

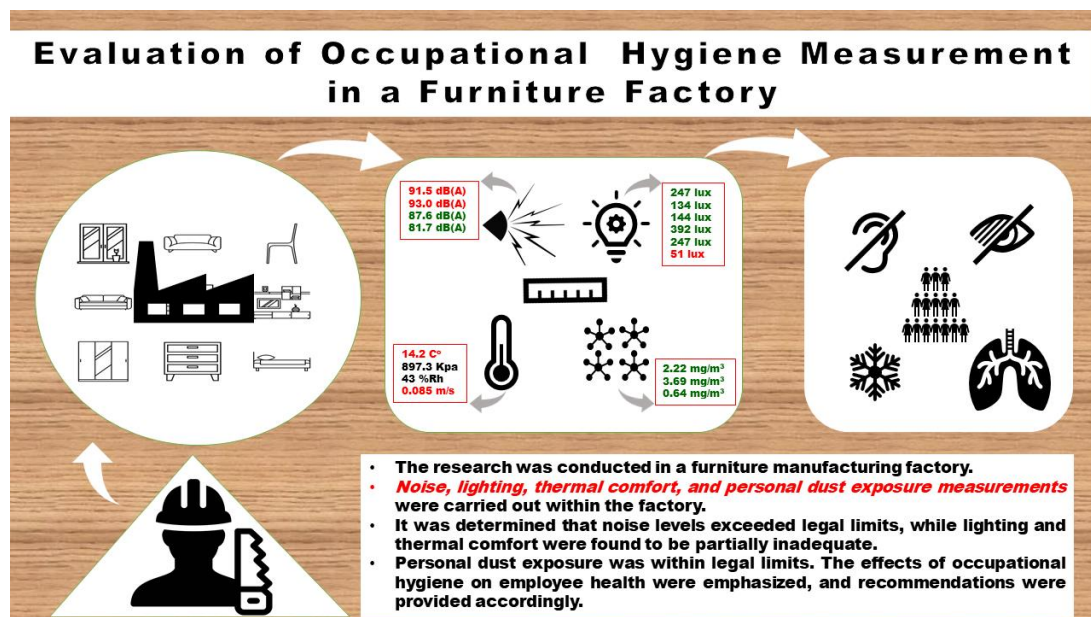
Occupational Safety and Hidden Risks in a Furniture Factory: A Comprehensive Assessment of Hazards Related to Noise, Lighting, Thermal Comfort, and Dust Exposure

Mustafa Özdemir,^{a,*} and Sirer Albayrak^b

* Corresponding author: mozdemir@bayburt.edu.tr

DOI: 10.15376/biores.19.4.9259-9270

GRAPHICAL ABSTRACT



Occupational Safety and Hidden Risks in a Furniture Factory: A Comprehensive Assessment of Hazards Related to Noise, Lighting, Thermal Comfort, and Dust Exposure

Mustafa Özdemir,^{a,*} and Sirer Albayrak^b

This study assessed the occupational health and safety conditions in a furniture manufacturing facility, focusing on key environmental factors such as noise, lighting, thermal comfort, and dust exposure. Noise measurements recorded levels as high as 95.3 dB(A) during CNC machine operations, exceeding legal exposure limits of 87 dB(A), posing significant risks to workers' hearing health. Lighting assessments showed levels ranging from 134 to 247 lux in production lines, which falls below the recommended threshold of 300 lux for adequate visibility. Thermal comfort was evaluated with temperature readings at 14.2 °C and relative humidity at 43%, revealing marginal comfort conditions that could reduce worker efficiency and satisfaction. Dust exposure measurements indicated respirable dust concentrations reaching 3.69 mg/m³ in the cutting department, which is close to the permissible exposure limit of 5 mg/m³, raising concerns about long-term respiratory health. These findings suggest several measures to improve workplace safety, including enhanced engineering controls, mandatory personal protective equipment (PPE), improved lighting systems, optimised thermal conditions, and advanced ventilation to reduce dust exposure. This comprehensive evaluation provides critical insights for improving furniture factories' occupational health and safety practices.

DOI: 10.15376/biores.19.4.9259-9270

Keywords: Occupational health and safety; Furniture industry; Occupational hygiene; Noise; Respirable dust

Contact information: a: Bayburt University, Faculty of Applied Sciences, Department of Emergency Aid and Disaster Management, 69010, Bayburt, Türkiye; b: Ağrı İbrahim Çeçen University, Department of Property Protection and Security, 04200, Ağrı, Türkiye *Corresponding author: mozdemir@bayburt.edu.tr

INTRODUCTION

In today's world, where industrial activities are rapidly increasing, occupational hygiene, health, and safety concepts are essential. Ensuring that all employees work in a healthy and safe environment enhances work productivity and reduces workplace accidents and occupational diseases (Benjamin 2008; Takala *et al.* 2014). Occupational hygiene involves identifying, assessing, and controlling physical, chemical, and biological risk factors in the work environment (Niciejewska and Kiriliuk 2020). In this context, occupational hygiene measurements are conducted to identify potential hazards in the workplace and mitigate their adverse effects on workers' health (Woźny 2020).

