BMC Public Health

RESEARCH

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Industrial noise: impacts on workers' health and performance below permissible limits

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Abstract

Background This study investigates the adverse effects of industrial noise below permissible limits on hearing health, work performance, and work stress among workers in medium-sized enterprises.

Methods The study included two medium-sized enterprises and a total of 172 workers. A comprehensive noise assessment was conducted in both enterprises. Workplace noise levels were recorded using a Larson Davis SoundAdvisor™ Model 831C sound level meter, following ISO 1996–2:2017 standards. The enterprises were categorized as low-noise (mean: 60.55 dB(A), range: 55.6–66.7 dB(A)) and high-noise (mean: 78.22 dB(A), range: 76.5–80.1 dB(A)) groups. Participants' air conduction hearing thresholds (0.5–8 kHz) were measured using an Interacoustics AS608 audiometer. Sociodemographic data were collected, and auditory complaints were assessed through face-to-face interviews. Workers completed the Job Stress Scale, while their supervisors evaluated their performance using the Job Performance Scale. Statistical significance was set at $P < 0.05$.

Results Our analysis revealed elevated hearing thresholds at 2000 and 4000 Hz in both ears and at 6000 Hz in the left ear among workers in the high-noise group. Additionally, employees exposed to higher noise levels demonstrated lower work performance ($P < 0.05$). However, no statistically significant difference was found in work stress levels between the low- and high-noise groups ($P > 0.05$). A significant positive correlation was observed between age and hearing thresholds in both groups, whereas no relationship was found between age and work stress or work performance. Furthermore, no correlation was detected between work stress and work performance.

Conclusion This study highlights the serious health risks associated with industrial noise, even when exposure remains below permissible limits. The findings emphasize the need for effective noise control measures to protect workers' health and performance.

Keywords Occupational noise, Hearing loss, Work stress, Work performance

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Introduction

Noise is a significant global concern, with the detrimental effects of industrial noise drawing increasing attention across various countries and industries. In many workplaces, noise is a pervasive environmental hazard that significantly affects employee well-being [1, 2]. Numerous studies have demonstrated that industrial noise has a serious impact on employee productivity and performance [3]. Evidence consistently shows that noise exposure leads to a wide range of long-term physiological and psychological effects, including hearing loss, cardiovascular diseases, cancer, reduced job satisfaction, impaired psychological well-being, communication difficulties, annoyance, sleep disturbances, decreased work performance, and increased work-related stress [4–6]. Furthermore, research indicates that occupational noise-induced hearing loss not only heightens aggression among employees but also diminishes their quality of life and work performance [7]. These scientific findings underscore the urgent need for effective workplace noise control measures.

The workplace plays a crucial role in shaping human health and well-being, as adults spend nearly half of their waking hours at work [8]. Research indicates that work environments significantly impact employees'cognitive and emotional states, with evidence suggesting a positive correlation between a calm work environment and improved employee performance [9]. Noise has been shown to influence work performance both directly and indirectly by exacerbating psychological distress [10]. Employee performance is a multifaceted construct shaped by various factors, including individual abilities, work-related stress, and workplace design. Enhancing work performance not only reduces costs but also increases workplace profitability [11].

According to the National Institute for Occupational Safety and Health (NIOSH), a hearing protection program must be implemented when workers are exposed to an average noise level of 85 A-weighted decibels (dB(A)) or more over an 8-h period [12]. The Occupational Safety and Health Administration (OSHA) permits an 8-h noise exposure limit of 90 dB(A) for hearing health protection [13]. Most studies in the literature have focused on evaluating workers' hearing health, stress levels, and work performance at noise levels exceeding 85 dB(A) [14–16]. Although research has shown that noise levels below these exposure limits can also impact human health—affecting heart rate, respiration rate, ectodermal activity, and cortisol levels—their effects on employees' work performance and work-related stress remain inconclusive [17]. Compared to large-scale companies, medium-sized enterprises often have more limited workforces, resources, and infrastructure, making them more vulnerable to environmental stressors such as noise. Consequently, these factors may have a greater influence on employee performance, potentially creating a global burden on overall enterprise productivity [18]. This issue is particularly prevalent in the manufacturing, retail, and service industries. This study aims to address this gap in the literature by evaluating the hearing health, work stress, and work performance of workers in medium-sized enterprises exposed to noise levels below the established exposure limits.

