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The indoor air quality and the occurrence of sick building syndrome among employees in the central surgery building of hospital X, Bandung

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Abstract

Background: The prevalence of SBS (Sick Building Syndrome) among employees working in hospitals ranges from 21% to 80%, which is higher compared to other places. SBS has become an issue due to poor indoor air quality, including at Hospital X in Bandung.
Purpose: To analyze the relationship between indoor air quality and the incidence of Sick Building Syndrome among workers in the Central Surgery Building of Hospital X, Bandung.
Method: An analytical observational study with a cross-sectional design. The study population consisted of 105 permanent employees of the Central Surgery Unit. A sample of 91 workers was selected using random sampling. Inclusion criteria were permanent employment and working >7 hours a day, while exclusion criteria included employees on leave, sick, or unavailable. Data were collected through observation using instruments such as a thermohygrometer to measure temperature and humidity, a lux meter for lighting, a sound level meter for noise, and an anemometer for ACH (Air Changes per Hour), following the standards of the Ministry of Health Regulation No. 2 of 2023. Additionally, interviews were conducted using a questionnaire containing questions about SBS symptoms to gather data on the occurrence of SBS. Data analysis used Chi-square and logistic regression at a 95% confidence level and an alpha of 0.05.
Results: The study results indicated that the indoor air quality did not meet the required standards: temperature (77.3%), humidity (86.4%), lighting (63.6%), noise (0%), bacterial count (63.3%), fungal count (77.3%), and ACH (63.3%). There was a significant relationship between temperature, humidity, and ACH with the occurrence of SBS (p=0.001; p=0.003; p=0.031). However, there was no significant relationship between lighting, bacterial count, and fungal count with SBS (p=0.181; p=0.264, p=0.066).
Conclusion: Temperature, humidity, and ACH are variables that are associated with the occurrence of SBS.

Keyword: ACH; Bacteria; Fungi; Humidity; SBS, Temperature.

INTRODUCTION

Sick Building Syndrome (SBS) is recognized as a health issue arising from the work environment, related to indoor air quality and poor building ventilation. Someone is diagnosed with SBS if they have 2/3 of a set of symptoms, including complaints such as dry cough, headaches, eye, nose, and throat irritation, dry skin, drowsiness, and other symptoms while being in the same room (Ministry of Environment and Forestry of the Republic of Indonesia, 2020; Ministry of Health of the Republic of Indonesia, 2021). In the long term, SBS can lead to respiratory disorders, pneumonia, lung diseases, kidney failure, reproductive system disorders, as well as nervous and cardiovascular system issues (Joshi,2008). Globally, 2.7 million people die from air pollution, with 2.2 million of these deaths caused by indoor air pollution. The Occupational Safety and Health Administration (OSHA) states that around 4.5 million people working

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inside buildings are more vulnerable to health problems due to poor indoor air quality. This is because 80-90% of human activities take place indoors or in buildings. SBS can only be considered if more than 20% or 50% of building users experience these symptoms (World Health Organization, 2019). In 1997, the National Institute of Occupational Safety and Health (NIOSH) stated that 52% of respiratory diseases associated with SBS were caused by poor ventilation and infrequent cleaning of air conditioners (AC) (United States Environmental Protection Agency, 1998). Common characteristics found in SBS include buildings with closed ventilation systems, the use of textile materials in the building's interior, carpets, and airtight walls. Additionally, SBS can also be caused by exposure to chemicals, dust contaminated by microorganisms (fungi and bacteria), interior decorations, ventilation systems, room cleanliness, temperature, humidity, and lighting (Kalender-Smajlović, Kukec, & Dovjak, 2022). Individual factors related to SBS include gender, age, length of work, smoking habits, and nutritional status (Ridwan, Nopiyanti, & Susanto, 2018).