Workers in the furniture manufacturing sector, like those in other industries, face various occupational health and safety hazards during production processes. These hazards

commonly include noise, thermal comfort, inadequate lighting, dust exposure, and vibrations. Noise, in particular, is a factor that can lead to hearing loss over the long term and negatively impact workers' concentration. Lighting is also crucial for the work environment's contribution to efficiency and employees' visual health. Another factor, dust exposure, can cause respiratory illnesses, while vibrations can harm the musculoskeletal system (Kielesińska 2020; Niciejewska and Obrecht 2020).

Noise is one of the most common occupational hazards in the workplace. Prolonged exposure to occupational noise can lead to hearing loss, as well as other auditory disorders such as tinnitus and auditory hypersensitivity, and it may also cause stress, cardiovascular diseases, and cognitive decline (Zeng *et al.* 2024). Noise pollution is a significant issue in furniture factories, leading to various health problems among workers (Ratnasingam *et al.* 2010; Turan and Töre 2021). In high-noise jobs (≥ 95 dBA), more accidents per worker have been reported among younger workers, although the natural risk of injury in such jobs was not controlled (Estill *et al.* 2017). Various studies conducted in furniture factories have shown that the noise levels to which workers are exposed are generally at or near the legal limits. For instance, a study in Southeast Asia found that rough milling operations in furniture factories recorded the highest noise levels, with 43% of workers exposed to noise levels above the permissible legal limits (Ratnasingam *et al.* 2010). Similarly, a study conducted in Denmark found that noise doses in furniture factories were at the same level as the permissible legal limits (Vinzents and Laursen 1993).

Workplace lighting conditions are a critical factor for ensuring workers' visual comfort and improving their job performance. Inadequate or overly bright lighting can cause eye strain, distractibility, and increase the likelihood of errors. In the furniture industry, where detailed work is performed, it is crucial to provide appropriate lighting levels in production areas. Numerous studies demonstrate the effects of lighting on the human body. Daylight synchronizes the biological clock and regulates the rhythms of hormones such as melatonin and cortisol, directly impacting brain function. Therefore, it can be argued that lighting may influence employees' job performance and productivity (Leprout *et al.* 2001). Optimized lighting has many positive features that can enhance comfort and safety in indoor environments. Several studies have investigated the impact of dynamic lighting on health and well-being (Zhang *et al.* 2020; Fukumura *et al.* 2021). Numerous studies emphasize the importance of the work environment on employee performance, well-being, and the incidence of occupational diseases (Andrejiová *et al.* 2019; Baloch *et al.* 2021; Sunde *et al.* 2020). An industrial study has demonstrated that an increase in lighting levels also leads to an increase in employee productivity (Juslén and Tenner 2005).

Workers in factories typically perform various physical tasks that result in higher metabolic rates than office workers. Therefore, they have a greater need to maintain thermal balance. Studies have shown that an appropriate thermal environment can enhance employees' thermal comfort and increase their work efficiency (Wang *et al.* 2020). In temperate or cold climates, cognitive and work performance is optimal between 22 and 24 °C; however, both higher and lower temperatures can impair performance and learning efficiency (Wolkoff *et al.* 2021). Ensuring proper thermal comfort in furniture factories is crucial for worker health and can positively affect productivity (Kadric *et al.* 2017). A study conducted in three furniture factories found that workers' productivity could be influenced by indoor temperature (Pham *et al.* 2024). Another study indicated that within a temperature range of 16 to 33 °C, women generally exhibited better cognitive

performance at warmer temperatures, while men performed better at lower temperatures (Bueno *et al.* 2021).

Studies on dust exposure have revealed significant health risks for workers in furniture factories. A study conducted in Southeast Asia found that dust concentrations in the sanding department were at levels that could negatively affect workers' respiratory health (Ratnasingam *et al.* 2010). Another study in Egypt reported that furniture factory workers had significantly lower respiratory function than a control group, with obstructive ventilatory patterns being more prevalent (Ibrahim *et al.* 2022).

This study aimed to scientifically examine the results of noise, lighting, thermal comfort, and personal respirable dust exposure measurements conducted in a furniture factory. The measurements taken in the factory are of great importance for evaluating existing working conditions and identifying areas that require improvement. This study aimed to provide valuable insights into the measures that need to be taken to enhance the effectiveness of occupational hygiene practices and protect worker health.