Materials and methods

Ethical statement

The study was conducted over a two-month period, from April 1 to May 31, 2024. Before data collection, the study protocol received ethical approval from the Non-Interventional Research Ethics Committee of Bezmialem Vakif University on February 29, 2024 (Decision No: 2024/57). All participants were thoroughly informed about the study's objectives, procedures, and potential implications. Voluntary informed consent was obtained from each participant before their involvement in the research.

Participants

This study assesses employees' hearing thresholds, work stress, and performance at a specific point in time. A comparative analysis was conducted between employees from two medium-sized enterprises with different levels of industrial noise. One enterprise operated in the logistics sector, which is generally associated with lower noise levels, while the other was engaged in furniture manufacturing, a field known for higher noise exposure. This approach aims to establish a scientific foundation for developing targeted noise control measures for medium-sized enterprises across various industries. Both enterprises met the standard definition of a medium-sized enterprise, employing fewer than 250 workers [19].

Based on noise measurements, the enterprises were categorized into two groups: low-noise and high-noise. The study included individuals aged 18–60 years who had been employed at these enterprises for at least one year. Employees with a history of childhood or pre-employment hearing loss, those with known otologic diseases, and individuals using hearing assistive devices (such as hearing aids or cochlear implants) were excluded from the study.

Sample size calculation was performed using G*Power 3.1.9.7 software. Based on Cohen's d criterion, a minimum of 86 participants per group (total $N = 172$) was required to achieve a moderate effect size ($d = 0.5$) with 90% statistical power. This sample size ensured sufficient power at a significance level of $\alpha = 0.05$. To maintain balanced representation, the final sample of 172 participants was evenly distributed between the two enterprises, with 86 participants selected from each based on the inclusion criteria.

Measurement tools

A face-to-face data collection approach was employed to ensure accurate data capture from the target population. Data were collected using a combination of standardized scales, on-site workplace noise measurements, and audiometric assessments. Each enterprise was visited three times for data collection. To minimize temporary threshold shifts and cognitive load, all data collection sessions were scheduled before the employees'shift begins [20].

Industrial noise measurement

A Larson Davis SoundAdvisor™ Model 831 C (New York, USA) sound level meter (SLM) was used for noise measurements, following internationally recognized ISO 1996–2:2017 standards [21]. These standards provide guidelines to ensure the consistency, reliability, and comparability of data. Additionally, these standards help accurately categorize workplace noise levels and support occupational health assessments. The SLM was mounted on a tripod to ensure optimal measurement conditions [22]. Prior to data collection, the business manager confirmed that noise levels remained consistent throughout working hours.

Noise measurements were conducted within the primary production area of each enterprise at four distinct locations. Each measurement lasted ten minutes during morning hours and was strategically positioned to account for the machinery's quantity, type, and noise emission characteristics. Measurements were taken indoors, with no external noise interference. To minimize reflections and ensure accuracy, the SLM was positioned at least 1 m from walls or other reflective surfaces, 1.2–1.5 m above the floor, and 1.5 m from windows. Before testing, the SLM was calibrated, and the ambient temperature was stabilized [23].

Participant information form

Participants' sociodemographic data and auditory complaints (e.g., tinnitus, difficulty understanding speech in noise, noise disturbance in the workplace), along with information on daily working hours, working days per week, prior noise exposure, noise exposure outside of work hours, and use of hearing protection, were collected using a researcher-developed form. This form was administered through face-to-face interviews, which took approximately five minutes to complete.