A study conducted by the Indonesian Public Health Association on 350 employees in 18 companies in Jakarta and Surabaya between July and December 2008 found that 50% of workers experienced SBS due to air pollution by chemicals (free radicals) (Mawarni, Lestari, Windusari, Andarini, Camelia, Nandini, & Fujianti, 2021). Research in a private hospital concluded that there was a significant relationship between room temperature and Sick Building Syndrome (SBS) complaints in workers (p value 0.036). Inadequate temperature increases the risk of SBS complaints by 4 times (Murniati, 2018). Humidity levels that are not in accordance with standards pose a 1,951 times higher risk of SBS compared to appropriate humidity levels (Karlina, Maharani, & Utari, 2021). A comprehensive literature review of 313 scientific studies and SBS reports and building-related diseases in both residential and non-residential environments showed that the prevalence of SBS was between 21-80% in hospitals, compared to around 30% in other indoor environments (Smajlović, Dovjak, & Kukec, 2019; Akova, Kiliç, Sümer, & Keklikçi, 2022; Chang, Yang, Wang, & Li, 2015). Research at the Pasutri Bogor Maternity and Child Hospital in 2020 revealed a prevalence of 71.6% (53 people) in hospital employees at risk of experiencing SBS, while 28.4% (21 people) were not at risk (Ulfa, Asnifatima, & Fathimah, 2022). Another study conducted on hospital staff in Turkey found the prevalence of SBS cases to be 20.9%, with 1.6% among women. The risk of SBS was found to be 2.9 times higher for women, 2.8 times higher for individuals who described their work environment as dusty, 2.6 times higher for subjects who complained of "stale" air, dry air, and unpleasant odors. The risk of SBS was found to be 1.2 times higher with increased noise levels and 2.1 times higher with elevated carbon dioxide (CO2) concentrations (Arikan, Tekin, & Erbas, 21018).

The central surgery unit building has unique characteristics that increase the risk of SBS for employees. This space requires a highly sterile environment to prevent infections, and strong chemicals and disinfectants are frequently used, affecting air quality. The specialized ventilation system used to control infections through positive or negative pressure can lead to the accumulation of air pollutants if not properly maintained. The rooms used for the survey included those in very high-risk zones (related to the risk of disease transmission), such as intensive care units, isolation rooms, and operating rooms. A preliminary study conducted by researchers at Hospital X in Bandung in April 2023 showed that several workers reported SBS symptoms, including dizziness, nausea, sore throat, flu, and fatigue. Physical parameter measurements in 2022 at Hospital X Bandung revealed that indoor air quality did not meet the required standards in terms of temperature (44.7%), humidity (39.5%), noise (31.6%), lighting (42.1%), and dust (15.8%), all of which did not comply with established quality standards. Based on these findings, this study aims to analyze the relationship between indoor air quality and the occurrence of Sick Building Syndrome.

RESEARCH METHOD

This research is an analytical observational study with a cross-sectional design. It was conducted from July 2023 to July 2024 at Hospital X in Bandung. The independent variables studied were the parameters of physical air quality, including temperature, humidity, lighting, noise, and air changes per hour (ACH), as well as biological quality parameters, including the bacterial index and fungal index. The dependent

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variable in this study was the incidence of Sick Building Syndrome (SBS), marked by symptoms such as headaches, fatigue, dizziness, nausea, eye irritation and dryness, respiratory infections, red skin rashes, and pruritus in respondents.

The population in this study consisted of all permanent employees working in the Central Surgery Unit at Hospital X Bandung, including nurses, pharmacy staff, and administrative staff, totaling 105 people. The sample size of this study was 91 people, calculated using the Isaac and Michael formula. Sampling was done using stratified random sampling. The inclusion criteria were permanent employees working in the operating room and working at least 7 hours a day in air-conditioned rooms. The exclusion criteria included employees who were sick, absent, or unavailable during the study.

Data collection was carried out through interviews using questionnaires to gather data on the incidence of Sick Building Syndrome in employees, with symptoms such as eye irritation, sore throat, skin irritation, headaches, nausea and sensitivity to certain odors, respiratory disorders, drowsiness, fever, fatigue, stomach pain, heartburn, diarrhea, and difficulty concentrating. Meanwhile, data on physical and biological air quality were obtained through measurements. Air temperature and humidity were measured using a thermohygrometer between 10:00 AM and 1:00 PM. Lighting intensity was measured using a lux meter. Noise intensity was measured using a sound level meter placed at a height of 1.5 meters from the floor for 60 minutes. Air changes per hour (ACH) were measured using an anemometer, taking measurements from the wind direction for 1 minute at five points, and the results were averaged. The number of air changes per hour was calculated by multiplying cubic feet per minute by 60, then dividing by the room volume. The bacterial and fungal indices were measured using a microbiology air sampler with the pour plate method and reagent sterilization to capture bacteria and fungi through an impinger tube with a flow meter.