EXPERIMENTAL

Materials and Method

This study was conducted in a factory in the Organized Industrial Zone of Konya, one of the leading cities in Türkiye's furniture manufacturing sector. The factory specialises in office furniture production and employs 120 workers. Within the scope of this study, occupational hygiene measurements were carried out, and standard methods were used to ensure the accuracy and reliability of the results.

Personal noise exposure levels were assessed using personal dosimeters by the TS EN ISO 9612 (2009) standard. Measurements were conducted at various workstations throughout the factory, considering the variability in noise levels (Golmohammadi *et al.* 2022).

Lighting conditions were evaluated using a light meter in compliance with the COHSR-928-1-IPG-039 (2009) standard. Measurements were taken at multiple locations within the factory to assess the adequacy and uniformity of lighting distribution (Kodaloğlu and Kodaloğlu 2022).

Thermal comfort conditions in the factory were measured according to the TS EN ISO 7730 (2006) standard, considering factors, including temperature, humidity, and air velocity, to determine whether the working environment was within acceptable thermal comfort limits (Lenzuni and Del Gaudio 2007).

Determining respirable personal dust concentration in the air was performed following the MDHS 14/3 (2000) methodology. Using dust sampling devices, personal dust samples were collected from workers in different factory areas. Every device used in the measurements was selected for its accuracy and reliability, and each was calibrated according to relevant standards before use. The information regarding the devices used in the measurements is provided in Table 1, and the photographs of the devices are provided in Fig. 1. Sample collection and measurements were conducted by authorised laboratory personnel. Before sampling, a preliminary assessment was performed per the TS EN 689:2018+AC (2019) standard (Baykan and Ünal 2021). This assessment evaluated exposure sources, durations, production processes, work organisation, shifts, and employee duties. The measurement strategies were determined based on this information.

All dust, lighting, thermal comfort, and noise exposure measurements were conducted on February 13, 2024, between 15:00 and 17:00, when the machines were operating at full capacity. This ensured that the data collected accurately represented the highest exposure conditions in the factory, allowing for a precise assessment of potential risks under maximum operational loads.

Table 1. Device Information for Occupational Hygiene Measurements

Measured Parameter	Device Name/Brand/Model	Device Code
Dust Measurement Device	Dust Pump / Buck / Libra L-4	DB-009
Dust Measurement Device	Dust Pump / Buck / Libra L-5	DB-023
Dust Measurement Device	Dust Pump / Buck / Libra L-5	DB-024
Lighting Measurement Device	Light Meter / Extech	DB-011
Thermal Comfort Measurement	Thermal Comfort / Kimo / HQ 210	DB-012
Sound Level Calibrator	Noise Calibrator / ND9	DB-017
Noise Exposure Measurement	Dosimeter / Extech / SL355	DB-006
Temperature-Humidity-Pressure	Environmental Conditions Meter / TFA	DB-010



Fig. 1. Occupational hygiene measurement devices, (a) personal dust exposure measurement device, (b) lighting measurement device, (c) thermal comfort measurement device, (d) personal noise exposure measurement device

During the measurements, the environmental conditions required by the methods were considered, and any environmental factors that could affect the validity of the results were monitored and recorded. Environmental conditions were controlled in both the field and laboratory environments during the measurements. No environmental conditions that could negatively affect the results were encountered. The expanded uncertainty value affecting each measurement result was reported as ‘ $\pm$ value’ in the relevant results tables. The expanded measurement uncertainty was calculated with a coverage factor of 2 to provide an approximate 95% confidence interval. The calculations were performed using the methods recommended by Magnusson *et al.* (2017) with the Microsoft Excel software (Microsoft Corporation, Microsoft Office 2021, Redmond, WA, USA).

RESULTS AND DISCUSSION

Noise Measurement Results

Personal noise exposure levels assessed using personal dosimeters according to the TS EN ISO 9612 (2009) standard for operators working at different workstations in the

furniture factory are presented in Table 2. The measurements were recorded in terms of personal exposure values ($L_{EX, 8h}$) and peak noise levels (P_{peak}) by selecting the “Task-Based Strategy” at the workplace in compliance with occupational health and safety regulations.

In Table 2, dB(A) is an A-frequency weighted sound level measure that places more weight on the mid and high frequencies where the human auditory system is most sensitive to low-intensity sounds. Personal Exposure ($L_{EX, 8h}$) is the time-weighted average of all A-frequency weighted noise exposure levels, including peak sound pressure and impulsive noise for an 8-h workday. In contrast, $L_{EX, 8h, m}$ is the contribution of the A-frequency weighted noise exposure level of the “m” task to the daily noise level. P_{peak} is the peak C-frequency weighted instantaneous noise pressure.

