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# The Effect of Noise and Lighting on Physiological and Psychological Health of Manufacturing Industry Workers

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A B S T R A C T

This study examines how noise levels and lighting intensity affect the physiological and psychological health of manufacturing workers. Using a quantitative explanatory design with a cross-sectional survey, data were collected from 80 workers through noise and lighting measurements as well as questionnaires assessing blood pressure, fatigue, and stress. Multiple regression analysis shows that both noise and lighting significantly influence workers' health, with noise having a stronger impact on stress and fatigue. The findings highlight the need for effective workplace environmental controls to protect workers' well-being and support productivity.

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## INTRODUCTION

The health of the work environment is an important factor that determines the welfare and productivity of workers, especially in the manufacturing industry sector. In the increasingly advanced era of industrialization, exposure to noise and substandard lighting is a serious challenge to the health of workers. According to Kim et al. (2021), noise above the 85 decibel threshold can cause hearing loss, increased blood pressure, and chronic work stress. Meanwhile, inadequate lighting can disrupt the body's biological rhythm, trigger visual fatigue, and decrease work concentration (Choi & Lee, 2020). This phenomenon shows that the ergonomic aspect of the work environment has a significant impact on the performance and welfare of workers. This condition is also starting to become a concern in Padang City, which has many manufacturing industries with a variety of working environment conditions.

In Indonesia, the implementation of Occupational Health and Safety (K3) principles still faces various obstacles, especially in terms of noise and lighting control. Based on Prasetyo's research (2022), around 60% of the manufacturing industry in Indonesia has not met lighting and noise standards in accordance with the Minister of Manpower Regulation Number 5 of 2018. This inconsistency has a direct impact on the increased risk of physiological disorders such as hypertension, fatigue, and psychological disorders such as stress and sleep disorders. Ramdani et al. (2023) found that most work areas in the West Sumatra industrial sector have lighting intensity below 300 lux and noise levels above 85 decibels. This condition shows that the health aspect of the work environment still requires serious attention, especially in the context of preventing occupational diseases. Therefore, research is needed that is able to comprehensively explain the relationship between environmental factors and worker health.

Previous research has highlighted more of the single effect between noise or lighting on worker health, without looking at the simultaneous effects. Zhao et al. (2021) found that high noise can significantly increase cortisol levels and blood pressure of factory workers. On the other hand, Martins and Silva (2022) highlight the effect of low lighting on visual fatigue and sleep disturbances, but do not review the psychological impact in depth. The limitations of the study create a gap in understanding how the combination of noise and lighting affects overall health. Thus, this study seeks to fill the gap by analyzing the influence of the two environmental factors simultaneously on the physiological and psychological health of manufacturing workers in Padang. This comprehensive approach is expected to provide a more realistic picture of working conditions in the field.

Research conducted in developed countries shows that physical environmental factors strongly determine the well-being of workers, but socio-economic context and regulatory compliance can affect the magnitude of the impact that arises. Rahman et al. (2023) stated that differences in surveillance systems and work facilities between developed and developing countries cause significant variations in the impact of noise and lighting. In the Indonesian context, the difference is evident in the limitations of measurement infrastructure

and low compliance with K3 regulations. Local research in West Sumatra still rarely assesses the relationship between noise and lighting factors simultaneously with physiological and psychological health indicators. Therefore, this study has a high urgency to be carried out in order to provide empirical evidence regarding the actual working environment conditions in the Padang industrial estate. The results are expected to strengthen the scientific basis for occupational health policies that are more adaptive to local needs.

The main purpose of this study is to analyze the influence of noise level and lighting intensity on the physiological and psychological health of manufacturing industry workers in Padang City. This study uses an explanatory quantitative approach with a cross-sectional survey design to explain the causal relationship between variables. Data collection was carried out through direct measurement of noise and lighting levels, as well as filling out questionnaires by respondents regarding their physiological and psychological conditions. According to Nielsen et al. (2020), a combination of objective and subjective measurement can provide a more comprehensive understanding of worker well-being. Thus, this study not only measures the level of environmental exposure, but also its impact on the biological and psychological aspects of workers. The results of the research are expected to provide an empirical understanding that is useful for the management of the industrial work environment.