The occurrence of Sick Building Syndrome is categorized as None, if the respondent does not experience symptoms that meet the case criteria and one of the symptoms is not experienced by 20% of the total respondents, and Exist if the respondent experiences symptoms that meet the case criteria and one of the symptoms is experienced by 20% of the total respondents. Temperature quality is categorized as not meeting standards if the temperature is <22ºC or >27ºC, and according to standards if the temperature is 22ºC - 27ºC. Humidity quality is categorized as not meeting standards if humidity is <40% or >60%, and according to standards if humidity is between 40% - 60%. Lighting intensity is categorized as not meeting standards if lighting is <300 lux or >500 lux and according to standards if lighting is between 300 - 500 lux. Noise intensity is categorized as not meeting standards if noise is >65 dBA and according to standards if noise is <65 dBA. The germ index is categorized as not meeting the standard if the concentration of microorganisms per m^3 >35 CFU/m^3, and according to the standard if the concentration of microorganisms per m^3 ≤35 CFU/m^3. The fungus index is categorized as not meeting the standard if the concentration of fungi per m^3 > 20 CFU/m^3, and according to the standard if the concentration of fungi per m^3 ≤20 CFU/m^3. The intensity of air exchange per hour is categorized as not meeting the standard if < 15 or > 20 times/hour, and according to the standard if the ACH is 15 – 20 times/hour.

Data analysis was conducted using univariate, bivariate, and multivariate analyses. Univariate analysis was used to obtain the frequency distribution of the independent and dependent variables. Bivariate analysis was performed using the chi-square test at a 95% confidence level and a 5% alpha to analyze the relationship between the independent and dependent variables. Multivariate analysis was performed using multiple logistic regression to analyze the factors most influencing the occurrence of SBS. This study received ethical approval from the Ethics Committee of the Faculty of Public Health, Diponegoro University, with approval number 272/EA/KEPK-FKM/2024.

RESEARCH RESULTS

Hospital X is a healthcare facility managed by the Ministry of Health, functioning as a National Referral Hospital. Established in 1923, Hospital X offers 21 specialties and 133 subspecialties, and employs 2,804 staff, including specialists, nurses, and other healthcare professionals. The Central Surgery Unit (Instalasi Bedah Sentral, IBS) at Hospital X in Bandung has 22 operating rooms and is responsible

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for various surgical procedures, ranging from simple to complex surgeries, while also supporting medical and nursing education. The Central Surgery Unit building covers an area of 22,330 m² and has 105 permanent employees. The building began operating as an emergency and surgical unit in 2000 and has since undergone only partial maintenance.

Table 1. Characteristics of Respondent (N=91)

Variable	Results
Age (Mean±SD)(Range)(Year)	(40.56±7.809)(21-55)
Age (n/%)	
21 – 30 years	7/7.7
31 – 40 years	32/35.2
41 – 50 years	43/47.2
> 50 years	9/9.9
Gender (n/%)	
Male	32/35.2
Female	59/64.8
Occupation Type (n/%)	
Nurse	73/80.2
Pharmacy	12/13.2
Administration	6/6.6
Work Experience (n/%)	
< 6 years	18/19.8
6 – 10 years	16/17.6
> 10 years	57/62.6
Working Hours (n/%)	
≥ 7 hours	81/89.0
< 7 hours	10/11.0
Smoking Habit (n/%)	
Yes	9/9.9
No	82/90.1
Allergy History (n/%)	
Yes	13/14.3
No	78/85.7
SBS Incidence (n/%)	
SBS	44/48.4
Non SBS	47/51.6

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Table 1 shows that the average and standard deviation of the respondents' age were (40.56±7.809), most of them were female (64.8%), worked as nurses (79.1%), had worked for more than 10 years (62.6%), worked ≥ 7 hours per day, did not have a smoking habit (90.1%), had no history of allergies (85.7%), and as many as 44 (48.4%) respondents experienced SBS, while 47 (51.6%) did not experience SBS.

