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The Impact of Industrial Noise Exposure on Work Stress and Mental Health of Workers: A Study in the Manufacturing Industry

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ABSTRACT
This study examined the relationship between industrial noise exposure, occupational stress, and mental health among manufacturing workers using a quantitative cross-sectional design. From a population of 450 workers, 212 respondents were selected through stratified random sampling. Noise exposure was assessed using a sound level meter with the time-weighted average (TWA) method, while occupational stress and mental health were measured using the Job Stress Scale (JSS) and the General Health Questionnaire (GHQ-12). Data were analyzed descriptively, bivariately with the Chi-Square test, and multivariately with logistic regression. Results showed that most workers were exposed to moderate noise levels (85–90 dB), with 29.2% experiencing high exposure (>90 dB). Moderate stress was reported by 44.3% of respondents, and 25.5% experienced high stress levels. Mental health assessment indicated that 51.9% of workers exhibited mild to moderate–severe psychological distress. Chi-Square analysis demonstrated significant associations between noise exposure and both occupational stress ($p = 0.003$) and mental health status ($p = 0.021$). Multivariate findings identified high noise exposure (>90 dB) and prolonged working hours (>8 hours/day) as dominant predictors of increased risk for occupational stress (OR = 2.85) and mental health disorders (OR = 2.34). These results highlight that industrial noise functions not only as an audiological hazard but also as a meaningful psychosocial stressor. The study emphasizes the necessity of integrating noise control strategies, regulation of working hours, and structured stress management interventions into Occupational Safety and Health (OSH) programs to reduce psychological burdens and enhance worker well-being in manufacturing environments.

Keywords: *Industrial Noise, Occupational Stress, Mental Health, Manufacturing Workers, Occupational Safety and Health*

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INTRODUCTION

Occupational health and safety (OHS) is a crucial foundation in the modern industrial world, as a safe and healthy work environment directly contributes to worker productivity and well-being. Various risk factors such as exposure to dust, vibration, extreme temperatures, and noise can threaten workers' physical and mental health. Uncontrolled working conditions have the potential to reduce workers' quality of life and increase the burden on public health (Lin et al., 2021)..

Globally, noise has been recognized as an environmental pollutant with a wide impact, not only on hearing but also on the nervous system and mental health. The WHO reports that noise is a public health risk factor with a significant contribution to non-communicable diseases, including sleep disorders, stress, hypertension, and psychological disorders (Park et al., 2019).

This phenomenon is further reinforced by the International Labour Organization (ILO), which notes that millions of workers in the manufacturing sector are exposed to high levels of noise daily. Scientific evidence indicates an increased risk of psychosocial disorders due to noise exposure, which not only causes discomfort but can also worsen workers' mental health (Yang et al., 2022).

In Indonesia, the manufacturing sector uses large machinery, generating high levels of noise in the workplace. In this context, prolonged exposure to noise (e.g., more than 8 hours a day) can cause hearing loss in workers. Research at a textile manufacturing company in Indonesia showed that approximately 62% of workers experienced subjective hearing loss due to workplace noise levels reaching approximately 99.3 dBA, exceeding the recommended maximum limit of 85 dBA. This hearing loss not only disrupts communication between workers but also negatively impacts work productivity (Damayanti et al., 2022).

Excessive noise exposure not only impacts audiological aspects but is also closely linked to psychological health. Research shows that workers exposed to chronic noise are more susceptible to work stress, sleep disorders, and even depression. This condition demonstrates a link between noise exposure and decreased worker mental well-being (Filiatreau et al., 2022).

Furthermore, noise-induced work stress is associated with decreased productivity, increased absenteeism, and the risk of burnout. In the long term, this condition not only harms individual workers but also negatively impacts company operational efficiency. This makes noise control an urgent need in the manufacturing industry (Kim et al., 2021).

Research on the psychological impact of noise in the workplace, particularly in Indonesia's manufacturing sector, is still limited and has received less attention than research focusing on the risk of Noise-Induced Hearing Loss (NIHL). Most occupational health regulations also place greater emphasis on noise control to prevent hearing damage (Kartiwa & Masudi, 2024).

At the national level in Indonesia, the implementation of noise control in the manufacturing sector remains limited. The use of personal protective equipment (PPE), such as earplugs and earmuffs, is still suboptimal, despite existing occupational safety standards. Several obstacles identified include a lack of worker awareness and compliance with PPE use, as well as limited outreach and training from company management (Sari et al., 2024).