Hearing screening

Pure tone air conduction hearing thresholds were measured in both ears at frequencies of 0.5, 1, 2, 4, 6, and 8 kHz, using 5 dB steps from − 15 dB HL to a maximum of 90 dB HL. An Interacoustics AS608 (Denmark) screening audiometer with TDH- 39 supra-aural headphones was used for the assessments. Pure-tone audiometry was conducted once by an audiologist, following the guidelines outlined in ISO- 8253 [24]. When selecting the test room, care was taken to ensure it was quiet and located away from potential noise sources. The hearing test was conducted in a room with ambient noise levels below 30 dB(A) [25].

Work stress

Employees'work stress levels were assessed using the Work Stress Scale (WSS) developed by Parasuraman et al. (1992). This 6-item scale measures role conflict, ambiguity, and stress associated with role overload (workload) [26]. The Turkish adaptation of the WSS was performed by Karabay (2015) and utilized a five-point Likert scale ranging from"I rarely experience it; one point"to"I constantly experience it; five points."Participants could score a maximum of five points and a minimum of one point on average from this scale. A score of five points indicates the highest level of stress, while one point represents the lowest level. The scale's internal consistency (Cronbach's alpha) was reported as 0.86 in the original study and 0.91 in the validation study [27]. Data collection was conducted through face-to-face interviews, each lasting approximately five minutes. To prevent bias, employees were not informed about which group they belonged to.

Work performance

The Job Performance Scale, developed by Goodman and Syvantek (1999), evaluates employee performance. This scale assesses both task and contextual performance through 25 items. Contextual performance closely aligns with the concept of organizational citizenship behaviors and is typically divided into two subdimensions: altruism, which involves directly helping and supporting colleagues, and conscientiousness, which refers to following rules, supporting organizational values, and demonstrating extra effort. Research indicates that contextual performance plays a vital role in achieving organizational goals and serves as a complement to task performance. Each item rated on a five-point Likert scale ranging from "Never" to "Always". Participants can score a maximum of five points and a minimum of one point on average. A score of five points represents the best performance, while one point indicates the worst performance [28]. In a previous Turkish study, the Cronbach's alpha coefficients for the scale's contextual performance, task performance, and overall performance dimensions were reported as 0.91, 0.91, and 0.93, respectively [29]. According to factor analysis, the performance scale has a one-dimensional structure. The internal consistency of the scale was 0.878 with Cronbach's Alpha value. To minimize bias, the performance scale was completed by the employee's supervisor rather than the employee themselves. Additionally, supervisors were not informed of which group the employees belonged to.

Statistical analysis

An exploratory factor analysis was conducted to assess the validity and reliability of the measurement model. The internal consistency of the resulting structure was evaluated using Cronbach's alpha coefficient. Normality of continuous variables was tested using the Kolmogorov–Smirnov test. Data with a normal distribution are expressed as mean ± standard deviation ($\bar{x} \pm s$) and analyzed using t-tests or analysis of variance. Data with a non-normal distribution are presented as median (M) and quartiles (P25, P75), and analyzed using the Mann–Whitney U test. Regression analysis was performed to evaluate the effect of age on work stress and work performance. Additionally, the relationships between variables were analyzed using Spearman's Rank Correlation Test. Statistical analyses were conducted at a 95% confidence interval, with $P < 0.05$ considered statistically significant.

Results

The equivalent noise levels (Leq) measured at four different points in each company were 55.6 dB(A), 59.7 dB(A), 60.2 dB(A), and 66.7 dB(A) (mean: 60.55 dB(A)) for the first enterprise, and 76.5 dB(A), 76.7 dB(A), 79.6 dB(A), and 80.1 dB(A) (mean: 78.22 dB(A)) for the second enterprise. Based on these noise levels, the enterprises were categorized into two groups: low-noise and high-noise. To provide a deeper insight into the data, we conducted detailed frequency analysis and chi-square tests to examine the distribution of categorical variables across the two groups. Table 1 presents the characteristics of the employees in both enterprises. The number of employees with prior noise exposure before joining the current enterprise was significantly higher in the low-noise group ($P < 0.0001$). Additionally, the number of employees using hearing protection and those reporting disturbance from noise in the workplace were significantly higher in the high-noise group (respectively $P < 0.0001$; $P = 0.013$).

