Identifying Significant Predictors of Sick Building Syndrome in the Office Area of a Fabrication Company

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Abstract

This study investigates the significant predictors of Sick Building Syndrome (SBS) in the office area of a fabrication company. Using a quantitative methodology, data were collected from SBS questionnaires, PSS-10 questionnaires for work stress, and lighting measurements. Binary logistic regression was employed to analyze the impact of working years, smoking habits, lighting, and work stress on SBS symptoms. It is found that 70% of workers reported symptoms of SBS, such as fatigue, drowsiness, and nasal congestion. The factors that influenced this study were smoking habits (p-value = 0.004), lighting (p-value = 0.026), and work stress (p-value = 0.003). In contrast, working years did not have a statistically significant effect. Recommendations include engineering controls to improve lighting, administrative controls for smoking restrictions through standard operating procedures and peer support programs, as well as stress management mechanisms such as employee suggestion boxes. These interventions are expected to create a healthier and safer office environment, increase well-being, and enhance productivity among employees.

Keywords: Lighting; Sick Building Syndrome; Work Years; Work Stress

1. Introduction

Rapid population growth is one of the main challenges in Indonesia, leading to a continued increase in demand for land for infrastructure development, while land availability is limited. This situation has prompted companies to construct multi-story buildings to maximize the use of limited land. One such company is a steel fabrication and construction firm whose buildings are modern in design, featuring artificial ventilation systems and other supporting facilities to enhance comfort and boost employee productivity. However, using air conditioning as artificial ventilation, substandard lighting, and specific office equipment can actually reduce indoor air quality, potentially causing adverse health effects for occupants (Aditama and Andarini, 2002). A survey by the Environmental Protection Agency (EPA) also shows that humans spend 90% of their time in artificial environments, such as office buildings or homes, where both indoor and outdoor pollutants may contaminate indoor air quality. The inability to respond appropriately to workplace environmental and indoor air quality issues can negatively impact human health, leading to the emergence of Sick Building Syndrome symptoms.

The Sick Building Syndrome (SBS) phenomenon has begun to attract attention because it often goes undiagnosed, yet has a direct impact on the comfort and health of individuals working in modern buildings (Environmental Protection Agency and Environments Division, 1991). According to the WHO, Sick Building Syndrome (SBS) is defined as a condition characterized by excessive irritation of the skin and mucous membranes, along with various other symptoms reported by workers in modern office buildings. These symptoms disappear when workers leave the building. Sick Building Syndrome (SBS) symptoms include headaches, fatigue, drowsiness, and respiratory tract irritation (Ooi and Goh, 1997). SBS complaints can be caused not only by poor air quality but also by environmental, work, and psychological factors that do not meet standards.

Lighting intensity measurements taken in the office area of the Manufacturing Company showed values of less than 300 lux, which does not comply with the standards Permenaker No. 5 Tahun 2018 about Occupational Safety and Health in the Workplace. Poor lighting can cause eye strain and dizziness, which can reduce work efficiency. Research conducted by Raharjo *et al*. (2017) and Izharulhaq (2023) indicates a correlation between substandard lighting and Sick Building Syndrome complaints. This is because insufficient lighting intensity can trigger Sick Building Syndrome symptoms such as eye irritation and drowsiness. In

addition to workplace factors, individual and psychosocial factors such as working years, smoking habits, and work stress can also cause a person to experience SBS complaints.

Larasati & Wahyuningsih (2023) found a positive correlation between years of service and SBS complaints, attributing this to increased cumulative exposure to causative occupational factors. Studies have linked both smoking habits and work stress to an increased risk of Sick Building Syndrome (SBS). Lu et al. (2018) found that active smokers report a higher prevalence of SBS symptoms, including respiratory issues (e.g., dry throat, shortness of breath) and non-specific complaints like headaches and fatigue. Similarly, Ooi & Goh (1997) demonstrated a significant association between work stress and the occurrence of SBS symptoms. It found that workers with high levels of stress, whether physical, mental, or social, are more likely to experience SBS symptoms such as headaches, fatigue, and respiratory tract irritation than environmental factors such as thermal comfort and lighting.