Table 2. Frequency Distribution of SBS Incidents Based on Symptoms (N=44)

Symptoms	Results
Eye Irritation (burning, itching, watery, red eyes, eye pain) (n/%)	
Yes	13/29.5
No	31/70.5
Throat (itchy, dry, hoarse voice, sore throat, throat discomfort) (n/%)	
Yes	15/34.1
No	29/65.9
Skin (itchy, dry, red, irritated) (n/%)	
Yes	17/38.6
No	27/61.4
Headache (dizziness, heaviness, nausea, migraine) (n/%)	
Yes	29/65.9
No	15/34.1
Nausea, Sensitivity to Certain Smells (n/%)	
Yes	12/27.3
No	32/72.7
Respiratory Issues (runny nose, flu, shortness of breath, cough, sneezing) (n/%)	
Yes	25/568
No	19/43.2
Easily Drowsy (n/%)	
Yes	33/75.0
No	11/25.0
Feeling Hot and Cold or Feverish (n/%)	
Yes	21/47.7
No	23/52.3
Fatigue (weak, sluggish) (n/%)	
Yes	32/72.7
No	12/27.3
Stomach Pain, Cramps, or Diarrhea (n/%)	
Yes	10/22.7
No	34/77.3
Difficulty Concentrating (n/%)	
Yes	23/52.3
No	21/47.7

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Table 2 explains that the complaints experienced by employees include eye irritation, upper respiratory symptoms (nose and throat), red skin rashes, headaches, nausea, drowsiness, fever, fatigue, and difficulty concentrating. From the table, the majority of employees experienced symptoms of drowsiness, with 33 employees (75%), fatigue with 32 employees (72.7%), headaches (dizziness, heaviness, nausea, migraine) with 29 employees (65.9%), respiratory issues (runny nose, flu, shortness of breath, cough, sneezing) with 25 employees (56.8%), and difficulty concentrating with 23 employees (52.3%).

Table 3. Frequency Distribution of Indoor Air Quality Measurements (N=22)

Variable	Results
Temperature (n/%)	
Not up to standard	17/77.3
Up to standard	5/22.7
Humidity (n/%)	
Not up to standard	19/86.4
Up to standard	3/13.6
Lighting Intensity (n/%)	
Not up to standard	14/63.6
Up to standard	8/36.4
Noise (n/%)	
Not up to standard	0/0
Up to standard	22/100
Germ Index (n/%)	
Not up to standard	14/63.6
Up to standard	8/36.4
Mold Index (n/%)	
Not up to standard	17/77.3
Up to standard	5/22.7
Air Changes per Hour (ACH) (n/%)	
Not up to standard	14/63.6
Up to standard	8/36.4

Table 3 explains that the majority of physical and biological quality parameters in the Central Surgical Building of Hospital X Bandung do not meet the standards. Specifically, the temperature in 17 rooms (77.3%), humidity in 19 rooms (86.4%), lighting intensity in 14 rooms (63.6%), germ index in 14 rooms (63.6%), mold index in 17 rooms (77.3%), and air changes per hour (ACH) in 14 rooms (63.3%) were all below standard. Meanwhile, noise levels in all areas met the standards.

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Table 4. The Relationship Between Indoor Air Quality and the Incidence of Sick Building Syndrome

Variable	SBS Incidence		*p-value*	PR	95 % CI	
	SBS (n=44)	Non SBS (n=47)			*Lower*	*Upper*
Temperature (n/%)						
Up to standard	41/93.2	25/70.2	0.001*	12.027	3.262	44.341
Not up to standard	3/6.8	22/29.8				
Humidity (n/%)						
Up to standard	37/84.1	26/55.3	0.003*	4.269	1.584	11.508
Not up to standard	7/15.9	21/44.7				
Lighting Intensity (n/%)						
Not up to standard	21/47.7	29/61.7	0.181	0.567	0.246	1.305
Up to standard	23/52.3	18/38.3				
Noise (n/%)						
Not up to standard	0/0	0/0	-	-	-	-
Up to standard	44/100	47/100				
Germ Index (n/%)						
Not up to standard	32/72.7	29/61.7	0.264	1.655	0.682	4.017
Up to standard	12/27.3	18/38.3				
Mold Index (n/%)						
Not up to standard	28/63.6	38/80.9	0.066	0.414	0.160	1.037
Up to standard	16/36.3	9/19.1				
Air Changes per Hour (ACH) (n/%)						
Not up to standard	33/75.0	25/53.2	0.031*	2.640	1.083	6.435
Up to standard	11/25.0	22/46.8				

***** Related

The results of statistical tests using chi-square on temperature obtained a p value = 0.001 (p < 0.05) which means that there is a significant relationship between the quality of room temperature and the occurrence of sick building syndrome. The calculation results of the PR value = 12.027 with 95% CI in the range of 3.262 - 44.341 which means that respondents who are in a room with a temperature that is not in accordance with the standard are at risk of more than 12 times to experience sick building syndrome. The calculation results of 95% CI show a value of more than 1 which means that room temperature that is not in accordance with the standard is a risk factor for the occurrence of sick building syndrome.

