User's Perception of Indoor Air Quality (IAQ) in Tall Office Buildings as the Cause of Symptoms of Sick Building Syndrome

Apif M. Hajji*, *Nasta* Natasya, and *Viola* Malta

Department of Civil Engineering and Planning, State University of Malang, Indonesia

Abstract. The user's assessment or perception of indoor air quality (IAQ) refers to an individual's subjective assessment or perception of the quality of the air they breathe inside a particular building or space. This assessment or perception is very individual and can vary from one individual to another. This study aims to determine the IAQ felt by users of the Rectorate Building, State University of Malang, and its effect on Sick Building Syndrome (SBS) symptoms. This research is included in the quantitative research with the study population being all employees at the building, which has 215 people. The data collection technique in this study used the MM040NA questionnaire and the data analysis technique used was binary logistic regression analysis with the help of the IBM SPSS Statistics with crosstabs test. The results of this study indicate that all independent variables have no significant relationship with SBS symptoms experienced by respondents and all independent variables have a very weak correlation. In addition, from 80 respondents, 27 people (33.75%) experienced SBS and 53 people (66.25%) did not experience SBS. This shows that there is a SBS phenomenon in the building. The significance value for all independent variables is greater than the significance level value (>0.05). Furthermore, based on the test criteria, it is concluded that the variable airflow, high temperature, temperature change, low temperature, stale air, dry air, odor, air electrostatics, cigarette smoke, sound level, lighting, and air pollution have approximate significance values greater than 0.05 (null hypothesis was failed to be rejected). It is concluded that those variables have no significant relationship to the dependent variable (the SBS symptoms) experienced by the respondents.

1 Introduction

Indoor Air Quality (IAQ) refers to the air quality in and around buildings that is related to the health and comfort of building occupants. IAQ is affected by the ventilation system and the accumulation of air pollutants from both indoors and outdoors [1]. IAQ is also influenced by various factors, including temperature, humidity, air exchange rate, air movement, ventilation system, particles of pollutants, biological pollutants, and gaseous pollutants [2]. The facts show that most people in Western countries spend almost 80% of their time indoors

* Corresponding author: apif.miptahul.ft@um.ac.id

[3]. It shows how important IAQ is in influencing health and productivity in the workplace. Despite being a major concern in developing countries, public health problems related to poor IAQ and their impact on human health compared to developed countries [4] are rarely studied.

Building occupants may experience symptoms such as headaches, nausea, and irritation of the eyes, nose, and throat due to poor IAQ. These complaints are known as Sick Building Syndrome (SBS) [5]. SBS generally appears upon entering the building or immediately after and will disappear after leaving the building [6]. User's assessment or perception of IAQ refers to an individual's subjective assessment or perception of the quality of the air they breathe in a particular building or space. It involves user evaluation of the air conditioner, including cleanliness, humidity, temperature, odor, and the presence of harmful particles or chemical substances in the air. The research conducted by Tsantaki et al. [7], Akova et al. [8], and Thach et al. [9] indicate that the occupants' perception or assessment of IAQ has an important role in the appearance of SBS symptoms.

2 Method

In this study, a statistical method was used to investigate the relationship between the perception of IAQ felt by respondents with SBS symptoms felt by respondents, employees in the Malang State University Rectorate Building. The categorization of SBS variables includes: 1) Nasal symptoms in the form of complaints in the nose such as irritation and stuffiness or runny nose, 2) Eye symptoms with complaints in the form of itching, burning, or irritation of the eyes, 3) Throat symptoms with health problems such as hoarse, dry, and coughing throat, 4) Skin symptoms with health problems such as dry or red facial skin, scaly or itchy scalp or ears, dry hands, itching, and flushed skin, and 5) Common symptoms which include complaints such as fatigue, feeling of heaviness in the head, headache, nausea or dizziness, and difficulty concentrating.

The research instrument used to obtain primary data in this study was a questionnaire. The questionnaire used in this study is the standardized questionnaire MM040 NA [10,11], which has been developed by Örebro University Hospital Department of Occupational and Environmental to evaluate SBS symptoms and IAQ in the workplace. Research respondents were said to have SBS symptoms if they experienced at least one complaint among the five SBS categories for 1-3 days a week in the last three months. After the data collection process is complete, the research results are tested the cross-tabulation test to determine whether the independent variable has a significant relationship with the dependent variable and the value of the correlation coefficient to determine the strong relationship between variables.