Based on a preliminary study at a fabrication company, it was found that 63.3% (19 out of 30) of employees experienced at least two symptoms of SBS in one work week, with the main complaints being fatigue, drowsiness, and dizziness. Consistent exposure to an unsupportive work environment, such as substandard lighting, increases the risk of health complaints in the workplace. This situation highlights the importance of researching the factors that influence SBS complaints among office workers, particularly in companies with closed and crowded environments such as fabrication companies. By identifying environmental, individual, and work-related stress factors associated with SBS, this study aims to provide a foundation for improving the work environment, thereby enhancing employee health and productivity.

2. Methods

Data was collected from 70 respondents working in the office area of the Fabrication Company. The number of respondents was obtained using a total sampling technique so that all workers became research respondents. This study used primary and secondary data. Primary data collected were Sick Building Syndrome (SBS) and work stress. The Perceived Stress Scale 10 (PSS-10) questionnaire developed by Cohen *et al*. (1983) was used to assess work stress. The questionnaire comprised 10 items rated on a 5-point Likert scale from 0 (Never) to 4 (Very Often). Items 4, 5, 7, and 8 were reverse-scored. The total score (range: 0-40) was categorized as low stress (0-13), moderate stress (14-26), or high perceived stress (27-40). The PSS-10 questionnaire was tested for validity and reliability with Pearson Product-Moment Correlation and Cronbach's Alpha method.

Primary data included Sick Building Syndrome (SBS) complaints, smoking habits, and work stress collected through questionnaires. The questionnaire used was the SBS complaint questionnaire from the study by Ooi & Goh (1997). Respondents could be said to have SBS symptoms if they experienced a series of symptoms such as skin irritation, headaches, fatigue, and difficulty concentrating while working inside the building. These symptoms decreased or disappeared when workers left the building, and they were not in a medical condition (Ooi and Goh, 1997). These symptoms are felt by more than 20% of workers working in one building (Gomzi & Bobic, 2009).

The lighting measurement was conducted using a lux meter at four specific points on the computer workstations, each measured three times. The obtained values were then classified in compliance with the SNI 7062:2019 standard. The number of employees and working years were obtained from the company. The respondent criteria included workers who worked on floors 1 to 3 of the building and were actively working from Monday to Friday. The relationship between the independent variables (working years, smoking habits, lighting, work stress) and the dependent variable (SBS symptoms) was analyzed using binary logistic regression.

3. Results and discussion

3.1. SBS Symptoms Assessment Result

Research has shown that 49 employees (70%) of the Fabrication Company experienced Sick Building Syndrome, while 21 employees (30%) did not. The following is a summary of SBS symptoms experienced by employees.

From Table 1, it can be seen that the most common symptoms experienced by employees of the Fabrication Company are fatigue, with a percentage of 90% (44 people), drowsiness, with a percentage of 80% (39 people), and nasal congestion, with a percentage of 49% (24 people).

The collected questionnaire results were then tested for validity and reliability. In this study, validity and reliability tests were conducted on the work stress variable questionnaire distributed to 70 employees. The r_{table} value in this study was 0.235 with a significance value of 0.05. The results of the validity test showed that

the value of each question item used was valid because the $r_{calculated\ value}$ was > r_{table}. The results of the questionnaire reliability test were reliable because the Cronbach's alpha value was > 0.6.

Table 1. Recapitulation of Sick Building Syndrome symptoms

No	SBS Symptoms	experienced (n=49)	%
1	Fatigue	44	90%
2	Headache	15	31%
3	Drowsiness	39	80%
4	Dizziness	21	43%
5	Shortness of breath	5	10%
6	Nausea/Vomiting	2	4%
7	Stuffy Nose	24	49%
8	Dry Throat	12	24%
9	Dryness/Skin Rash	6	12%
10	Eye Irritation	16	33%

3.2. Statistic Test

Table 2. Simultaneous Tests

Dependent Variable	Independent Variable	*A*	*p-value*	Hypothesis
SBS symptoms (Y)	Working years, smoking habits, Lighting and work stress	0.05	0.001	H_0 Rejected

From the results in Table 2, it is evident that the simultaneous test results were ≤0.05, leading to the conclusion that work years, smoking habits, lighting, and work stress simultaneously affect sick building syndrome symptoms. Next, the data test will proceed to the individual test as follows.

