.734 dB, approaching the limit value, whereas this value was determined as 77.368 dB in the operator's movement area (Table 3).

The difference in noise exposure observed between the operator's fixed position and the movement area is directly linked to workplace acoustics and expo-

sure dynamics. The operator's close proximity to the machine minimizes distance-induced sound attenuation, thereby elevating direct exposure.

Statistically significant differences were found in noise levels between the idle and loaded operating conditions of the machines. In all three plant sizes, the average noise level, which was 77.920 dB during idle operation, approached the limit value, reaching 84.182 dB when the machines were under load (Table 4). The significantly higher noise levels observed under operational loads compared to idle states are directly linked to technical process variables. The escalation of noise emissions under load is primarily driven by increased cutting and contact resistance between the cutting tool and the wood, alongside material type, density, and

Table 4 *T*-test results for noise data according to the machine operating status variable**Tablica 4.** Rezultati *t*-testa za podatke o buci prema varijabli radnog stanja stroja

Enterprise scale <i>Veličina poduzeća</i>	Location <i>Lokacija</i>	<i>N</i>	Mean, dB <i>Srednja vrijednost, dB</i>	Standard deviation <i>Standardna devijacija</i>	<i>F</i>	<i>t</i>	<i>df</i>	Mean differences <i>Razlike srednjih vrijednosti</i>	Sig. (2-tailed) <i>Značajnost (dvosmjerna)</i>
Whole <i>sve veličine</i>	Loaded <i>pod opterećenjem</i>	414	84.182	17.910	3.263	6.489	826	6.262	0.000*
	Idle / u praznom hodu	414	77.920	8.041					
Micro <i>mikro</i>	Loaded <i>pod opterećenjem</i>	74	84.251	9.280	0.009	2.959	146	4.379	0.004*
	Idle / u praznom hodu	74	79.873	8.715					
Small <i>mala</i>	Loaded <i>pod opterećenjem</i>	116	88.528	30.635	2.442	3.046	230	8.986	0.003*
	Idle / u praznom hodu	116	79.543	8.415					
Medium <i>srednja</i>	Loaded <i>pod opterećenjem</i>	224	81.908	8.178	1.968	7.464	446	5.473	0.000*
	Idle / u praznom hodu	224	76.435	7.316					

* $p < 0.05$

Table 5 One-way ANOVA test results for noise data according to the machine variable**Tablica 5.** Rezultati jednosmjernje analize varijance (ANOVA) za podatke o buci prema varijabli vrste stroja

Enterprise scale <i>Veličina poduzeća</i>	Variation source <i>Izvor varijacije</i>	Sum of squares <i>Suma kvadrata</i>	Degrees of freedom <i>Stupnjevi slobode</i>	Mean of squares <i>Srednji kvadrat</i>	F-value <i>F-vrijednost</i>	Sig. (2-tailed) <i>Značajnost (dvosmjerna)</i>
Micro <i>mikro</i>	Between groups <i>među skupinama</i>	4501.490	17	264.794	4.282	0.000*
	Within groups <i>unutar skupina</i>	8039.088	130	61.839		
	Total / <i>ukupno</i>	12540.578	147			
Small <i>mala</i>	Between groups <i>među skupinama</i>	9286.772	18	515.932	0.986	0.477
	Within groups <i>unutar skupina</i>	111467.633	213	523.322		
	Total / <i>ukupno</i>	120754.404	231			
Medium <i>srednja</i>	Between groups <i>među skupinama</i>	6579.111	37	177.814	3.086	0.000*
	Within groups <i>unutar skupina</i>	23625.889	410	57.624		
	Total / <i>ukupno</i>	30205.000	447			

* $p < 0.05$

tool wear. Additionally, the heightened motor load during processing, combined with aerodynamic and mechanical forces generated at high rotational speeds, provides the technical causal framework for these quantitative findings.