Figure 1 illustrates the hearing thresholds of employees in both enterprises. Statistical analysis of the participants' hearing thresholds revealed significant differences ($P < 0.05$). In the high-noise group, poorer hearing thresholds were observed at specific frequencies, including 2000 Hz and 4000 Hz in the right ear and 2000 Hz, 4000 Hz, and 6000 Hz in the left ear.

Table 2 presents the differences in test results between employees in the low-noise and high-noise groups, based on their work stress and work performance. According to the results summarized in Table 2, no statistically significant difference was found between the two groups regarding work stress levels ($P = 0.848$). However, the low-noise group demonstrated significantly higher work performance compared to the high-noise group ($P = 0.009$).

A regression analysis was conducted to determine whether groups have a moderating effect on the impact of age on work stress and work performance (Fig. 2). No

Table 1 Characteristics of employees in both enterprises

Variables	Low-noise	High-noise	*P* value
Age [years, M (P25, P75)]	36 (27, 48.25)	39 (27.75, 48.25)	0.972
Gender [female, male]	6 female 80 male	2 female 84 male	0.148
Daily working hours (n)	5–8 h: 57 (66%)	5–8 h: 54 (63%)	0.633
	> 8 h: 29 (34%)	> 8 h: 32 (37%)	
Working days per week (n)	3–4 days: 2 (2%)	3–4 days: 1 (1%)	0.507
	5–6 days: 84 (98%)	5–6 days: 85 (99%)	
Prior noise exposure (n)	Yes: 53 (62%)	Yes: 40 (47%)	**< 0.0001**
	No: 33 (38%)	No: 46 (53%)	
Noise exposure outside of work hours (n)	Yes: 13 (15%)	Yes: 24 (28%)	0.242
	No: 73 (85%)	No: 62 (72%)	
Use of hearing protection (n)	Yes: 2 (2%)	Yes: 27 (31%)	**< 0.0001**
	No: 84 (98%)	No: 59 (69%)	
Complaints;			
Tinnitus (n)	Yes: 7 (8%)	Yes: 10 (12%)	0.739
	No: 79 (92%)	No: 76 (88%)	
Difficulty understanding speech in noise (n)	Yes: 14 (16%)	Yes: 23 (27%)	0.095
	No: 72 (84%)	No: 63 (73%)	
Noise disturbance during working (n)	Yes: 8 (9%)	Yes: 14 (16%)	**0.013**
	No: 78 (91%)	No: 66 (84%)	