This knowledge gap opens up opportunities for further research. Studies on the relationship between noise exposure and the mental health of workers in the Indonesian

manufacturing industry are still limited, even though its impact is highly relevant in the context of increasing workloads and increasingly competitive industries.

Based on this background, this research focuses on examining the impact of industrial noise exposure on occupational stress and the mental health of workers in the manufacturing sector. The results are expected to contribute significantly to the formulation of occupational health and safety (OHS) policies, the development of occupational stress prevention interventions, and noise control strategies in manufacturing workplaces in Indonesia.

METHODS

The study design and participants are described as follows. This study used an analytical quantitative design with a cross-sectional approach. This design was chosen because it provides an overview of the relationship between exposure to industrial noise, work stress, and mental health status in a single period of time, and is relevant for identifying early risk factors in the context of the manufacturing work environment. In addition, this design allows for efficient estimation of associations between variables in a large population of workers.

The study population consisted of all workers in a metal manufacturing industry in Indonesia, numbering approximately 450 people, covering the production, machine maintenance, and administration divisions. This population was selected because of the differences in noise exposure levels between divisions, allowing for comparative analysis between exposure groups.

The sample was determined using stratified random sampling, with stratification based on noise exposure levels in each division. The sample requirement was calculated using the Slovin formula at a 95% confidence level and a 5% margin of error, resulting in a minimum sample size of 212 workers. The sample was then taken randomly in proportion to each stratum to ensure representation of low, medium, and high exposure groups.

Noise exposure was measured using a sound level meter calibrated according to international standards (ISO 9612:2009). Measurements were taken at key work points during operating hours using the Time-Weighted Average (TWA) method to obtain the average daily exposure value. These values were then compared with the noise threshold limit value (NAB) according to the Regulation of the Minister of Manpower of the Republic of Indonesia (85 dB).

Work stress was measured using the Job Stress Scale (JSS), which has been validated for psychosocial research. Workers' mental health was assessed using the General Health Questionnaire (GHQ-12), an instrument widely used to detect psychological disorders such as anxiety, depression, and burnout. Both instruments were presented in the form of structured questionnaires and completed independently by the respondents.

Prior to data collection, the researchers explained the study to all prospective respondents and distributed participation consent forms. The questionnaires were completed over a period of 20–25 minutes during work breaks in the company's administration room. All data were collected by a research team that had obtained official permission from the company, and all questionnaire files were anonymously coded to maintain the confidentiality of the respondents' identities.

This study was approved by the STIK Siti Khadijah Palembang Health Research Ethics Committee, with the approval number issued prior to the study. Each respondent signed an informed consent form and was given the right to withdraw from the study at any time without consequences.

All data were analysed using SPSS software. Descriptive analysis was used to describe the characteristics of the respondents, noise exposure levels, work stress distribution, and mental health conditions.

Bivariate analysis using the Chi-Square test was chosen to assess the relationship between noise exposure categories and two outcome variables (work stress and mental health), as both variables were categorical. Furthermore, multivariate logistic regression analysis was used to identify dominant predictors after controlling for confounding variables such as age, length of service, and working hours. This method was chosen because logistic regression is capable of modelling the probability of binary outcome events and providing relevant Odds Ratio estimates for risk assessment in the context of occupational epidemiology.

RESULTS

Descriptive analysis was performed to summarize respondents' sociodemographic characteristics, noise exposure levels, and the distribution of occupational stress and mental health conditions. These findings provided a baseline understanding of the study population before inferential analysis. Bivariate associations between noise exposure and the two outcomes were examined using the Chi-square test. Variables that demonstrated statistically significant relationships were subsequently included in logistic regression models to identify dominant predictors of occupational stress and mental health outcomes.

Table 1. Respondent Characteristics

Characteristics	Category	n	%
Age	<30 years	78	36.8
	30–40 years	92	43.4
	>40 years	42	19.8
Gender	Man	168	79.2
	Woman	44	20.8
Years of service	<5 years	64	30.2
	5–10 years	88	41.5
	>10 years	60	28.3
Division of Work	Production	132	62.3
	Machine Maintenance	52	24.5
	Administration	28	13.2

The majority of respondents were male (79.2%) and aged 30–40 years (43.4%), with most working in the production division (62.3%), indicating that most participants worked in high-noise environments.