The results of the variance analysis regarding the machine variable for the noise levels observed in micro-scale enterprises revealed statistically significant differences ($p < 0.05$) in noise levels among the machines used in these enterprises. The results of the variance analysis regarding the machine variable for the noise levels observed in small-scale enterprises showed that there were no statistically significant differences ($p > 0.05$) among the machines used in these enterprises in terms of noise levels. It was determined that there were statistically significant differences in the measured noise levels among the machines used in medium-scale enterprises (Table 5).

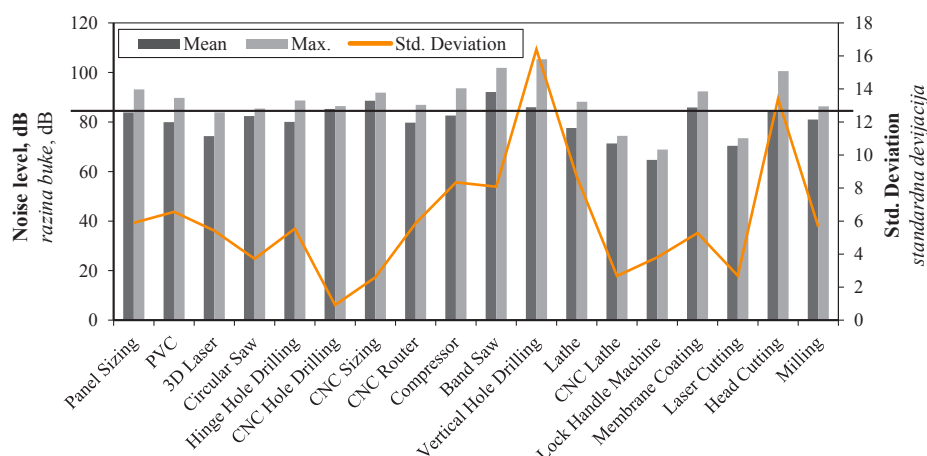
In micro-scale businesses where measurements were taken, the average noise levels of CNC drilling,

CNC sizing, band saw, vertical drilling, and membrane pressing machines were found to be above 85 dB. On the other hand, the measured maximum values of all machines except 3D laser, CNC lathe, door handle drilling, and laser cutting machines exceeded 85 dB (Figure 2).

The values related to the machine variable for noise levels in small-scale enterprises are presented in Figure 3. Accordingly, the machine with the highest average noise level was the planer machine, while the lowest value was measured in the fabric cutting machine.

The measurement values related to the machine variable for noise levels in medium-scale enterprises are presented in Figure 4. Accordingly, the machine with the highest average noise level was the circular saw machine, while the machine with the lowest measured value was the horizontal drilling machine.

Similarly, studies conducted in the forest products industry sector have reported that the noise levels of band saw machines, planer machines, and multi-rip machines exceed the legal limit value and that the sec-

**Figure 2** Measurement values at the machine level in micro-scale enterprises**Slika 2.** Izmjerene vrijednosti na razini strojeva u mikropoduzećima