Table 3. Individual Tests

Dependent Variable	Independent Variable	*A*	*p-value*	Hypothesis
SBS Symptoms (Y)	Working years (X1)	0.05	0.958	H_0 Accepted
	Smoking habits (X2)	0.05	0.004	H_0 Rejected
	Lighting (X3)	0.05	0.026	H_0 Rejected
	Work stress (X4)	0.05	0.003	H_0 Rejected

Table 4. Model Suitability Test

Chi-square	Df	Sig.
6.678	8	0.572

3.3. Discussion

Table 3 shows that smoking habits, lighting, and work stress significantly affect SBS symptoms (p>0.05). in comparison, the variables of smoking habits, lighting, and work stress are declared to have an effect (p<0.05). The work years do not significantly affect SBS symptoms (p-value>0.05). The results of the binary logistic regression test indicate that the working years of employees do not significantly affect SBS Symptoms. This is likely because workers with longer service have adapted to the work environment. This finding is supported by Mawarni et al. (2021), Asri (2019), and Raharjo et al. (2017), who showed no correlation between years of service and SBS symptoms. Nonetheless, without intervention, it could potentially become a risk factor over time (Mawarni et al., 2021).

Smoking habits have a significant effect on SBS symptoms because most of the male employees of the Fabrication Company have a habit of smoking indoors and outdoors (31 people). It is because cigarette smoke contains respirable particles and volatile organic compounds that can cause respiratory tract irritation, unpleasant odors, and have the potential to be carcinogenic and systemic. Exposure to cigarette smoke can also trigger SBS symptoms such as eye, nose, and throat irritation, as well as various symptoms such as fatigue and headaches (WHO, 1983). Bhakti *et al*. (2025) and Lu *et al.* (2018) found a correlation between smoking habits

and an increased risk of Sick Building Syndrome (SBS). Smokers were more likely to report symptoms including respiratory issues like dry throat and itchy nose, as well as non-specific symptoms such as difficulty concentrating and headaches.

Workplace environmental factors, particularly lighting, also influenced SBS symptoms. Measurements revealed an average office illuminance of 240 lux at the Fabrication Company, which falls below the 300 lux minimum standard stipulated in Permenaker No. 5 (2018). This deficiency was attributed to the use of lighting with an inappropriate intensity for the workspace. Research conducted by Tritama et al. (2017), Azhar Ulfa et al. (2022), and Raharjo *et al.* (2017) indicated that lighting affects SBS, with inappropriate lighting causing employees to experience SBS symptoms. If the amount of light received by the retina were insufficient, the pupils would dilate to receive more light from the room's light source (The British Medical Association, 2002*)*. As long as the light from the light source was too little, the pupils would continue to dilate, causing the eyes to lose focus on the object being viewed, thereby reducing vision. This condition could trigger SBS symptoms in employees, such as dizziness, difficulty concentrating, and eye strain. Work stress among employees could also cause them to experience sick building syndrome. Based on research conducted, it appeared that the majority of employees at the Fabrication Company experience medium (33 people) and high (19 people) levels of work stress. Employees feel that many things are not going as they wish, causing a discrepancy between their expectations and reality. Sustained stress could lead to a decrease in immunity and cause psychological and physical symptoms (Vroom, 1964). Research by Ooi & Goh (1997) showed that there was a significant influence between work stress and SBS symptoms. This study found that workers who experience high levels of stress, whether physical, mental, or social, are more likely to experience SBS symptoms such as headaches, fatigue, and respiratory tract irritation.

Table 4 indicates that the results of the model suitability test had a significance value of >0.05. Therefore, it can be concluded that there is no significant difference between the observed and predicted results of the model. Based on the results of the impact assessment that has been conducted, which shows that smoking habits, lighting, and work stress have an impact on sick building syndrome symptoms, appropriate recommendations are needed to address these factors. Recommendations can be made using the occupational safety and health (OSH) control hierarchy, such as elimination, substitution, engineering controls, administrative controls, and personal protective equipment.