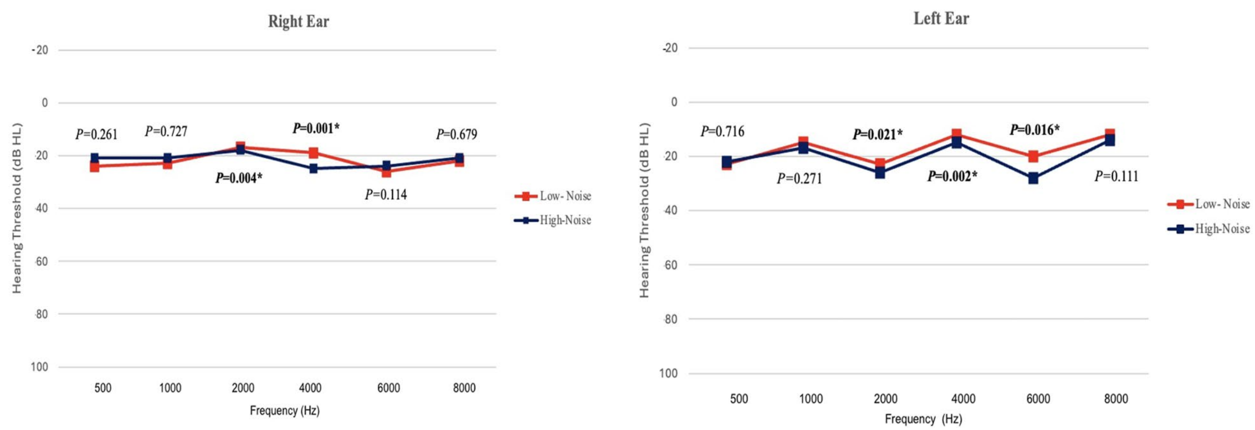

Fig. 1 Hearing thresholds of employees in both enterprises

Table 2 Analysis of differences in work stress and performance levels among enterprises

Variables	Groups	N	x̄ ± std	Median	IQR	*P* value
Work Stress	Low-Noise	86	1.700 ± 0.906	1.400	1.050	0.848
	High-Noise	86	1.676 ± 0.661	1.400	0.800	
Performance	Low-Noise	86	3.648 ± 0.757	3.625	0.604	**0.009**
	High-Noise	86	3.415 ± 0.456	3.292	1.187	

IQR Interquartile range

statistically significant relationship was found between age and work stress or work performance in either enterprise. The detailed regression analysis results are presented in Table 3.

The relationship between age and hearing thresholds was analyzed using Spearman's correlation. A positive correlation was observed between age and hearing thresholds in both the low-noise and high-noise groups, except at 500 Hz in the right ear for the high-noise group. The detailed relationship between age and hearing thresholds is provided in Table 4.

The relationship between work stress and work performance was analyzed using Spearman's correlation. No correlation was found between work stress and work performance, as detailed in Table 5.

Discussion

Occupational noise-induced hearing loss (NIHL) typically first manifests as a notch at 3000, 4000, or 6000 Hz, with partial recovery at 8000 Hz. As noise exposure continues, other frequencies may also be affected [30]. Hearing loss can sometimes vary between the right and left ears due to several factors, including anatomical and physiological differences, asymmetrical noise exposure, behavioral and environmental influences, pathological conditions, and age-related asymmetry (presbycusis) [31]. Consistent with this, our study found elevated pure-tone hearing thresholds in the high-noise group at 2000 and 4000 Hz in both ears and at 6000 Hz in the left ear compared to the low-noise group. However, no significant difference was observed at 8000 Hz, indicating recovery at this frequency. This finding highlights the frequency-specific impact of noise on hearing and underscores the importance of implementing targeted hearing protection measures tailored to workplace noise exposure.

When assessing the impact of noise on hearing health, attention is typically focused on permissible exposure limits of 85–90 dB(A) [14–16]. However, research suggests that the recommended 8-h exposure limit may not be entirely safe, as even lower noise levels can negatively affect hearing [32]. For instance, a study on rats aimed at identifying the minimum noise intensity that could impact cochlear function found that the critical level for long-term exposure was approximately 60 dB SPL, with significant decreases in distortion product otoacoustic emission amplitudes occurring at 68 dB SPL [33]. Electrophysiological studies have also shown that chronic exposure to noise levels below 77 dB can affect the cochlea [34]. Another study suggested that noise levels up to 75 dB are generally safe for hearing but that prolonged and repeated exposure above this threshold may lead to NIHL