In addition, this study aims to identify the most dominant work environment factors affecting workers' health. Based on the study of Liang and Huang (2022), noise is known to have a stronger impact on psychological stress than lighting. However, the variation in worker characteristics and working conditions in Indonesia allows for different results from study abroad. Using multiple linear regression analysis, this study seeks to test the simultaneous and partial influence of the two variables. This approach provides a solid foundation for prioritizing occupational health interventions. With these results, it is hoped that more appropriate policy recommendations can be obtained in controlling work environment risks in the manufacturing sector.

Theoretically, this research contributes to the development of occupational health science, especially in the concept of occupational health ecology that links physical and psychological factors. Morimoto and Tanaka (2021) emphasize the importance of integrating physical and mental dimensions in occupational health research in order to design effective intervention strategies. This research contributes by expanding the theoretical framework through empirical testing in the context of the manufacturing industry in developing countries. Thus, the results of the study can strengthen the theory of multifactor relationships in occupational health. These findings also support efforts to develop intervention models that consider the balance between ergonomics and psychological well-being. This study is expected to enrich the national literature in the field of occupational health and the working environment.

Practically, the results of this study have implications for industry managers and policymakers in designing a healthy and productive work environment. Fernandez et al. (2023) explained that the implementation of

evidence-based risk management is a strategic step in reducing the rate of occupational diseases. Through the results of this research, the company can design a noise and lighting control system that is in accordance with the characteristics of the work environment in Indonesia. In addition, the recommendations from this study can also be a reference for government agencies in strengthening K3 regulations in the manufacturing sector. Thus, this research is not only academically relevant, but also provides real practical benefits for improving the quality of working life. The implementation of the results is expected to strengthen a healthy work culture in the West Sumatra industrial estate.

As a follow-up, this research could serve as the basis for broader research into other environmental factors such as temperature, humidity, and vibration, as well as their relationship to worker health. Torres and Delgado (2024) emphasized that a multidisciplinary approach is indispensable in understanding the complexity of the interaction between environmental factors and human well-being. Future research may also broaden the focus by including psychosocial aspects such as social support, work motivation, and leadership. Thus, the direction of development of this research can create a more holistic model in assessing the health of the work environment. The results will make a sustainable contribution to improving the safety and welfare of workers in Indonesia's manufacturing industry sector. Therefore, this research has strategic value in supporting industrial development oriented towards human health and sustainability.

## LITERATURE REVIEW

### *Noise and Occupational Physiological Risks of Workers*

Noise is the most common physical factor associated with workers' health problems in the manufacturing industry. Exposure to noise above the threshold can lead to increased blood pressure, hearing loss, as well as autonomic nervous system dysfunction. According to Zhou (2024), long-term noise exposure is significantly associated with an increased risk of hypertension and cardiovascular system disorders. Similar research by Kumar and Lee (2021) showed that workers exposed to high noise experienced increased cortisol levels and heart rate, signaling a chronic physiological stress reaction. This condition has a direct impact on the body's homeostasis balance and has the potential to reduce work capacity. In the context of the manufacturing industry in developing countries, the limitations of noise control facilities exacerbate the physiological risks experienced by workers.

### *The Psychological Impact of Noise on Worker Well-Being*

In addition to biological effects, noise also has complex psychological impacts. Continuous exposure to noise can trigger work stress, sleep disturbances, and decreased concentration. A study conducted by Yazdanirad et al. (2023) showed that industrial noise was positively correlated with increased symptoms of mental fatigue and anxiety. In addition, research by Singh and Rajput (2022) confirms that exposure to high noise during working hours decreases motivation as well as increases emotional irritability in factory

workers. Psychological disturbances due to noise are often cumulative and can lead to burnout syndrome if left unchecked. Therefore, the psychological aspect is an important indicator in assessing the impact of noise in the manufacturing work environment.

***Work Lighting and Its Impact on Visual and Mental Health***

Poor lighting in the workplace can interfere with visual function and trigger psychological stress due to eye fatigue. According to Khayam et al. (2023), low-intensity lighting decreases work accuracy and increases visual complaints such as dry eyes and blurred vision. On the other hand, a study conducted by Luo and Kim (2021) revealed that excessive lighting can also cause visual discomfort and cognitive fatigue. Unbalanced lighting has the potential to disrupt the circadian rhythms that regulate sleep patterns, impacting workers' mental well-being. In the context of the manufacturing industry, the implementation of a standard-compliant lighting system is essential to maintain the overall performance, safety, and health of workers.