Table 2. Noise Measurement Results

Measured Section	Task	Task Duration (h)	Measurement Duration (min)	Noise Level dB(A)	Contribution to Task's Personal Exposure ($L_{EX, 8h, m}$) dB(A)	Personal Exposure Result ($L_{EX, 8h}$) dB(A) ± Measurement Uncertainty	P_{Peak} dB (C)
Production Line 1	CNC Operator	8	15	95.3	93.4	91.5 ± 3.2	139.4
				90.8			
				92.8			
Production Line 2	Cutting Operator	8	15	92.9	93.0	93.0 ± 3.1	138.8
				91.8			
				93.8			
Welding Section	Welder	8	15	87.0	87.1	87.6 ± 3.2	138.8
				88.8			
				84.0			
Sewing Section	Sewing Operator	8	15	80.5	81.7	81.7 ± 3.1	138.8
				82.6			
				81.5			

The “Regulation on the Protection of Workers from Noise-Related Risks” published by the Turkish Ministry of Labor and Social Security has determined the limit values as follows:

Lowest exposure action values: ($L_{EX, 8 \text{ hours}}$) = 80 dB(A) or P_{peak} = 135 dB(C) re. 20 μ Pa].

Highest exposure action values: ($L_{EX, 8 \text{ hours}}$) = 85 dB(A) or (P_{peak}) = 140 Pa [137 dB(C) re. 20 μ Pa].

Exposure limit values: ($L_{EX, 8 \text{ hours}}$) = 87 dB(A) or (P_{peak}) = 200 Pa [140 dB(C) re. 20 μ Pa] (Republic of Türkiye Ministry of Labour and Social Security 2013a).

The noise level measured for CNC operators in Production Line 1 was recorded at an average of 91.5 dB(A). This value exceeds the acceptable limits for noise exposure and poses a risk to workers’ hearing health (Feder *et al.* 2017). The Peak value was measured at 139.4 dB(C), which is high enough to pose a risk of sudden hearing loss. Therefore, noise-reducing measures and personal protective equipment (PPE) are mandatory for CNC operators.

For cutting operators in Production Line 2, the average noise level was determined to be 93.0 dB(A). Like CNC operators in Production Line 1, this level threatens workers’

hearing health. The exposure result again exceeds acceptable limits, necessitating a review of technical and engineering controls for noise reduction (Themann and Masterson 2019).

The average noise level for welders in the welding section was 87.6 dB(A). Although this value is below the acceptable limits, the welding noise may negatively affect workers' hearing health. The peak noise level (P_{peak}) during welding operations, measured at 138.8 dB(C), carries a significant risk of hearing loss. Thus, regular hearing tests and the implementation of noise reduction measures, such as sound insulation, are recommended for the welding section to protect workers' health. Additionally, using PPE effectively minimises exposure risks (Reinhold *et al.* 2014).

The average noise level for sewing operators in the sewing section was 81.7 dB(A). Although this level is lower than in other production areas, continuous exposure could still cause discomfort and impact hearing health. While the sewing section has relatively lower noise levels, ergonomic improvements and noise reduction measures should be implemented. For instance, insulating sewing machines may further reduce the noise to which operators are exposed, thereby helping to protect their hearing health and enhancing overall workplace comfort (Lie *et al.* 2016).

Lighting Measurement Results

The natural and artificial lighting levels at different workstations in the furniture factory were measured by the COHSR-928-1-IPG-039 (2009) standard (Kodaloğlu and Kodaloğlu 2022). The lighting measurement results are presented in Table 3.

Table 3. Lighting Measurement Results

Measured Section	Measurement Time	Task Performed by Worker	Type of Lighting	Lighting Level (lux) $\pm$ Measurement Uncertainty	Reference Limit Value (lux)*
Production Line 1	15:15	Manufacturing	Natural + LED	247 $\pm$ 6.933	300
Production Line 2	15:15	Manufacturing	Natural + LED	134 $\pm$ 3.761	300
Welding Section	15:15	Welding	Natural + LED	144 $\pm$ 4.042	300
Sewing Section	15:15	Sewing Tasks	Natural + LED	392 $\pm$ 11.003	300
Warehouse	15:15	Stocking	Natural + Projector	51 $\pm$ 1.432	100
* TS EN 12464-1 (2021)					

The lighting measurements in Production Line 1 showed an average of 247 lux ($\pm$ 6.933), while in Production Line 2, the lighting level was determined to be 134 lux ($\pm$ 3.761). These values are below the reference limit of 300 lux. Insufficient lighting in production areas can negatively impact workers' visual performance, increase error rates, and raise the risk of accidents. Therefore, increasing the lighting levels in production lines and ensuring more suitable and uniform lighting is crucial for enhancing worker productivity and safety (Caporale *et al.* 2022).

The lighting measurement in the welding section revealed an average lighting level of 144 lux ($\pm$ 4.042). This value is significantly below the recommended limit of 300 lux for welding tasks. Insufficient lighting can hinder welders from performing their tasks safely and precisely, potentially leading to accidents. Because welding requires focused

attention to detail, improving lighting conditions is necessary. This may involve increasing the number of lighting sources and using more powerful lighting systems (Boyce 2022).