On humidity obtained p value = 0.003 (p < 0.05) which means that there is a significant relationship between the quality of room humidity and the occurrence of sick building syndrome. The calculation result of PR value = 4.269 with 95% CI in the range of 1.584 - 11.508 which means that respondents who are in a room with humidity that is not in accordance with the standard are at risk of more than 4 times to experience sick building syndrome. The calculation result of 95% CI shows a value of more than 1 which means that room humidity that is not in accordance with the standard is a risk factor for the occurrence of sick building syndrome.

In lighting intensity, the p value was obtained = 0.181 (p > 0.05), which means that there is no significant relationship between the intensity of room lighting and the occurrence of sick building syndrome.

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In the noise aspect, the p value was obtained = 0.264 (p > 0.05), which means that there is no significant relationship between the indoor germ index and the incidence of sick building syndrome.

In the germ count index, the p value was obtained = 0.264 (p > 0.05), which means that there is no significant relationship between the germ count index in the room and the occurrence of sick building syndrome.

In the fungal count index, the p value was obtained = 0.066 (p > 0.05), which means that there is no significant relationship between the fungal count index in the room and the occurrence of sick building syndrome.

And in the air exchanges per hour (ACH), the p value is obtained = 0.031 (p < 0.05) which means that there is a significant relationship between the quality of air exchange per hour in the room and the occurrence of sick building syndrome. The calculation result of the PR value = 2.640 with 95% CI in the range of 1.083 - 6.435 which means that respondents who are in a room with an air exchange per hour in the room that is not in accordance with the standard are at risk of more than 2 times to experience sick building syndrome. The calculation result of 95% CI shows a value of more than 1 which means that the air exchange per hour in the room that is not in accordance with the standard is a risk factor for the occurrence of sick building syndrome.

Table 5. The Relationship between Indoor Air Quality and the Incidence of Sick Building Syndrome

Variable	B	*p-value*	*Exp B*	95% CI	
				Lower	*Upper*
Temperature	2,355	0,001	10,534	2,783	39,869
Humidity	1,250	0,023	3,489	1,185	10,267
Constant	-4,423	0,000	0,012		

From the table above, it is known that the most dominant variables for the occurrence of sick building syndrome in workers are temperature (p = 0.001) and humidity (p = 0.023). Then, the Exp B value obtained for the temperature variable is 10.534 and humidity is 3.489. This means that respondents who are in a room with non-standard temperature quality have a chance of experiencing SBS more than 10 times while humidity has a chance of more than 3 times. In addition, the McFadden R2 value was obtained of 0.224, which means that the temperature and humidity variables in the room contribute to the occurrence of sick building syndrome.

DISCUSSION

Room Temperature Quality

The research findings indicate a significant relationship between room temperature quality and the incidence of sick building syndrome among employees in the Central Surgical Building of Hospital X Bandung (p = 0.001), thus the hypothesis of this study is accepted. The results also show that respondents in rooms with substandard temperature quality are more than 12 times at risk of experiencing sick building syndrome compared to those in rooms with standard temperature quality. The substandard room temperature quality is significantly associated with sick building syndrome among employees in the Central Surgical Building of Hospital X Bandung, as 41 (62.1%) out of 44 respondents experienced sick building syndrome, compared to 25 (37.9%) out of 47 respondents who did not experience it.

Temperature quality measurements in several rooms of the Central Surgical Building using a thermohygrometer showed temperatures below 22°C, which do not comply with applicable regulations, where the standard temperature range is between 22 – 27°C (Ministry of Health of the Republic of Indonesia, 2023). The substandard temperature quality is attributed to a lack of maintenance and care for the air conditioning system (HVAC). Excessively cold temperatures in the Central Surgical Building can lead to uneven temperature distribution, making it difficult for rooms to maintain standard temperatures. Rooms that are too cold contribute to SBS because such temperatures can trigger physiological responses in the body, such as shivering and feelings of cold, which are the body's efforts to stabilize core temperature. This physical discomfort can result in thermal stress that affects a person's ability to concentrate and function optimally. This thermal stress can lead to increased blood pressure, heart

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rate, and fatigue (Ministry of Health of the Republic of Indonesia, 2021; DiNardi, 2003).