***Interactive Relationship between Noise and Lighting to Worker Health***

The relationship between noise and lighting is often interactive and mutually reinforcing their impact on health. Zeng (2024) states that the combination of noise exposure and poor lighting increases the risk of simultaneous physiological and psychological disorders. The results of a study by Park and Huang (2022) also show that low lighting conditions exacerbate the stress effects caused by noise on factory workers. This combined effect magnifies cognitive load and improves the perception of fatigue. Thus, a holistic approach to controlling the work environment is needed so that these physical factors can be optimized to maintain the welfare of workers. This study tries to fill the gap by analyzing the simultaneous effects of the two environmental variables.

***Research Gaps and Contributions to Occupational Environmental Health***

The literature suggests that most previous studies examined the effects of noise and lighting separately, without considering the mutual relationship between the two. According to Zhang (2022), there is still little field research that measures the combined exposure of physical factors and their impact on physiological and psychological indicators. Research by Alvarez and Chen (2023) also highlights the need for integrative measurement methods that include objective data such as blood pressure and lighting intensity along with subjective assessments of stress and fatigue. Therefore, this study contributes to filling the theoretical gap by combining quantitative analysis of two main environmental factors that affect worker health. The results are expected to enrich the health literature on the work environment and become the basis for policy recommendations for the manufacturing industry in Indonesia.

## METHODOLOGY

### *Types and Approaches to Research*

This study uses an explanatory quantitative approach with a cross-sectional survey design. This approach was chosen to identify the cause-and-effect relationship between independent variables in the form of noise and lighting and dependent variables, namely the physiological and psychological health of manufacturing industry workers. The cross-sectional design allows data to be collected at a specific time to empirically describe the actual conditions of the work environment (Nguyen & Tran, 2022). This method is effective for measuring the relationship between exposure and health response without intervention, as well as being relevant in industrial ergonomics studies that focus on real-world working conditions (Li et al., 2021).

### *Population and Sampling Techniques*

The research population includes all production line workers, machine maintenance, and quality control at one of the manufacturing companies in Padang City, West Sumatra. The researcher uses a probability sampling technique with a stratified random sampling method, where the strata division is based on the work area so that the representation of each part is proportional. The number of samples of 80 respondents was determined based on the calculation of medium effect size for multiple regression analysis with a 95% confidence level. The selection of this technique ensures better representation than purposive sampling, especially in the context of ergonomics studies (Cohen, 2020). Inclusion criteria included workers with a minimum of three months of service, ages 18–60, and good general health conditions, while workers with chronic diseases were excluded from the sample to avoid bias.

### *Data Collection Techniques and Instruments*

Data were collected through a combination of objective measurements and subjective questionnaires. Noise measurement is done using a sound level meter to obtain data in decibels (dB), while lighting measurement uses a lux meter that measures the intensity of light (lux) in each work area. In addition, physiological health is measured through blood pressure and fatigue levels, while psychological health is measured using the Job Stress Scale and Fatigue Assessment Scale that have been validated in previous studies (Lopez et al., 2021). The validity of the contents was tested by ergonomics and occupational health experts, while the reliability was tested using Cronbach's Alpha coefficient with a minimum value of 0.70 to ensure internal consistency (Singh & Kumar, 2023).

### *Research Implementation Procedure*

The research is carried out through several stages. The initial stage includes the management of research ethics permits and socialization to company management and workers. Furthermore, calibration of the measuring instrument is carried out to ensure the accuracy of noise and lighting data. Environmental measurements are carried out during active working hours to reflect actual conditions in the workplace. After that, respondents were asked to

fill out a stress and fatigue questionnaire, followed by a blood pressure check and vital signs. All data collection was carried out within one month to maintain the stability of environmental variables. This process is in line with the principles of ergonomics research that emphasizes participant safety and data validity (Rahman et al., 2022).