Table 2. Noise Exposure Levels in the Workplace

Exposure Category	Intensity (dB)	n	%
Low (<85 dB)	75–84	58	27.4
Moderate (85–90 dB)	85–90	92	43.4
High (>90 dB)	91–98	62	29.2

Most workers were exposed to moderate noise levels (85–90 dB; 43.4%), while nearly one-third (29.2%) were exposed to high levels exceeding 90 dB.

Table 3. Distribution of Job Stress (Job Stress Scale)

Stress Level	n	%
Low	64	30.2
Currently	94	44.3
Tall	54	25.5

Approximately 44.3% of respondents reported moderate work stress, and 25.5% experienced high stress, indicating that work stress is common in the study population.

Table 4. Mental Health Conditions (GHQ-12)

Mental Health Conditions	n	%
Normal	102	48.1
Mildly disturbed	74	34.9
Moderately to severely impaired	36	17.0

Mental health screening shows that while 48.1% of workers are within the normal range, more than half show signs of psychological distress.

Table 5. Relationship between Noise Exposure and Work Stress

Noise Exposure	Low Stress	Moderate Stress	High Stress	Total	p-value (Chi-Square)
Low (<85 dB)	28 (48.3%)	22 (37.9%)	8 (13.8%)	58	0.003
Moderate (85–90 dB)	22 (23.9%)	46 (50.0%)	24 (26.1%)	92	
High (>90 dB)	14 (22.6%)	26 (41.9%)	22 (35.5%)	62	
Total	64 (30.2%)	94 (44.3%)	54 (25.5%)	212	

Table 6. Relationship between Noise Exposure and Mental Health

Noise Exposure	Normal	Mildly Disturbed	Moderate–Severe Impairment	Total	p-value
Low (<85 dB)	34 (58.6%)	18 (31.0%)	6 (10.4%)	58	0.021
Moderate (85–90 dB)	42 (45.7%)	34 (37.0%)	16 (17.4%)	92	
High (>90 dB)	26 (41.9%)	22 (35.5%)	14 (22.6%)	62	
Total	102 (48.1%)	74 (34.9%)	36 (17.0%)	212	

The Chi-square test in Table 5 and Table 6 shows a significant relationship between noise exposure and work stress ($p = 0.003$) and mental health ($p = 0.021$). Workers exposed to noise levels above 90 dB are more likely to experience high stress (35.5%) and moderate to severe mental health disorders (22.6%) compared to those exposed to noise levels below 85 dB.

Table 7. Logistic Regression Results – Factors Influencing Work Stress

Independent Variables	OR	95% CI	p-value
Noise exposure (>90 dB vs <85 dB)	2.85	1.42 – 5.73	0.003
Age (>40 years vs <30 years)	1.62	0.84 – 3.13	0.142
Years of service (>10 years vs <5 years)	1.94	1.02 – 3.70	0.041
Working hours (>8 hours/day vs ≤8 hours)	2.12	1.09 – 4.11	0.027

Table 8. Logistic Regression Results – Factors Affecting Mental Health

Independent Variables	OR	95% CI	p-value
Noise exposure (>90 dB vs <85 dB)	2.34	1.15 – 4.76	0.019
Age (>40 years vs <30 years)	1.21	0.62 – 2.38	0.566
Years of service (>10 years vs <5 years)	1.73	0.91 – 3.29	0.089
Working hours (>8 hours/day vs ≤8 hours)	2.05	1.01 – 4.16	0.046

Multivariate logistic regression confirmed that exposure to high noise levels (>90 dB) significantly increased the risk of work-related stress (OR = 2.85; 95% CI: 1.42–5.73; p = 0.003) and poor mental health (OR = 2.34; 95% CI: 1.15–4.76; p = 0.019). Longer working hours (>8 hours/day) also significantly increased the risk of stress (OR = 2.12; p = 0.027) and psychological disorders (OR = 2.05; p = 0.046). These findings indicate that environmental factors and workload significantly contribute to the psychosocial outcomes of workers in industrial settings.

DISCUSSION

This study shows that most workers in the manufacturing industry are exposed to moderate noise levels (85–90 dB), while nearly a third are exposed to high levels (>90 dB). This condition clearly exceeds the noise Threshold Limit Value (TLV) of 85 dB recommended in occupational safety standards. Theoretically, chronic noise exposure at this level acts as an environmental stressor that not only impacts audiological aspects but also has broad implications for workers' psychological well-being. In line with this, research in the automotive sector reports that every 1 dB increase in noise is associated with increased psychological distress and a decrease in the work ability index (Esmaielpour et al., 2021). Even noise levels below the safe threshold (60–80 dB) are still reported to reduce worker performance and health (Toker et al., 2025).