This study does not discuss variables related to sources of danger, such as machinery, processes, or the operation of work equipment. Therefore, elimination and substitution measures for risk factors causing SBS symptoms in the office area cannot yet be implemented. A recommended engineering control for the lighting is to replace the existing lamps with types and quantities that provide the lumen output required by the workspace, as stipulated in SNI 03-6575-2001, which concerns Tata Cara Perencanaan Sistem Pencahayaan Buatan (Procedures for Planning Artificial Lighting Systems). To meet the required illuminance standards, it is recommended to install 30W/3500 lumen LED downlights on the first and third floors (13 units each), and 30W/3700 lumen LED downlights on the second floor (12 units). A lighting calculation was performed to determine the lamp specifications required to achieve the standard illuminance of 300 lux, as stipulated in SNI 03-6575-2001, for the office area (Length: 13 m, Width: 9 m, Height: 3 m; Area: 117 m²). Room index (k) was calculated using the standard formula:

$$k = \frac{pxl}{h\,(p+l)} = = \frac{13x9}{3\,(13+9)} = 1.77$$

The utilization factor (Kp) was then determined through interpolation from standard luminaire tables, resulting in a value of Kp = 0.991. With a depreciation factor (Kd) of 0.8, the total required luminous flux (Φ) for the workspace was calculated as follows:

$$\Phi \text{ total} = \frac{E\ x\ A}{KpxKd} = = \frac{300\ lux-117\ m2}{0{,}991-0{,}8} = 44273 \text{ lumens}$$

Based on the existing number of fixtures—13 for the 1st and 3rd floors and 12 for the 2nd floor—the required luminous flux per lamp was determined:

Floor 1 and 3: $\Phi = \frac{44273}{13} = 3405$ lumens/lamp

Floor 2: $\Phi = \frac{44273}{12} = 3689$ lumens/lamp

As standard LED downlights with these exact lumen outputs are not available, the closest commercially available models were selected for the recommendation. The final specification calls for:

Floors 1 & 3: 30W LED downlights with a 3500-lumen output.

Floor 2: 30W LED downlights with a 3700-lumen output.

A verification calculation confirms that these specifications meet the target illuminance, requiring approximately 13 and 12 fixtures for the respective floors.

Administrative control can be implemented for smoking habits and work stress variables. Smoking habits can be reduced by implementing SOPs (Standard Operating Procedures) that prohibit smoking in the workplace. The Fabrication Company does not yet have a written workplace smoking ban that strictly regulates smoking restrictions, including permitted and prohibited locations, as well as penalties for violations. This is expected to create a comfortable and healthy work environment. Additionally, a Peer Support Group Smoking Cessation Program can be implemented. A Peer Support Group is a system of giving and receiving assistance based on the main principles of appreciation, shared responsibility, and mutual agreement on what is considered beneficial (Mead Shery et al., 2001). This program can be carried out through brainstorming and sharing experiences. Yuan *et al.* (2023) stated in their research that participants who joined peer support groups were 1.34 times more likely to quit smoking within 3-9 months after the activity.

According to Permenaker No. 5 (2018), work stress is a potential psychological hazard, and administrative control measures can be implemented by providing a suggestion box for employees to submit symptoms, criticism, or suggestions to the company. This suggestion box was expected to provide a platform for employees who wish to express their aspirations without fear. The last control measure was personal protective equipment (PPE), which cannot be applied because the subjects of this study are office employees.

4. Conclusion

Based on the research conducted, it can be seen that 70% of employees (49 people) of the Fabrication Company experience sick building syndrome (SBS) symptoms. The most common symptoms experienced by employees are fatigue, drowsiness, and nasal congestion. The results of the binary logistic regression test indicate that smoking habits, substandard lighting, and work stress significantly affect sick building syndrome (SBS) symptoms among office employees, with p-values of 0.004 for smoking habits, 0.026 for lighting, and 0.03 for work stress. Smoking habits increase the risk of respiratory tract irritation, while substandard lighting triggers symptoms such as fatigue, dizziness, and eye strain. Work stress also exacerbates SBS symptoms by affecting employees' physical and psychological conditions. Conversely, the working years variable did not show a significant effect on SBS symptoms because employees with longer service tend to have adapted to the work environment. Control recommendations include improving the lighting system (engineering control), implementing SOPs that prohibit smoking and include a Peer Support Group Smoking Cessation Program, and providing suggestion boxes at the company (administrative control) to foster a healthier and more productive work environment.

Credit authorship contribution statement

Kharisma Innayatul Zulfa: Conceptualization, Writing – original draft, Writing – review and editing, Data curation, Software, Methodology, Validation, Formal analysis, Resources. **Wiediartini**: Conceptualization, Writing – review and editing, Supervision, Validation, Formal analysis. **Am Maisarah Disrinama**: Conceptualization, Writing – review and editing, Supervision, Formal analysis.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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