This finding is in line with research on PLN UIW Sulselrabar Makassar City employees which showed that there was a significant relationship between room temperature quality and the incidence of sick building syndrome (Bardi, Fachrin, & Tussaadah, 2021). Another study conducted on employees of the Central Java Provincial Health Office also showed a significant relationship between room temperature quality and the incidence of sick building syndrome (Larasati & Wahyuningsih, 2023).

Efforts that Hospital X Bandung can undertake to reduce the incidence of sick building syndrome among employees include conducting routine maintenance on the HVAC system in the Central Surgical Building and regularly checking room temperature quality to ensure that indoor air quality meets the established standards.

Room Humidity Quality

The research findings indicate a significant relationship between room humidity quality and the incidence of sick building syndrome among employees at Hospital X Bandung (p = 0.003), thus the hypothesis of this study is accepted. The results also show that respondents in rooms with substandard air humidity are more than four times at risk of experiencing sick building syndrome compared to those in rooms with standard air humidity. The substandard humidity quality significantly correlates with the incidence of sick building syndrome among employees in the Central Surgical Building of Hospital X Bandung, as 37 (58.7%) out of 44 respondents experienced sick building syndrome, while 26 (41.3%) out of 47 respondents did not.

The indoor air humidity in the Central Surgical Building, measured using a thermohygrometer, showed an average of 64.78%, which does not comply with applicable regulations where standard indoor humidity should be in the range of 40 – 60% (Ministry of Health of the Republic of Indonesia, 2023).

. The substandard humidity quality is attributed to a lack of maintenance and cleaning of the HVAC system. Observations revealed that the HVAC systems in several rooms were dirty and contained a lot of dust due to infrequent cleaning. Additionally, cleaning efforts for the HVAC systems were not effective, as the operating rooms on the 3rd and 4th floors are always occupied, limiting the time available for cleaning. Maintenance on the HVAC system only includes filter replacement once a year. Modern HVAC systems are equipped with humidifiers and dehumidifiers to increase or decrease humidity as needed. If the HVAC system is not optimally maintained, it can diminish the functionality of these features. Humidity plays a crucial role in thermal comfort. When indoor humidity exceeds 60% or falls below 40%, it affects the body's heat dissipation. High humidity levels make it difficult for the body to release heat, leading to discomfort and increasing the risk of SBS (DiNardi, 2003).

This finding is in accordance with a study conducted on non-faculty staff at the Faculty of Medicine building, Bandung Islamic University, which explained that there was a significant relationship between the quality of room humidity and the incidence of sick building syndrome (Ramadhan, Wargahadibrata, & Suryani, 2020). Another study conducted on employees of PT. X Palembang also showed a significant relationship between the quality of room humidity and the incidence of sick building syndrome (Mawarni et al., 2021). Efforts that can be made by Hospital X Bandung to reduce the risk of SBS include carrying out routine maintenance on the HVAC system so that it functions properly and carrying out regular cleaning so that the humidity in the Central Surgery Building meets the standards set by applicable regulations.

Lighting Intensity

The research findings indicate that there is no relationship between lighting intensity and the incidence of sick building syndrome among workers in the Central Surgical Building of Hospital X Bandung (p = 0.181), thus the hypothesis of this study is rejected. Measurements of lighting intensity showed that 14 rooms (63.4%) had lighting intensity below 300 lux, which does not meet the standards set by applicable regulations (Ministry of Health of the Republic of Indonesia, 2023). However, these results are not related to the incidence of sick building syndrome among employees in the Central Surgical Building because there were more respondents in those rooms who did not experience SBS, totaling 29 respondents (58%), compared to those who did experience SBS,

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totaling 21 respondents (42%). This finding is supported by research on employees of PT. X Palembang, which explains that there is no significant relationship between lighting intensity and the incidence of sick building syndrome (Mawarni et al., 2021). However, research conducted on students of STIKES Persada Husadan Indonesia, showed a significant relationship between classroom lighting intensity and the incidence of sick building syndrome (Vestabilivy & Hadien, 2023).