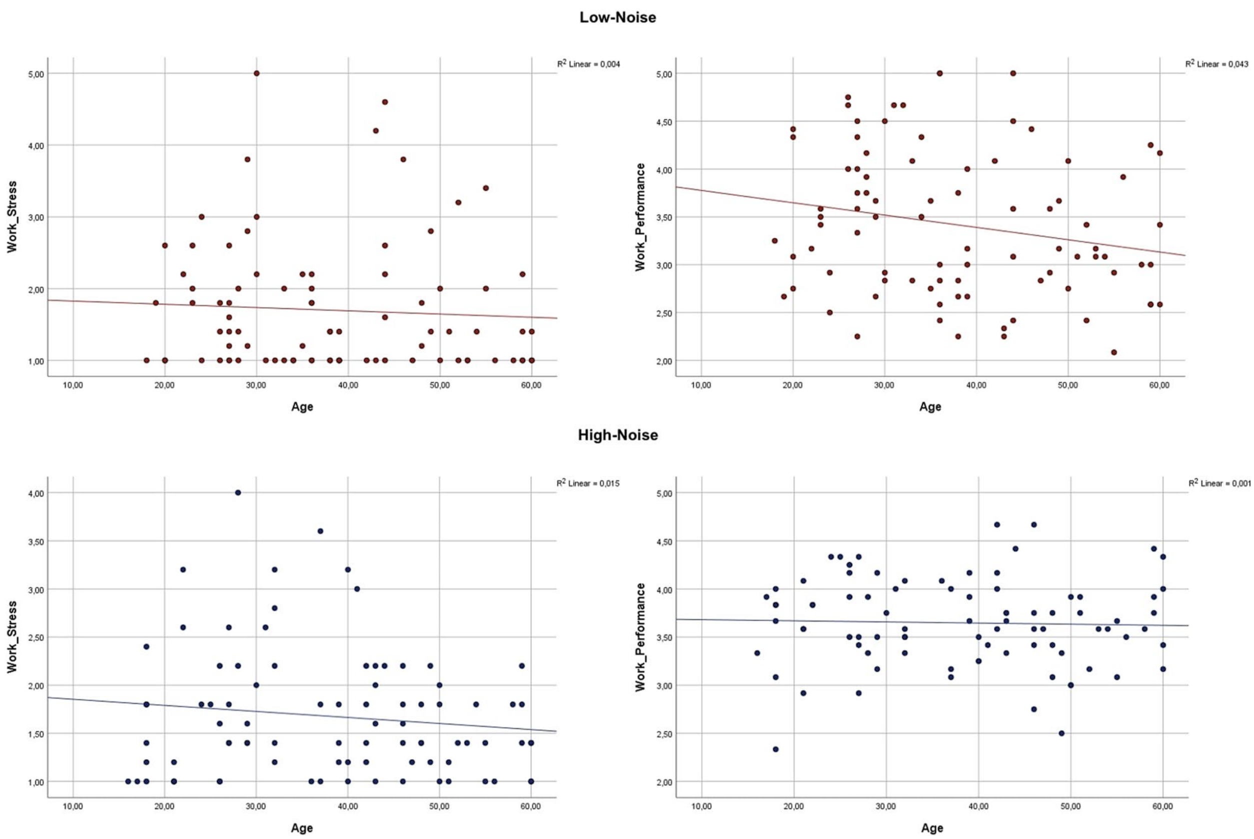

Fig. 2 Regression analysis of age on work stress and work performance in both enterprises

Table 3 Regression analysis results of age on work stress and work performance

Group	Dependent Variables		Unstandardized Coefficients		Standardized Coefficients	t	*P* value
		Adjusted R Square	B	Std. Error	Beta		
Low-Noise	Work Stress	– 0.008	– 0.004	0.008	– 0.060	– 0.551	0.583
	Work Performance	0.031	– 0.013	0.007	– 0.206	– 1.931	0.057
High-Noise	Work Stress	0.004	– 0.006	0.006	– 0.124	– 1.141	0.257
	Work Performance	– 0.011	– 0.001	0.004	– 0.034	– 0.307	0.759