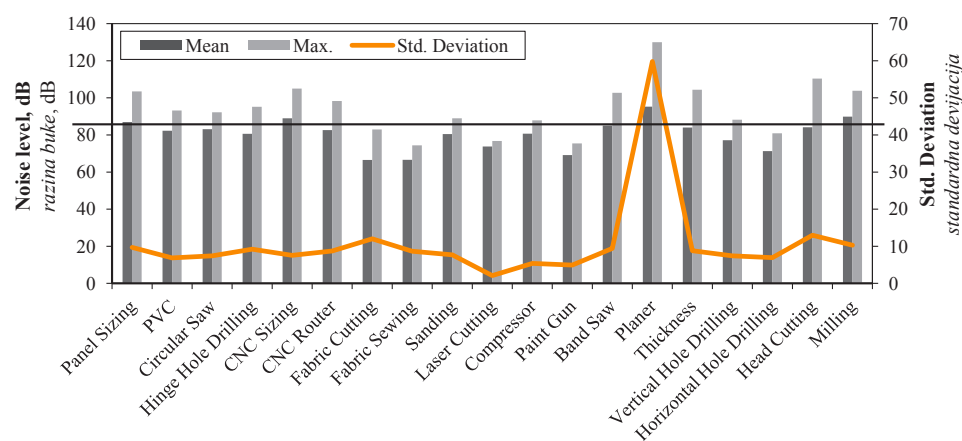


Figure 3 Measurement values at the machine level in small-scale enterprises

Slika 3. Izmjerene vrijednosti na razini strojeva u malim poduzećima

tor generally requires precaution in terms of workplace noise levels (Fidan *et al.*, 2020). On the other hand, in the furniture industry sector, it was measured that the miter cutting machine and the circular saw machine produce noise levels above the limit value (Yaşar *et al.*, 2024). Another study reported that the 85 dB highest exposure action value was exceeded especially in machines located in raw material and semi-finished material cutting and drilling lines in the furniture sector (Turan and Yıldız Töre, 2021; Özdemir and Albayrak, 2024). However, it has been observed that employee complaints continue even in cases where the noise limit value is not exceeded (Helmy and Dwi Sanrani, 2025). In the sector, circular saws, milling machines, CNC units, sanding lines, air compressors, and various assembly machines generate high noise levels due to their operating principles (Owoyemi *et al.*, 2016; Serin *et al.*, 2017). It is also reported that all machines used in wooden furniture production exceed the limit value (Hasan *et al.*, 2024). On the other hand, in workplaces where noise levels are measured below the limit value

in this sector, it has been reported that personal protective equipment should still be used due to instantaneous increases in noise levels (Corlan *et al.*, 2022).

Statistically significant differences were detected among production lines in medium-scale enterprises in terms of noise levels (Table 6).

In medium-scale enterprises, the highest noise level was detected in the carpentry line, whereas the lowest noise level was observed in the upholstery line (Table 7). Noise levels above the limit value have been reported in production lines where wood processing machines are predominantly used (carpentry workshops) (Hasan *et al.*, 2024). On the other hand, welding processes used in metal component production lines have also been reported to exceed the threat threshold for employee health (Özdemir and Albayrak, 2024).

The findings reveal the inadequacy of a purely PPE-focused approach to noise control and highlight the necessity of an occupational safety and health control hierarchy. Therefore, noise should be controlled primarily at the source (insulation, damping) and sec-