In the sewing section, the measured lighting level was 392 lux (± 11.003), exceeding the reference limit of 300 lux, indicating that the lighting level is adequate for sewing tasks. Adequate lighting can reduce visual fatigue for sewing operators and improve work quality (Gahlot *et al.* 2017). Maintaining existing lighting conditions and ensuring regular maintenance will positively impact worker productivity and work quality.

The lighting measurements in the warehouse area showed an average of 51 lux (± 1.432), which is below the recommended reference limit of 100 lux for warehouses. This low lighting level can hinder adequate visual performance during stock counting, placement, and material retrieval tasks, increasing the risk of errors. Therefore, improving the lighting in the warehouse area and bringing it to an adequate level is recommended (Bellia *et al.* 2011).

Thermal Comfort Measurement Results

The TS EN ISO 7730 (2006) standard measures the thermal comfort conditions at different workstations in the furniture factory. The thermal comfort measurement results from four different sections of the factory are presented in Table 4.

Table 4. Thermal Comfort Measurement Results

Measured Section	Exposure Duration	Total Measurement Duration (h)	Temperature (°C)	Pressure (kPa)	Humidity (%RH)	Air Flow Rate (m/s)
Production Line 1	8	1	14.2	897.3	43	0.165
Production Line 2	8	1	14.2	897.3	43	0.162
Welding Section	8	1	14.2	897.3	43	0.111
Sewing Section	8	1	14.2	897.3	43	0.085

The thermal comfort measurements in Production Lines 1 and 2 showed a temperature of 14.2 °C, a humidity level of 43%, and airflow rates of 0.165 m/s and 0.162 m/s, respectively. These conditions indicate that thermal comfort in the workspace was marginal.

Workers' thermal comfort may be compromised at these temperature and humidity levels, negatively affecting job performance. The low air flow rate may also increase the perceived temperature for workers (Wolkoff *et al.* 2021). Regulating the temperature and humidity in the workspace could improve worker comfort and health.

Thermal comfort measurements in the welding section showed a temperature of 14.2 °C, a humidity level of 43%, and an airflow rate of 0.111 m/s. The sewing section measured the temperature at 14.2 °C, humidity at 43%, and the airflow rate at 0.085 m/s. These results indicate that thermal comfort in both areas was significantly low, with temperature and airflow rate being marginal in the welding section and minimal in the sewing section.

The low air flow rate, in particular, may exacerbate the perceived temperature for workers, further deteriorating thermal comfort. Maintaining these temperature and humidity levels may negatively impact worker comfort and, over time, reduce job performance. Thus, increasing air flow rates and optimising temperature and humidity levels in both sections are essential steps to improve thermal comfort (Brager *et al.* 2015).

Results of Personal Exposure Measurements for Respirable Dust in Air

The results of respirable dust measurements, which were conducted to determine the concentration of dust particles dispersed in the workplace air and to classify the dust based on particle size, are presented in Table 5. The TWA (Time Weighted Average) in this table refers to the time-weighted average measured or calculated for the specified reference period of 8 h.

Table 5. Results of Personal Exposure Measurements for Respirable Dust in Air

Work Area	Exposure Duration (h)	Type of Dust	Detected Respirable Dust Concentration TWA (mg/m ³) ± Measurement Uncertainty	Threshold Limit Value TWA (mg/m ³) *
CNC Operator	8	Inert/Nuisance Dust	2.22 ± 0.335	5
Cutting Operator	8	Inert/Nuisance Dust	3.69 ± 0.558	5
Welder	8	Inert/Nuisance Dust	0.64 ± 0.097	5

*(Republic of Türkiye Ministry of Labour and Social Security 2013)

The respirable dust concentration was 2.22 mg/m³ for the CNC operator, 3.69 mg/m³ for the cutting operator, and 0.64 mg/m³ for the welder. These values are below the threshold limit value (TWA) of 5 mg/m³ for the 8-h reference period. This indicates that the personal exposure measurements for respirable dust across all operators were within safe limits.

The low dust concentration generally indicates good air quality; however, monitoring the type and concentration of dust regularly and maintaining dust control measures is essential. Overall, the measured dust concentrations remain below the threshold limits, demonstrating that respirable dust exposure in the workplace is well-controlled. Optimizing workplace cleanliness and airflow would benefit long-term health protection (Sriproed *et al.* 2013).