[30]. Recent research in rats, cats, and mice has demonstrated that long-term exposure to moderate noise (75 dB SPL) can induce neuroplastic changes in the medial geniculate body and inferior colliculus along the central auditory pathway. Continuous exposure to low-intensity noise can alter tonotopic maps in the auditory cortex and impair frequency discrimination [33]. Additionally, Wang et al. (2021) reported that participants exposed to 70 dB(A) roadway noise had significantly worse hearing thresholds at all frequencies between 250–8000 Hz than the control group, proposing 70 dB(A) as a cut-off value for adverse auditory effects [35]. In our study, the highest noise levels recorded in both enterprises were below the permissible exposure limits. However, employees in the high-noise group exhibited worse pure-tone hearing thresholds at high frequencies, highlighting the potential risks associated with prolonged exposure to noise levels lower than the regulatory limits.

In addition to its auditory effects, noise also has significant non-auditory effects, such as stress [36]. Research on the relationship between noise and stress has shown that high noise exposure leads to increased cortisol levels, which are associated with heightened neuroendocrine activity, vasoconstriction, elevated pulse and blood

Table 4 Correlation between age and hearing thresholds

		Right Ear						Left Ear					
		500 Hz	**1000 Hz**	**2000 Hz**	**4000 Hz**	**6000 Hz**	**8000 Hz**	**500 Hz**	**1000 Hz**	**2000 Hz**	**4000 Hz**	**6000 Hz**	**8000 Hz**
Low-Noise	**Correlation Coefficient**	0.290**	0.475**	0.495**	0.663**	0.615**	0.539**	0.338**	0.385**	0.382**	0.606**	0.546**	0.517**
	***P* value**	0.007	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0,001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
High-Noise	**Correlation Coefficient**	0.169	0.461**	0.448**	0.590**	0.624**	0.456**	0.217*	0.340**	0.527**	0.574**	0.589**	0.352**
	***P* value**	0.121	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.045	0.001	< 0.0001	< 0.0001	< 0.0001	0.001

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Table 5 Correlation between work stress and work performance

	Groups	Work Performance	
		Correlation Coefficient	*P* value
Work Stress	**Low-Noise**	– 0.095	0.385
	High-Noise	– 0.017	0.876

pressure, and muscle tension [16]. This activation of the endocrine and sympathetic nervous systems has been linked to various cognitive responses, stress, and anxiety [3, 37]. A dose–response relationship exists between noise and its effects, meaning that both noise intensity and duration of exposure contribute to the level of stress induced by industrial noise [4]. Workers in quieter environments tend to exhibit better concentration, reduced distraction, and lower work-related psychosocial stress [38]. While most studies have focused on the impact of high noise levels on work stress, research has also shown that lower noise levels can contribute to stress and discomfort. For example, Golmohammadi et al. (2022) reported that stress responses—such as increased electrodermal activity and cortisol levels—occurred at noise levels exceeding 65 dB(A) [3]. In our study, work stress was evaluated in enterprises where noise levels remained below the permissible exposure limit. No significant differences in work stress were observed between the groups. The variation in findings across studies may be attributed to several factors, including the nature of the work performed, other physical conditions in the workplace (such as lighting, humidity, and temperature), individual differences among employees, and variations in the parameters assessed.

Noise can directly impact cognitive performance in the workplace, leading to reduced efficiency in tasks that require concentration, increased errors, and a higher risk of workplace accidents [39]. It interferes with cognitive processes, impairs attention, and elevates stress levels and mental workload. Numerous studies have demonstrated that workplace noise exceeding 85 dB negatively affects workers' performance and well-being, establishing a direct link between higher noise levels and reduced cognitive function [38]. However, the effects of lower occupational noise levels on cognitive performance have not been extensively studied. Kang et al. (2022) highlighted the relationship between workplace acoustic conditions and job performance, emphasizing that employees working in environments with good acoustic quality exhibit significantly higher work performance and greater acoustic satisfaction [40]. Similarly, Ke et al. (2021) examined the impact of noise intensity and content on performance and found that both factors significantly affected response accuracy. Their study revealed that mechanical noise substantially increased mental workload compared to music and dialogue. Furthermore, moderate noise levels (below 75 dB) had a more detrimental effect on response accuracy, with short-term memory being particularly affected. Moderate mechanical noise was also shown to impair reaction time and attention [41]. Additionally, research has demonstrated that moderate noise negatively influences attention, working memory, long-term memory, and reading comprehension [38]. In another study, Astuiti et al. (2024) reported that participants exposed to both continuous and intermittent noise at 70 dB began to experience signs of increased mental workload [38]. Our findings further support the notion that work performance declines at noise levels below the permissible exposure limits. Additionally, our study aligns with existing literature indicating that higher workplace noise levels are associated with lower employee performance [42]. These findings highlight the importance of maintaining quieter work environments to promote employee well-being, emphasizing the need to mitigate workplace noise across all industries.