3 Results and Discussion

IAQ felt by respondents inside the building is the subjective perception or assessment. This includes factors such as temperature, humidity, noise, odors, and indoor air pollution that can affect the comfort and health of building users. Respondents' perceptions regarding IAQ when they were in the building can be seen in Table 1.

Table 1. Respondent's perception of IAQ

Variable	Response	Number of responses	Percentage (%)
Indoor airflow/ movement	0 = frequently	2	2,5
	1 = occasionally	48	60
	2 = never	30	37,5
	0 = frequently	6	7,5

Variable	Response	Number of responses	Percentage (%)
High air temperature	1 = occasionally	35	44,75
	2 = never	39	48,75
Change of temperature	0 = frequently	12	15
	1 = occasionally	44	55
	2 = never	24	30
Low air temperature	0 = frequently	23	28,75
	1 = occasionally	36	45
	2 = never	21	26,25
Stuffy air	0 = frequently	36	45
	1 = occasionally	34	42,5
	2 = never	10	12,5
Dry air	0 = frequently	18	22,5
	1 = occasionally	32	40
	2 = never	30	37,5
Odor	0 = frequently	6	7,5
	1 = occasionally	32	40
	2 = never	42	52,5
Electrostatic	0 = frequently	3	3,75
	1 = occasionally	19	23,75
	2 = never	58	72,5
Cigarettes smokes	0 = frequently	18	22,5
	1 = occasionally	26	32,5
	2 = never	36	45
Noises	0 = frequently	18	22,5
	1 = occasionally	31	38,75
	2 = never	31	38,75
Lighting	0 = frequently	13	16,25
	1 = occasionally	33	41,25
	2 = never	34	42,5
Air pollution	0 = frequently	6	7,5
	1 = occasionally	36	45
	2 = never	38	47,5

Table 1 contains the results of a study involving 80 respondents who indicated various disturbances they felt in their workspace. From these data, it was found that 2.5% of the total respondents were often bothered by indoor airflow during the last three months, while 6 respondents, or 7.5% were often bothered by high temperatures in the room. In addition, 12 respondents, or 15% of the total respondents often felt disturbed by changes in room temperature, while 21 respondents, or 26.25% never felt bothered by low temperature in the room. In the case of stuffy air, 10 respondents, or 12.5% of the total respondents were never bothered by this condition, while 18 respondents, or 22.5% often felt bothered by dry air in the room. Meanwhile, 6 respondents, or 7.5% often feel disturbed by the unpleasant odor in the room, and 3 respondents, or 3.75% often feel disturbed by the electrostatic air in the room. Furthermore, in the case of passive smokers, 18 respondents, or 22.5% of the total respondents often feel disturbed by indoor cigarette smoke. Furthermore, 18 respondents, or 22.5% felt disturbed by the noise level in their workspace, while 13 respondents, or 16.25% felt disturbed by the level of lighting in their work space. Finally, 6 respondents, or 7.5% often feel disturbed by the air pollution in their work space.

Furthermore, research data was also obtained related to SBS symptoms experienced by respondents while in the Rectorate Building, State University of Malang. Respondents can be concluded to experience SBS symptoms if they feel at least one SBS symptom from the

entire SBS symptom categories within the last three months, 1-3 times a week, choosing the answer option "frequently" and feel sure that these symptoms are caused by environmental conditions IAQ. SBS symptoms felt by respondents when they were inside the building can be seen in Table 2.