The distribution of job stress in this study shows that nearly half of respondents were in the moderate category, and another quarter were already experiencing high levels of job stress. This phenomenon is consistent with the Job Demand-Control Model, which emphasizes that high job demands with low worker control will increase the risk of stress. Noise, as an environmental factor, can amplify perceptions of workload and increase psychological vulnerability. Research in the food industry shows that noise combined with unergonomic working postures contributes significantly to increased stress (Chaharaghran et al., 2022). Similar findings were also reported in other studies in the manufacturing sector, which found that noise is positively correlated with perceived workload and decreased mental well-being (Aminian et al., 2021).

Respondents' mental health conditions showed that more than half of the workers experienced symptoms of disturbance, ranging from mild to moderate to severe. This finding can be explained by the Environmental Stress Theory, which states that chronic noise exposure has the potential to disrupt central nervous system regulation, triggering symptoms of anxiety, depression, and even sleep disturbances. This is supported by research in the steel industry that reported an increased risk of depression and anxiety in workers exposed to noise levels >85 dB (Alimoradi et al., 2021). Meanwhile, more recent research confirms that noise exposure combined with high workloads worsens mood and reduces workers' psychological regulatory capacity (Madvari et al., 2024).

The correlation analysis showed a significant link between noise exposure levels and both occupational stress and mental health. Workers exposed to >90 dB had a higher proportion of

those in the severe stress group and moderate-to-severe mental health disorders compared to workers with low exposure. This aligns with the concept of a dose-response relationship, which states that the higher the intensity of noise exposure, the greater the psychological impact. Previous studies have confirmed a similar pattern, reporting that noise intensity is directly associated with increased psychological distress and poor sleep quality (Esmaielpour et al., 2021; Javad et al., 2016).

Multivariate analysis showed that high noise exposure and long working hours were the dominant factors influencing both work stress and mental health. Long working hours were also shown to be associated with work stress, although the effect was not significant for mental health. This finding is consistent with the cumulative exposure theory, which emphasizes that repeated long-term environmental exposure can worsen workers' physiological and psychological conditions. Previous research also shows that the combination of noise and long working hours increases the risk of stress and reduces an individual's ability to adapt (Esmaielpour et al., 2021). Thus, it can be confirmed that work environment factors (noise, working hours) are more dominant in determining psychological well-being than demographic factors (age, length of service).

Overall, the results of this study provide a basis for assuming that chronic noise exposure exceeding the NAB plays a significant role in triggering occupational stress and mental health disorders in workers. Physiologically, noise is thought to stimulate the activation of the sympathetic nervous system and the hypothalamic-pituitary-adrenal axis (HPA axis), thereby increasing cortisol secretion. This condition, if persistent, causes an accumulation of physiological load (allostatic load) that ultimately affects workers' psychological balance, triggering mental fatigue, sleep disturbances, anxiety, and even depression. Furthermore, long working hours amplify these impacts through mechanisms of chronic physiological and psychological fatigue.

From a practical perspective, these findings underscore the need to strengthen Occupational Safety and Health (OHS) policies in the manufacturing sector. Companies need to implement noise control strategies, both through engineering controls such as sound dampening and machine maintenance, and through administrative interventions such as job rotation and working hour restrictions. Optimizing the use of personal protective equipment (PPE) in the form of earplugs or earmuffs must also be accompanied by increased worker awareness through ongoing training and education. Furthermore, it is crucial for management to incorporate mental health aspects into OHS programs, for example by providing counseling services, stress management programs, and regular psychological monitoring. Thus, the results of this study provide not only academic contributions but also relevant practical recommendations for the formulation of policies and intervention strategies to protect worker health and increase productivity.

CONCLUSIONS

This study demonstrates that noise exposure in manufacturing environments is significantly associated with increased levels of occupational stress and mental health disorders among workers. Most participants were exposed to noise levels exceeding recommended safety limits, with a substantial proportion reporting moderate to severe occupational stress and mental health disturbances ranging from mild to severe. Multivariate analysis revealed that high noise

exposure and extended working hours were the primary determinants of workers' psychological well-being, whereas age and length of service did not show significant associations.

These findings suggest that industrial noise constitutes not only an audiological hazard but also a considerable threat to mental health and productivity. Consequently, implementing effective noise control measures, regulating working hours, and integrating stress management and mental health support into Occupational Safety and Health (OSH) frameworks should be prioritized to protect workers' overall well-being.

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