### *Data Analysis Techniques*

The data collected were analyzed using multiple linear regression analysis to test the simultaneous and partial influence of noise and lighting on the physiological and psychological health of workers. Before the main analysis was carried out, the data were tested through classical assumption tests including normality, multicollinearity, and homocedasticity. The analysis was carried out with SPSS software version 26 and the results were declared significant if the p value < 0.05. This statistical approach allows for a quantitative interpretation of the magnitude of the influence of the work environment on worker health (Zeng, 2024). The use of the regression method is in accordance with the recommendations of modern occupational epidemiology studies that emphasize the measurability of the relationship between variables in the context of industrial exposure (Hernandez et al., 2023).

## RESEARCH RESULTS

### *Respondent Overview*

The number of respondents in this study was 80 manufacturing workers who were selected through stratified random sampling techniques according to the work area. Respondents were divided into three main parts, namely production lines (45%), machine maintenance (30%), and quality control (25%). The majority of workers are in the age group of 25–40 years (62.5%), followed by the age group over 40 years old (28.7%), and the rest are 18–24 years old (8.8%). The average working period of respondents was 6.8 years, with a minimum range of 3 months to a maximum of 22 years.

In terms of general health, most of the respondents were in good health at the time of the study, but there were 28.7% who experienced health complaints in the form of recurrent fatigue and high blood pressure. This shows that even if respondents meet the inclusion criteria, working environment conditions that do not meet ergonomic standards begin to impact their health.

Table 1. Distribution of Respondent Characteristics

| Characteristics | Quantity (n) | Percentage (%) |
|---|---|---|
| Age 18–24 years old | 7 | 8.8 |
| Age 25–40 years old | 50 | 62.5 |
| Age >40 years old | 23 | 28.7 |
| Working period <5 years | 28 | 35.0 |
| Tenure 5–10 years | 32 | 40.0 |
| Working period >10 years | 20 | 25.0 |

| Characteristics | Quantity (n) | Percentage (%) |
|---|---|---|
| Healthy condition | 57 | 71.3 |
| Early health complaints | 23 | 28,7 |

Note: Early health complaints include high blood pressure, fatigue, and recurrent headaches.

***Noise Level in the Work Area***

Noise measurement using a sound level meter is carried out in three main areas, namely production, machine maintenance, and quality control. The measurement results showed that the two main areas (production and maintenance of machinery) had noise levels above the threshold set by Permenaker No. 5 of 2018, which was 85 dB.

Table 2. Average Noise in the Work Area

| Work Area | Average Noise (dB) | Standard Limit (85 dB) | Information |
|---|---|---|---|
| Production | 91.3 dB | 85 dB | Exceeding standards |
| Machine Maintenance | 95.7 dB | 85 dB | Far exceeding the standard |
| Quality Supervision | 82.1 dB | 85 dB | Compliant with standards |

Based on the results above, as many as 72.5% of workers are in areas with noise above the threshold. This condition has great potential to increase physiological risks such as hypertension, hearing loss, and increased heart rate, as well as psychological risks in the form of stress, irritability, and mental fatigue.

***Lighting Intensity in the Work Area***

In addition to noise, lighting in the work area is also measured using a lux meter. The measurement results show that the intensity of the lighting varies between work areas. Most areas, especially production lines and quality control, have lighting levels below the recommended minimum standard (300 lux).

Table 3. Lighting Intensity in the Work Area

| Work Area | Lighting Intensity (Lux) | Standard Limit (300–500 lux) | Information |
|---|---|---|---|
| Production | 285 lux | 300–500 lux | Below standard |
| Machine Maintenance | 310 lux | 300–500 lux | Compliant with standards |
| Quality Supervision | 260 lux | 300–500 lux | Below standard |

The results of this measurement showed that 57.5% of respondents worked in areas with less than minimum lighting, which resulted in increased visual fatigue, headaches, decreased concentration, and reduced work accuracy. Inadequate lighting conditions can also affect a worker's biological rhythm, including the sleep-wake cycle, which ultimately affects psychological health in the form of stress, mental fatigue, and concentration disorders.

***Physiological Condition of Workers***

The physiological condition of workers is measured through two main indicators, namely blood pressure and physical fatigue level. The results of the examination showed that there was a proportion of workers who experienced physiological health problems, especially in areas with high noise levels.

*Blood Pressure*

As many as 35% of workers were identified as having blood pressure above normal (≥140/90 mmHg). The majority of workers with high blood pressure come from the machinery maintenance department, which is the area with the highest noise exposure (95.7 dB). These findings indicate a strong relationship between noise exposure and increased blood pressure.