Previous studies investigating the impact of age on work stress and work performance have reported higher levels of work stress among younger individuals. This has been linked to factors such as limited work experience, lower autonomy in job-related decisions, increased exposure to workplace politics, and higher expectations [43]. However, our study did not observe a similar relationship. This discrepancy may be attributed to age-related illnesses in the older population, leading to a perceived sense of inadequacy among workers. Additionally, while previous research has identified a relationship between work stress and work performance [44], our study did not find such an association in either group. We speculate that this may be due to the influence of other factors affecting work performance beyond work stress. Further research is needed to explore these potential factors and their implications for workplace dynamics. Lastly, it is clear that the relationship between hearing thresholds and age observed in our study aligns with presbycusis, a well-documented phenomenon in the literature [45].

Limitations

In our study, both groups had similar working and noise exposure outside of work. There were no significant differences between the groups regarding daily, weekly, or total working hours, as well as noise exposure outside of work hours. However, a significantly higher number of participants in the low-noise group had previous occupational noise exposure. Since we lacked detailed information about their prior workplaces and noise conditions, this represents a limitation of our study.

Additionally, some workers were observed to use hearing protection even when noise levels were below the permissible exposure limit, suggesting that individual noise exposure levels varied within the same work environment. More research is needed to explore the long-term psychological and physical effects of continuous noise exposure. Another limitation is that the selected medium-sized enterprises belonged to different sectors, leading to variations in employees' roles and responsibilities. Workers in the high-noise group had higher cognitive loads and required greater attention during tasks, which may have influenced their work performance. Furthermore, work stress and work performance were assessed using standardized self-report scales, which may introduce subjective bias. The study also did not conduct separate analyses based on income level, education level, marital status, number of children, or pre-existing health conditions, which should be considered in future research. Future studies should expand the sample size, include multicenter investigations across different industries, and develop specific recommendations for enterprises regarding noise exposure limits. Additionally, incorporating demographic and health-related variables could provide a more comprehensive understanding of noise exposure's impact on employees.

Conclusion

This study highlights the importance of a holistic workplace design that addresses industrial noise to enhance employee well-being and performance in medium-sized enterprises. Our findings suggest a need to reassess industrial noise exposure limits, particularly regarding the long-term effects of low-level noise exposure in such workplaces. Additionally, business managers should be more aware of the potential impact of noise on performance and employee hearing. In light of these results, industrial noise regulations should be re-evaluated, and greater emphasis should be placed on effective noise control measures in the workplace.

Acknowledgements
None.

Authors' contributions
ÖGT, KT, ZG, and AG performed conception and design. ÖGT, KT, NTE, and EK performed material preparation and data collection. ÖGT and KT wrote the first draft of the manuscript. All authors commented on previous versions of the manuscript. All authors read and approved of the final manuscript.

Funding
None.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
The projects were conducted by the Helsinki Declaration and approved by the ethics committee of Bezmialem Vakif University on February 29, 2024 (Decision No: 2024/57). Informed consent was obtained from all individuals who volunteered to participate in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 24 December 2024 Accepted: 10 April 2025
Published online: 01 May 2025

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