CONCLUSIONS

Based on the results for dust, lighting, thermal comfort, and noise exposure measurements conducted in the furniture factory within the scope of this study, the following recommendations are proposed to address the identified non-compliances:

1. Noise Reduction: The noise levels measured, particularly in CNC and cutting operations, exceeded the legal limits and pose a risk to hearing health. To mitigate this, soundproofing materials should be installed around high-noise equipment, and workers should be provided with mandatory personal protective equipment (PPE), such as noise-cancelling earmuffs. Regular hearing screenings for employees are also recommended.
2. Improving Lighting Conditions: The lighting measurements in the production lines and welding sections were below the recommended levels. To address this, increasing the intensity of artificial lighting in these areas is essential, ensuring that it meets the standard of at least 300 lux. Replacing or upgrading current lighting

- systems with energy-efficient LEDs and providing localised lighting for critical tasks could enhance safety and productivity.
3. Enhancing Thermal Comfort: The factory's thermal comfort measurements indicated that temperature and humidity levels were close to the discomfort threshold. A regulated ventilation and air conditioning system is recommended to improve worker comfort to maintain optimal temperature and humidity levels. Airflow in critical areas like the welding section should also be increased to prevent discomfort.
 4. Dust Control: Dust concentrations approached the permissible exposure limits, particularly in the cutting section. More efficient extraction systems should be installed in high-dust areas to further control dust, and workers should be provided with appropriate respiratory protection, such as dust masks. Regular maintenance of ventilation and filtration systems is crucial to ensure continued effectiveness in controlling dust levels. The noise measurements conducted in the furniture factory indicate that the noise levels exposed to employees exceed the permissible legal limits. The hearing health of CNC and cutting operators is particularly at risk. Therefore, it is urgently necessary to review workplace noise-reducing technical and engineering measures and make personal protective equipment mandatory.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude to the management of the company operating in the Konya Organized Industrial Zone, for allowing the measurements of dust, lighting, thermal comfort, and noise exposure to be conducted and for permitting the publication of the results, thus contributing to this study.

REFERENCES CITED

- Andrejiová, M., Piňosová, M., Králiková, R., Dolník, B., Liptai, P., and Dolníková, E. (2019). "Analysis of the impact of selected physical environmental factors on the health of employees: Creating a classification model using a decision tree," *International Journal of Environmental Research and Public Health* 16(24), article 5080. DOI: 10.3390/ijerph16245080
- Baloch, R. M., Nichole Maesano, C., Christoffersen, J., Mandin, C., Csobod, E., de Oliveira Fernandes, E., and Sinphonie Consortium. (2021). "Daylight and school performance in European schoolchildren," *International Journal of Environmental Research and Public Health* 18(1), article 258. DOI: 10.3390/ijerph18010258
- Baykan, P., and Ünal, E. S. (2021). "Wood dust in furniture manufacturing: An exposure determinant study in Ağrı City," *Gümüşhane Üniversitesi Sağlık Bilimleri Dergisi* 10(4), 740-750. DOI: 10.37989/gumussagbil.958563
- Bellia, L., Bisegna, F., and Spada, G. (2011). "Lighting in indoor environments: Visual and non-visual effects of light sources with different spectral power distributions," *Building and Environment* 46(10), 1984-1992. DOI: 10.1016/j.buildenv.2011.04.007
- Benjamin, O. (2008). *Fundamental Principles of Occupational Health and Safety*, International Labour Office, Geneva, Switzerland.