*Physical Fatigue*

Based on measurements using the Fatigue Assessment Scale (FAS), as many as 41.3% of workers are categorized as experiencing moderate to high levels of fatigue. This fatigue is mainly reported by workers in production and quality control areas, where lighting is below the minimum standards (285 lux and 260 lux).

Table 4. Physiological Condition of Workers

| Physiological Indicators | Yield (%) | Dominant Areas | Information |
|---|---|---|---|
| Blood pressure ≥140/90 mmHg | 35% | Machine Maintenance | Higher in areas with noise > 90 dB |
| Moderate–high fatigue | 41.3% | Production & Quality Control | Relating to 300 lux < lighting |

These results show that environmental factors, particularly noise and lighting, play an important role in influencing the physiological health of workers.

***Psychological Condition of Workers***

In addition to the physiological aspect, the study also assessed the psychological condition of workers through the Job Stress Scale and indicators of mental fatigue. The results of the study show that the psychological condition of workers is also affected by the discomfort of the work environment.

*Work Stress*

As many as 47.5% of workers are in the category of moderate work stress, while 21.3% are in the category of high work stress. Workers in the machinery maintenance area had an average stress score of 23% higher than workers in the quality control department. High noise has been shown to be one of the main triggers of stress as it affects the perception of comfort, communication, and concentration in the workplace (Nguyen & Tran, 2022).

*Mental Fatigue*

About 39% of workers report symptoms of mental fatigue, such as difficulty focusing, irritability, and decreased motivation. This condition is more common for workers who work in areas with substandard lighting.

Table 5. Psychological Condition of Workers

| Psychological Indicators | Yield (%) | Dominant Areas | Information |
|---|---|---|---|
| Moderate work stress | 47.5% | All areas | Common found in production line workers |
| High work stress | 21.3% | Machine Maintenance | 95.7 dB noise increases the risk of stress |
| Mental fatigue | 39% | Production & Quality Control | Affected by 300 lux < lighting |

These findings reinforce the understanding that noise factors are more closely related to work stress, while low lighting contributes more to mental fatigue and focus disorders.

***Analysis of the Multiple Linear Regression***

To determine the simultaneous and partial influence of noise and lighting on the physiological and psychological health of workers, multiple linear regression analysis was performed.

*Analysis Results*

The results of the analysis showed that the two independent variables, namely noise and lighting, had a significant influence on worker health. Noise has a greater influence than lighting, especially in terms of blood pressure and work stress.

Table 6. Results of Multiple Linear Regression Analysis

| Variabel | β (Koefisien) | Sig. (p) | Information |
|---|---|---|---|
| Noise | 0.521 | 0.001 | Significant effect on physiological & psychological health |

| Variabel | β (Koefisien) | Sig. (p) | Information |
|---|---|---|---|
| Lighting | -0.284 | 0.032 | Has a significant effect, especially on visual fatigue & concentration |
| $R^2 = 0.47$ | | | Model explains 47% variation in worker health |

*Interpretation*

The regression results showed that noise had a coefficient of β = 0.521 (p = 0.001), which means that the higher the noise level, the more likely the worker was to experience physiological (high blood pressure, physical fatigue) and psychological (stress, mental fatigue) disorders. Meanwhile, lighting had a coefficient of β = -0.284 (p = 0.032), which means that low lighting negatively impacts workers' health, although the effect is not as large as noise. Simultaneously, these two factors of the work environment are able to explain 47% of the variation in the physiological and psychological health conditions of workers. The rest can be explained by other factors, such as workload, sleep patterns, or individual factors.

## DISCUSSION

The results of this study show that noise is the most dominant factor affecting workers' health, both physiologically and psychologically. The data showed that as many as 35.0% of workers had high blood pressure, with an average systolic blood pressure value of 140 mmHg or more in areas with an average noise exposure of 95.7 dB. This condition is in line with the results of a recent study by Beshir et al. (2021) which found that workers in factories with noise exposure above 90 dB have almost twice the risk of hypertension compared to workers with normal exposure. The underlying mechanism is chronic stimulation of the sympathetic nervous system that increases the release of stress hormones, thus impacting vasoconstriction and increased blood pressure (Wang et al., 2022). From the psychological side, the results of the study showed that 47.5% of workers were in the moderate stress category and 21.3% were in the high stress category, especially in workers who worked in machine production areas. This reinforces the theory that prolonged noise exposure not only causes physiological disturbances, but also triggers stress, emotional exhaustion, and decreased work motivation (Ezenwa et al., 2023).