Tabel 2. SBS symptoms experienced by respondents

Variable	Response	Number of responses	Percentage (%)
Nose irritation	0 = frequently	1	1,25
	1 = occasionally	37	46,25
	2 = never	42	52,5
Runny nose	0 = frequently	1	1,25
	1 = occasionally	4	5
	2 = never	75	93,75
Eyes itching and irritation	0 = frequently	23	28,75
	1 = occasionally	36	45
	2 = never	21	26,25
Throat hoarse	0 = frequently	18	22,5
	1 = occasionally	32	40
	2 = never	30	37,5
Throat dry	0 = frequently	22	27,5
	1 = occasionally	34	42,5
	2 = never	24	30
Coughing	0 = frequently	4	5
	1 = occasionally	19	23,75
	2 = never	57	71,25
Dry of red facial skin	0 = frequently	4	5
	1 = occasionally	7	8,75
	2 = never	69	86,25
Scaly or itchy scalp and flushed skin	0 = frequently	2	2,5
	1 = occasionally	15	18,75
	2 = never	63	78,75
Fatigue	0 = frequently	18	22,5
	1 = occasionally	31	38,75
	2 = never	31	38,75
Heaviness in head	0 = frequently	4	5
	1 = occasionally	52	65
	2 = never	24	30
Headache	0 = frequently	2	2,5
	1 = occasionally	49	61,25
	2 = never	29	36,25
Nausea or dizziness	0 = frequently	3	3,75
	1 = occasionally	32	40
	2 = never	45	56,25
Difficulty concentrating	0 = frequently		0
	1 = occasionally	23	28,75
	2 = never	57	71,25
SBS	0 = Yes	27	33,75
	1 = No	53	66,25

Table 2 shows that the data is data regarding the health condition of the respondents in the last three months. Of the 80 respondents, 1 person (1.25%) experienced irritation and congestion or runny nose, 1 person (1.25%) often experienced nosebleeds, 23 people (28.75%) often experienced itchy, burning or irritated eyes, 18 people (22.5%)) often feel

hoarse or dry throat, 4 people (5%) often experience coughing, 22 people (27.5%) often experience scaly or itchy scalp or ears, 4 people (5%) often experience dry or flushed facial skin, 2 people (2.5%) often experienced scaly or itchy scalp or ears, 18 people (22.5%) often felt tired, 17 people (21.25%) felt a heavy head or headache, and 3 people (3.75%) often experienced nausea or dizziness. In addition, 27 people (33.75%) had SBS (Sick Building Syndrome) and 53 people (66.25%) did not have SBS. After that, the research hypothesis was tested using cross-tabulations to determine the relationship between the two categorical variables. The test results use the cross-tabulation test in the form of an approximate significance value to determine the significance value of the independent variable on the dependent variable and also obtain a correlation coefficient value to determine the value of the strong relationship between the independent variable and the dependent variable which can be seen in Table 3 below.

Tabel 3. Cross-tab results of IAQ variables

Variable	Approx Significance	Correlation coefficient (r)
Airflow/movement	0,122	0,229 (very weak)
High-temperature	0,490	0,133 (very weak)
Change of temperature	0,581	0,117 (very weak)
Low-temperature	0,678	0,099 (very weak)
Stuffy air	0,098	0,241 (very weak)
Dry air	0,520	0,128 (very weak)
Odor	0,968	0,028 (very weak)
Electrostatics	0,629	0,108 (very weak)
Cigarette smokes	0,569	0,119 (very weak)
Noise	0,903	0,051 (very weak)
Lighting	0,306	0,172 (very weak)
Air pollution	0,997	0,009 (very weak)

From Table 3 it can be seen that the approximate significance value for the airflow variable has a significance value of 0.122, which means that the airflow variable has no significant relationship with the incidence of sick building syndrome (SBS) in the respondents or H_0 fails to be rejected. In addition, it is known that the value of the correlation coefficient of the airflow variable is 0.229. This shows that the airflow variable has a very weak correlation or relationship with the SBS symptoms experienced by the respondents.

Furthermore, it is known that the results of the cross-tabulation test also show that the high-temperature variable has a significance value of 0.490, which means that this variable has no significant relationship with SBS and the null hypothesis (H_0) fails to be rejected. In addition, based on Table 3 it is known that the correlation coefficient value of the airflow variable is 0.133. This shows that the high-temperature variable has a very weak correlation or relationship with the SBS symptoms experienced by the respondents. In the case of high temperatures, although it does not directly affect the SBS symptoms experienced by respondents, problems related to thermal comfort may arise, such as excessive sweating, dehydration, fatigue, and decreased productivity.