- Boyce, P. R. (2022). "Light, lighting and human health," *Lighting Research & Technology* 54(2), 101-144. DOI: 10.1177/14771535211010267
- Brager, G., Zhang, H., and Arens, E. (2015). "Evolving opportunities for providing thermal comfort," *Building Research & Information* 43(3), 274-287. DOI: 10.1080/09613218.2015.993536
- Bueno, A. M., de Paula Xavier, A. A., and Broday, E. E. (2021). "Evaluating the connection between thermal comfort and productivity in buildings: A systematic literature review," *Buildings* 11(6), article 244. DOI: 10.3390/buildings11060244
- COHSR-928-1-IPG-039 (2009). "Measurement of lighting levels in the work place part VI," Canada Occupational Health and Safety Regulations, Ottawa, Canada.
- Caporale, A., Botti, L., Galizia, F. G., and Mora, C. (2022). "Assessing the impact of environmental quality factors on the industrial performance of aged workers: A literature review," *Safety Science* 149, article ID 105680. DOI: 10.1016/j.ssci.2022.105680
- Estill, C. F., Rice, C. H., Morata, T., and Bhattacharya, A. (2017). "Noise and neurotoxic chemical exposure relationship to workplace traumatic injuries: A review," *Journal of Safety Research* 60, 35-42. DOI: 10.1016/j.jsr.2016.11.005
- Feder, K., Michaud, D., McNamee, J., Fitzpatrick, E., Davies, H., and Leroux, T. (2017). "Prevalence of hazardous occupational noise exposure, hearing loss, and hearing protection usage among a representative sample of working Canadians," *Journal of Occupational and Environmental Medicine* 59(1), 92-113. DOI: 10.1097/JOM.0000000000000920
- Fukumura, Y. E., Gray, J. M., Lucas, G. M., Becerik-Gerber, B., and Roll, S. C. (2021). "Worker perspectives on incorporating artificial intelligence into office workspaces: Implications for the future of office work," *International Journal of Environmental Research and Public Health* 18(4), article 1690. DOI: 10.3390/ijerph18041690
- Gahlot, N., Mehta, M., and Singh, K. (2017). "Assessment of workplace environment for sewing machine activity," *Indian Journal of Positive Psychology* 8(1), 55-58.
- Golmohammadi, R., Darvishi, E., Motlagh, M. S., Faradmal, J., Aliabadi, M., and Rodrigues, M. A. (2022). "Prediction of occupational exposure limits for noise-induced non-auditory effects," *Applied Ergonomics* 99, article ID 103641. DOI: 10.1016/j.apergo.2021.103641
- Ibrahim, A. F., El-Hussiny, M. A. B., Al Wehedy, A., El-Bestar, S., and Abdel Hamied, A. H. M. (2022). "Ventilatory and auditory findings among workers in Asal's furniture factory at New Damietta City, Damietta Governorate, Egypt," *The Egyptian Journal of Hospital Medicine* 89(1), 5991-5999. DOI: 10.21608/ejhm.2022.266830
- Juslén, H., and Tenner, A. (2005). Mechanisms involved in enhancing human performance by changing the lighting in the industrial workplace. *International Journal of Industrial Ergonomics* 35(9), 843-855. DOI: 10.1016/j.ergon.2005.03.002
- Kadric, D., Delalic, N., Midzic-Kurtagic, S., Delalic, B., and Medar, K. (2017). "Energy efficiency assessment and improvement measures for furniture factory," *Annals of DAAAM & Proceedings* 28. DOI: 10.2507/28th.daaam.proceedings.043
- Kielesińska, A. (2020). "Safety of imported machines-selected issues in the context of Polish (UE) regulation," *System Safety: Human-Technical Facility-Environment* 2(1), 174-182. DOI: 10.2478/czoto-2020-0021
- Kodaloğlu, M., and Kodaloğlu, F. A. (2022). "Investigation of lighting values in weaving business in terms of occupational health and safety," *International Journal of Engineering and Innovative Research* 4(3), 191-195. DOI: 10.47933/ijeir.1166996

- Lenzuni, P., and Del Gaudio, M. (2007). "Thermal comfort assessment in comfort-prone workplaces," *Annals of Occupational Hygiene* 51(6), 543-551. DOI: 10.1093/annhyg/mem032
- Leproult, R., Colecchia, E. F., L'Hermite-Balériaux, M., and Van Cauter, E. (2001). "Transition from dim to bright light in the morning induces an immediate elevation of cortisol levels," *The Journal of Clinical Endocrinology & Metabolism* 86(1), 151-157. DOI: 10.1210/jcem.86.1.7102
- Lie, A., Skogstad, M., Johannessen, H. A., Tynes, T., Mehlum, I. S., Nordby, K.-C., Engdahl, B., and Tambs, K. (2016). "Occupational noise exposure and hearing: A systematic review," *International Archives of Occupational and Environmental Health* 89, 351-372. DOI: 10.1007/s00420-015-1083-5
- Magnusson, B., Näykki, T., Hovind, H., Krysell, M., and Sahlin, E. (2017). *Handbook for Calculation of Measurement Uncertainty in Environmental Laboratories* (Report No. TR 537), Nordtest Institute, Taastrup, Denmark.
- MDHS 14/3 (2000). "General methods for sampling and gravimetric analysis of respirable and inhalable dust," Health and Safety Executive, Bootle, UK.
- Niciejewska, M., and Kiriliuk, O. (2020). "Occupational health and safety management in small size enterprises, with particular emphasis on hazards identification," *Production Engineering Archives* 26(4), 195-201. DOI: 10.30657/pea.2020.26.34
- Niciejewska, M., and Obrecht, M. (2020). "Impact of behavioral safety (behavioural-based safety-BBS) on the modification of dangerous behaviors in enterprises," *System Safety: Human-Technical Facility-Environment* 2(1), 324-332. DOI: 10.2478/czoto-2020-0040
- Pham, A. D., Nguyen, T. T. H., and Vu, T. M. H. (2024). "Assessment of indoor air quality of the furniture manufacturers in Binh Duong industrial parks, Vietnam," *IOP Conference Series: Earth and Environmental Science* 1368(1). DOI: 10.1088/1755-1315/1368/1/012008
- Ratnasingam, J., Natthondan, V., Ioras, F., and McNulty, T. (2010). "Dust, noise and chemical solvents exposure of workers in the wooden furniture industry in South East Asia," *Journal of Applied Sciences* 10(4), 1413-1420. DOI: 10.3923/jas.2010.1413.1420
- Reinhold, K., Kalle, S., and Paju, J. (2014). "Exposure to high or low frequency noise at workplaces: Differences between assessment, health complaints and implementation of adequate personal protective equipment," *Agronomy Research* 12(3), 895-906.
- Republic of Türkiye Ministry of Labour and Social Security Regulation (2013). "Regulation on combating dust," Ankara, Türkiye.
- Republic of Türkiye Ministry of Labour and Social Security Regulation (2013a). "Regulation on the protection of employees from risks related to noise," Ankara, Türkiye.
- Sriproed, S., Osiri, P., Sujirarat, D., Chantanakul, S., Harncharoen, K., Ong-Artborirak, P., and Woskie, S. R. (2013). "Respiratory effects among rubberwood furniture factory workers in Thailand," *Archives of Environmental & Occupational Health* 68(2), 87-94. DOI: 10.1080/19338244.2011.646361
- Sunde, E., Pedersen, T., Mrdalj, J., Thun, E., Grønli, J., Harris, A., and Pallesen, S. (2020). "Alerting and circadian effects of short-wavelength vs. long-wavelength narrow-bandwidth light during a simulated night shift," *Clocks & Sleep* 2(4), 502-522. DOI: 10.3390/clockssleep2040037