Noise

The research findings indicate that all respondents, both those experiencing SBS and those not experiencing SBS, were in rooms with noise intensity that met the standards. From this result, it can be concluded that all respondents were in the same or homogeneous condition. This led to the data not being able to proceed to the statistical testing phase, thus the relationship between noise intensity and the incidence of sick building syndrome at Hospital X Bandung could not be advanced to statistical testing.

Research conducted on secretaries at Kutahaya Regional Hospital, explained that there was a significant relationship between noise intensity and the incidence of sick building syndrome (Arikan et al., 2018). Another study conducted on workers at Haji Indonesia Regional Hospital, showed that there was no significant relationship between noise intensity and the incidence of sick building syndrome (Drastyana, Ambag, Ningrum, & Wijayanti, 2023).

Microbial Index

The research findings indicate that there is no significant relationship between the microbial index in rooms and the incidence of sick building syndrome among workers in the Central Surgical Installation of Hospital X Bandung ($p = 0.264$), thus the hypothesis of this study is rejected. Measurements of the microbial index showed that 14 rooms (63.3%) had an average value of 47.95 CFU/m³, indicating that the microbial index does not meet the standards set by applicable regulations (Minister of Health Regulation No. 2 of 2023), which is ≤ 35 CFU/m³. The absence of a relationship between the microbial index in the rooms and SBS may be due to the species of microorganism found, which was *Staphylococcus hominis*. This bacterium is a gram-positive bacterium that is part of the normal flora on the skin surface and plays a role in breaking down sweat and producing fatty acids, thus generally not causing disease. The lack of a relationship between the substandard microbial index and SBS is also supported by statistical results showing that the number of respondents experiencing SBS and those not experiencing SBS is nearly the same (Alang, Kusnadi, Ardyati, & Suharjono, 2020). The number of respondents experiencing SBS was 32 out of 44 respondents (52.5%), while those not experiencing SBS was 29 out of 47 respondents (47.5%).

This finding align with research conducted on workers in the Operating Room Unit of Cilandak Regional Hospital, South Jakarta, which explained that there was no significant relationship between the number of bacterial colonies and the incidence of sick building syndrome (Ridwan et al., 2018). However, this study does not align with research conducted on workers at the Central Java Provincial Health Office, which showed a significant relationship between the number of microbes and the incidence of sick building syndrome (Larasati & Wahyuningsih, 2023).

Fungal Index

The research findings indicate that there is no significant relationship between the fungal index in the rooms and the incidence of sick building syndrome among workers in the Central Surgical Installation of Hospital X Bandung ($p = 0.066$), thus the hypothesis of this study is rejected. Measurements of the fungal index showed that 17 rooms (77.3%) had a fungal index that did not meet the standards, with an average value of 74.68 CFU/m³, indicating that the fungal index in the Central Surgical Building does not comply with the standards set by applicable regulations (Minister of Health Regulation No. 2 of 2023), which is ≤ 20 CFU/m³. The absence of a relationship between the fungal index and SBS may be due to the species of fungi found in the central surgical installation being *Penicillium sp.* The *Penicillium sp.* species is not always harmful to humans; only a few species can produce mycotoxins and cause disease infections, such as *Penicillium citrinum* and *Penicillium marneffei.* Some species of *Penicillium sp.* are also beneficial to humans, such as *Penicillium notatum*, which produces penicillin for antibiotics, and *Penicillium citrinum*, which is used in the pharmaceutical industry to

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produce citric acid. In addition, *Penicillium sp.* can act as an antagonist against pathogenic fungi, such as *Cercospora nicotianae (*Darliana, & Wilujeng, 2020).

The lack of a relationship between the substandard fungal index and SBS is also supported by statistical results showing that respondents experiencing SBS were fewer than those not experiencing SBS. The number of respondents experiencing SBS was 28 out of 44 respondents (42.4%), while those not experiencing SBS was 38 out of 47 respondents (57.6%). These findings align with research conducted among employees at RRI Banjarmasin, which explains that there is no significant relationship between the microorganism count and the incidence of sick building syndrome (Aryadni, Juanda, & Santoso, 2018). However, this study does not align with research conducted among employees in the administration room of the UMI Tower in Makassar, which indicates a significant relationship between the total microorganism count and the incidence of sick building syndrome (Putra, Ikhtiar, & Emelda, 2018).