In addition to noise, lighting has also been shown to have a significant effect on workers' health. The study's findings showed that 41.3% of workers experienced moderate to high fatigue in areas with lighting below 300 lux. This condition shows that lighting that is not in accordance with standards contributes to visual disorders such as tired eyes, headaches, and decreased work concentration. These results are in line with the research of Yoon et al. (2021) which explains that low lighting in the long term decreases productivity, increases work errors, and disrupts the body's circadian rhythm. Furthermore, poor lighting conditions not only impact the physiological aspect, but also

increase the risk of mental fatigue, which ultimately affects the psychological health of workers (Wessel et al., 2022).

The interaction between noise and lighting has also been shown to be significant in affecting worker health. Regression analysis showed that the combination of these two factors was able to explain 47.0% variation in the physiological and psychological conditions of workers. This means that almost half of a worker's health conditions can be explained by simultaneous exposure to noise and lighting. This supports research conducted by Stansfeld et al. (2021), who found that simultaneous exposure to various work environment factors exacerbates cognitive stress and disrupts workers' emotional regulation. These findings confirm that occupational health interventions cannot be carried out partially, but must integrate noise control as well as lighting optimization.

Theoretically, this study expands the understanding of the relationship between physical factors of the work environment and worker health, both in physiological and psychological aspects. Previously, many studies emphasized the single influence of noise or lighting, while this study showed empirical evidence that both had significant simultaneous effects. This supports the idea that environmental ergonomic factors are interinteracting, so they must be understood as complex systems (Alimohammadi et al., 2020). Practically, these findings provide important implications for the implementation of occupational health and safety management in the industrial sector, especially in the formulation of policies regarding lighting standards and noise control in work areas.

However, this study has some limitations that need to be considered. First, the cross-sectional design of the study limits the ability to infer causal relationships between noise, lighting, and worker health. Second, other variables that have the potential to affect health, such as age, body mass index, sleep patterns, smoking habits, and physical workload, were not analyzed in depth. Third, this research was only conducted on one industrial sector with a limited number of respondents, so generalization of results to other industry sectors needs to be done carefully. Therefore, further research with a longitudinal design, larger sample counts, and consideration of other confounding variables are strongly encouraged to reinforce these findings.

## CONCLUSION AND RECOMMENDATION

This study shows that the conditions of the work environment, especially noise and lighting factors, have a significant influence on the physiological and psychological health of workers in the manufacturing industry. Noise has been shown to have a more dominant impact on increased blood pressure, stress, and worker fatigue than lighting. Meanwhile, substandard lighting mainly contributes to visual fatigue and decreased concentration, which indirectly affects the mental health of workers. Regression analysis proves that these two factors are simultaneously able to explain almost half of the variation in workers' health conditions, so it can be concluded that the ergonomic aspect of the work environment plays an important role in maintaining the physical and mental balance of workers.

These findings confirm the importance of comprehensive interventions in occupational health and safety management in the manufacturing sector. Noise control efforts through technical engineering, provision of personal protective equipment, and lighting arrangements according to standards are needed to reduce negative impacts on workers' health. With the implementation of proper ergonomics strategies, companies can not only improve the health and well-being of workers, but also drive productivity and operational sustainability of the manufacturing industry as a whole.

## ADVANCED RESEARCH

Future studies should explore a broader range of ergonomic and psychosocial factors that may interact with noise and lighting to affect workers' health in manufacturing environments. Longitudinal studies are recommended to examine the long-term physiological and psychological impacts of chronic exposure to suboptimal work conditions, as cross-sectional data may not fully capture cumulative effects. Additionally, future research could investigate the effectiveness of specific engineering controls, organizational policies, and ergonomic interventions in reducing health risks, as well as assess differences across various types of manufacturing industries. Incorporating wearable health-monitoring devices and advanced environmental sensors may also provide more accurate, real-time data to better understand how workplace conditions influence workers' overall well-being and productivity.

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