- Takala, J., Härmäläinen, P., Saarela, K. L., Yun, L. Y., Manickam, K., Jin, T. W., Heng, P., Tjong, C., Kheng, L. G., and Lim, S. (2014). "Global estimates of the burden of injury and illness at work in 2012," *Journal of Occupational and Environmental Hygiene* 11(5), 326-337. DOI: 10.1080/15459624.2013.863131
- Themann, C. L., and Masterson, E. A. (2019). "Occupational noise exposure: A review of its effects, epidemiology, and impact with recommendations for reducing its burden," *The Journal of the Acoustical Society of America* 146(5), 3879-3905. DOI: 10.1121/1.5134465
- TS EN 689:2018+AC (2019). "Workplace exposure, measurement of exposure by inhalation to chemical agents, strategy for testing compliance with occupational exposure limit values," Turkish Standards Institution, Ankara, Türkiye.
- TS EN 12464-1 (2021). "Light and lighting, lighting of workplaces, part 1 indoor workplaces," Turkish Standards Institution, Ankara, Türkiye.
- TS EN ISO 7730 (2006). "Ergonomics of the thermal environment, analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria," Turkish Standards Institution, Ankara, Türkiye.
- TS EN ISO 9612 (2009). "Acoustics, determination of occupational noise exposure, engineering method," Turkish Standards Institution, Ankara, Türkiye.
- Turan, G., and Töre, G. Y. (2021). "Evaluation of major occupational hazards encountered in the furniture production process on employee health," *European Journal of Engineering and Applied Sciences* 4(2), 36-44. DOI: 10.55581/ejeas.1033299
- Vinzents, P., and Laursen, B. (1993). "A national cross-sectional study of the working environment in the Danish wood and furniture industry - air pollution and noise," *The Annals of Occupational Hygiene* 37(1), 25-34. DOI: 10.1093/annhyg/37.1.25
- Wang, H., Xu, Z., Ge, B., and Li, J. (2023). "Experimental study on a phase change cooling garment to improve thermal comfort of factory workers," *Building and Environment* 227. DOI: 10.1016/j.buildenv.2022.109819
- Wolkoff, P., Azuma, K., and Carrer, P. (2021). "Health, work performance, and risk of infection in office-like environments: The role of indoor temperature, air humidity, and ventilation," *International Journal of Hygiene and Environmental Health* 233, article ID 113709. DOI: 10.1016/j.ijheh.2021.113709
- Woźny, A. (2020). "Selected problems of managing work safety-case study," *Production Engineering Archives* 26(3), 99-103. DOI: 10.30657/pea.2020.26.20
- Zeng, A., Huang, Y., Xin, J., Li, J., Qiu, W., and Zhang, M. (2024). "Progress and recommendations of developing occupational exposure limits for noise-a systematic review," *Heliyon* 10(18). DOI: 10.1016/j.heliyon.2024.e37878
- Zhang, R., Campanella, C., Aristizabal, S., Jamrozik, A., Zhao, J., Porter, P., and Bauer, B. A. (2020). "Impacts of dynamic LED lighting on the well-being and experience of office occupants," *International Journal of Environmental Research and Public Health* 17(19), article 7217. DOI: 10.3390/ijerph17197217

Article submitted: August 28, 2024; Peer review completed: September 21, 2024;

Revisions accepted: October 3, 2024; Published: October 16, 2024.

DOI: 10.15376/biores.19.4.9259-9270