Air Changes per Hour (ACH)

The research findings indicate a significant relationship between the quality of air changes per hour (ACH) and the incidence of sick building syndrome among employees in the Central Surgical Building of Hospital X Bandung (p = 0.031), thus the hypothesis of this study is accepted. The results also show that respondents in rooms with non-compliant ACH are more than twice as likely to experience sick building syndrome compared to those in rooms with compliant ACH. The quality of ACH in rooms that do not meet the standards has a significant relationship with the occurrence of sick building syndrome among employees in the Central Surgical Building of Hospital X Bandung, as the number of respondents experiencing SBS is greater than those not experiencing SBS. The number of respondents experiencing SBS was 33 out of 44 respondents (56.9%), while those not experiencing SBS numbered 25 (43.1%). The quality of ACH measured in the Central Surgical Building, using an anemometer, showed an average result of 12.9 times per hour, which does not comply with the applicable regulations where the standard ACH is within the range of 15 – 20 times per hour (DiNardi, 2003). The non-compliance of ACH quality is due to a lack of maintenance and care of the HVAC system. Some rooms on the 3rd and 4th floors of the Central Surgical Building were found to have dirty and dusty HVAC conditions because they are rarely cleaned. Additionally, trash bins obstructing airflow were noted, causing poor air circulation in the rooms, leading to substandard ACH quality. The inadequate ACH quality impacts humidity levels, which can become uncontrolled. High humidity makes it difficult for the body to release heat, creating discomfort that increases the risk of SBS.

These findings are consistent with research conducted among educational staff at Faculty of Medicine, Universitas Pembangunan Nasional Veteran Jakarta, which explains that ventilation conditions are related to the incidence of sick building syndrome (Krismondani, Chairani, & Nugrohowati, 2020). Efforts that Hospital X Bandung can take to reduce SBS among workers in the Central Surgical Building include conducting routine maintenance and care of the HVAC system, regular cleaning, periodic monitoring of ACH quality, and relocating objects that may obstruct air circulation. These actions will help maintain the ACH quality in the Central Surgical Building in accordance with applicable regulatory standards.

The Most Dominant Variables

The results of the multivariate analysis using logistic regression indicated that two variables were most related to the occurrence of sick building syndrome among workers in the Central Surgical Building of Hospital X Bandung: temperature quality (p = 0.001; PR = 10.534; 95% CI = 2.7783 – 39.869) and humidity quality (p = 0.023; PR = 3.489; 95% CI = 1.185 – 10.267). Measurements of temperature and humidity in several rooms of the Central Surgical Building showed non-compliance with regulatory standards (Minister of Health Regulation No. 2 of 2023), with temperatures below 22°C (standard 22-27°C) and an average humidity of 64.78% (standard 40-60%). This non-compliance was due to a lack of maintenance and cleaning of the HVAC system, which was dirty and infrequently cleaned. Additionally, there were trash bins obstructing the air outlet pathways of the HVAC system, causing poor air circulation and uncontrolled humidity levels. Excessively cold temperatures resulted in uneven temperature distribution, triggering physiological responses in the

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body such as shivering and thermal stress, which could disrupt concentration, increase blood pressure, and lead to fatigue, contributing to SBS (Ministry of Health of the Republic of Indonesia, 2021). Non-standard humidity affects the release of heat from the body, creating discomfort and increasing the risk of SBS (DiNardi, 2003). Efforts are needed for optimal HVAC maintenance, including routine cleaning, more frequent filter replacements, and relocating objects that obstruct the HVAC system to maintain temperature and humidity within standards and reduce the risk of SBS. Furthermore, the hospital can conduct regular inspections of indoor air quality to ensure that air quality requirements meet established standards.

CONCLUSION

Non-standard temperature, humidity, and air exchange rates are related to the occurrence of sick building syndrome among employees in the operating rooms of Hospital X Bandung. Non-standard levels of lighting intensity, noise intensity, fungal index, and bacterial index are not associated with the occurrence of sick building syndrome. Non-standard temperature and humidity are the most influential factors affecting the occurrence of sick building syndrome in the operating rooms of Hospital X Bandung.

SUGGESTION

The hospital can maintain the HVAC system through routine cleaning and regular filter replacements to ensure optimal functioning. Additionally, measuring air quality according to the standards of Minister of Health Regulation No. 2 of 2023 is necessary to minimize the incidence of sick building syndrome among workers.

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