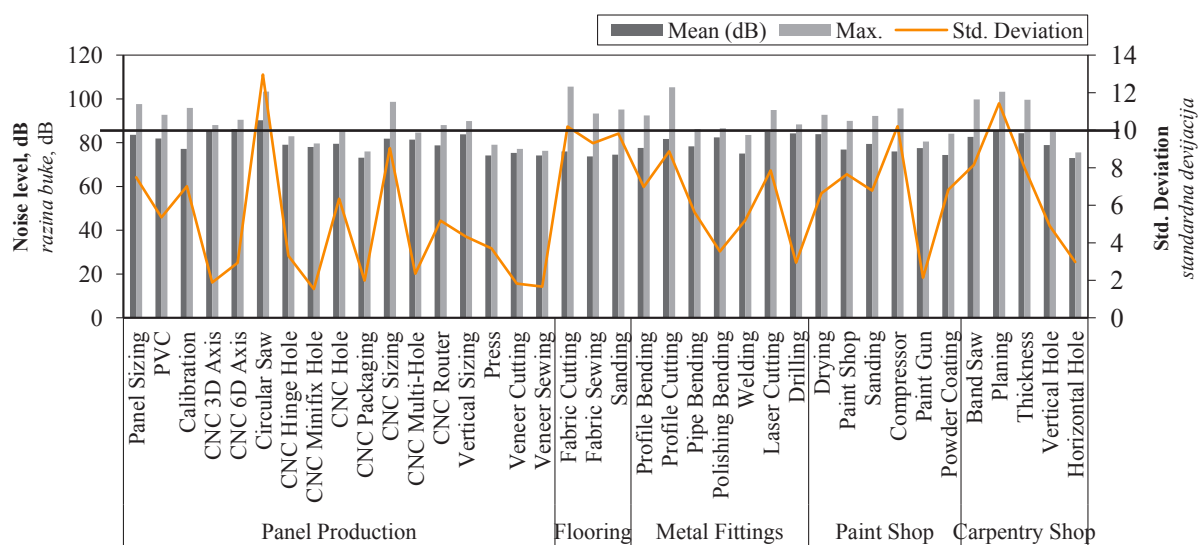


Figure 4 Measurement values at the machine level in medium-scale enterprises

Slika 4. Izmjerene vrijednosti na razini strojeva u srednje velikim poduzećima

Table 6 One-way ANOVA test results for noise data according to the production line variable in medium-scale enterprises
Tablica 6. Rezultati jednosmjerne analize varijance (ANOVA) za podatke o buci prema varijabli proizvodne linije u srednje velikim poduzećima

Variation source <i>Izvor varijacije</i>	Sum of squares <i>Suma kvadrata</i>	Degrees of freedom <i>Stupnjevi slobode</i>	Mean of squares <i>Srednji kvadrat</i>	F-value <i>F-vrijednost</i>	Sig. (2-tailed) <i>Značajnost (dvosmjerna)</i>
Between groups / među skupinama	2780.927	4	695.232	11.231	0.000*
Within groups / unutar skupina	27424.073	443	61.905		
Total / ukupno	30205.000	447			

* $p < 0.05$

Table 7 Descriptive statistics of measurements conducted according to the production line variable in medium-scale enterprises for noise data

Tablica 7. Deskriptivna statistika mjerenja provedenih prema varijabli proizvodne linije u srednje velikim poduzećima za podatke o buci

Production line <i>Proizvodna linija</i>	N	Mean, dB <i>Srednja vrijednost, dB</i>	Standard deviation <i>Standardna devijacija</i>	Std. Error <i>Standardna pogreška</i>	Min.	Max.
Panel production / linija pločastog namještaja	172	80.377	6.782	0.517	53.93	103.33
Upholstery line / linija za ojaštavanje	84	74.754	9.706	1.059	54.83	105.60
Metal parts / strojna obrada metala	64	79.302	6.927	0.866	64.20	105.30
Painting shop / lakirnica	68	78.183	7.765	0.942	50.73	95.70
Carpentry shop / stolarska radionica	60	82.878	8.904	1.150	55.30	103.30
Total / ukupno	448	79.171	8.220	0.388	50.73	105.60

only along its propagation path (acoustic panels, layout) through engineering measures; administrative measures and technically supported PPE applications should be used only as a last resort.

4 CONCLUSIONS

4. ZAKLJUČAK

This study comprehensively analyzed noise exposure in the furniture industry sector based on enterprise scale, machine type, and operational variables (loaded/idle operation and measurement location). The study utilized empirical data obtained from furniture enterprises operating at different enterprise scales.

This study has demonstrated that noise control strategies in the furniture industry cannot be uniform. Findings presented for the first time in this scope show that as the scale of the operation decreases, the impact of operational variables (such as load conditions) on noise exposure increases exponentially. This holistic analysis offers a new perspective to occupational safety and health professionals, enabling them to create risk maps not only based on machines but also related to the scale of the operation.

The findings confirmed an inverse relationship between enterprise scale and noise levels. As the scale of the enterprise increased, the average noise levels decreased. In particular, small-scale enterprises were found to have significantly higher noise risk compared to medium-scale enterprises. This situation can be associated with the more modern machinery infrastructure and better-structured OHS management systems in larger-scale facilities.

Although the overall average noise level across all enterprises remained below the highest exposure action value of 85 dB, machine-based analyses revealed that the risk exhibited a heterogeneous distribution. Especially in micro-scale enterprises, it was found that critical machines such as CNC drilling, CNC sizing, band sawing, and membrane pressing machines exceeded 85 dB. On the other hand, there was a statistically significant difference in noise emissions between machines operating under load and those operating idle. When machines operated under load, the average noise levels approached the limit value. Furthermore, the operator's fixed working position posed a significantly higher risk compared to the operator's movement area.

The finding that the highest risk in medium-scale enterprises occurred in carpentry production lines, while the lowest risk was observed in upholstery lines, indicates that sectoral improvement strategies should be developed specifically for different production departments.

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