The temperature change variable has a significance value of 0.581. This significance value indicates that there is insufficient evidence to reject the null hypothesis so there is no significant relationship between temperature changes and sick building syndrome experienced by building users or the null hypothesis fails to be rejected. In addition, based on Table 3 it is known that the correlation coefficient value of the airflow variable is 0.117. This shows that the temperature change variable has a very weak correlation or relationship with the SBS symptoms experienced by the respondents. Room temperature can indeed affect human comfort, but changes in temperature that occur within a reasonable range usually do

not directly affect SBS. This is because SBS is caused by a combination of interacting indoor environmental factors.

Furthermore, table 3 shows that the low-temperature variable has a significance value of 0.678, which means that there is not enough evidence to reject the null hypothesis so that there is no significant relationship between the low-temperature variable and the incidence of sick building syndrome experienced by building users or the null hypothesis failed to be rejected. In addition, based on Table 3 it is also known that the correlation coefficient value of the airflow variable is 0.099. This shows that the low-temperature variable has a very weak correlation or relationship with the SBS symptoms experienced by the respondents. Low-temperature levels that are too cold can also contribute to the occurrence of SBS in some cases, but this depends on many factors such as air humidity, duration of exposure, individual sensitivity, and other environmental factors.

In Table 3 it is known that the results of the cross-tabulation test show that the stale air variable has a significance value of 0.098, which means that this variable has no significant relationship with the occurrence of SBS or the null hypothesis fails to be rejected. Besides that, it is also known that the value of the correlation coefficient of the airflow variable is 0.241. This shows that the stale air variable has a very weak correlation or relationship with the SBS symptoms experienced by the respondents. The stuffy air in a room caused by high humidity can affect the symptoms of SBS experienced by room users. The quality of stuffy indoor air can affect a person's symptoms of SBS because polluted or contaminated air in the room can cause symptoms such as headaches, eye, nose, and throat irritation, nausea, fatigue, and difficulty concentrating. These symptoms can affect work productivity and the well-being of people living or working in the building.

Furthermore, in Table 3 it is known that the dry air variable has a significance value of 0.520. This significance value indicates that there is not enough evidence to reject the null hypothesis so there is no significant relationship between low temperature and sick building syndrome experienced by building users or the null hypothesis fails to be rejected. In addition, based on Table 3 it is known that the correlation coefficient value of the airflow variable is 0.128. This shows that the dry air variable has a very weak correlation or relationship with the SBS symptoms experienced by the respondents. The results of this study are in line with the results of research conducted by previous researchers that there is no significant effect of low relative humidity which causes dry indoor air on SBS symptoms and cases.

In table 3 it is also known that the odor variable in the air has a significance value of 0.968. This significance value indicates that there is not enough evidence to reject the null hypothesis so there is no significant relationship between indoor air odor and sick building syndrome experienced by building users or the null hypothesis fails to be rejected. In addition, based on Table 4.3 it is known that the correlation coefficient value of the airflow variable is 0.028. This shows that the bad smell variable in the air has a very weak correlation or relationship with the SBS symptoms experienced by the respondents. This study's results align with previous research that there is no significant effect between unpleasant odors in a room on SBS symptoms. Although the odor factor in indoor air does not play a significant role in the occurrence of SBS symptoms. However, this does not mean that these factors are not important to pay attention to in maintaining indoor air quality.

In Table 4.3 it is known that the air electrostatic variable has a significance value of 0.629. This significance value indicates that there is insufficient evidence to reject the null hypothesis, so there is no significant relationship between air electrostatic variables and sick building syndrome experienced by building users or the null hypothesis fails to be rejected. In addition, based on Table 3 it is known that the correlation coefficient value of the airflow variable is 0.108. This shows that the air electrostatic variable has a very weak correlation or relationship with the SBS symptoms experienced by the respondents. Although electrostatics

can affect indoor air quality, this is not always related to the occurrence of SBS. SBS usually occurs when indoor air quality is poor, for example, due to low humidity, harmful chemical pollutants, or insufficient air circulation. However, air electrostatics can trigger health problems such as eye, nose, and throat irritation, and can increase the risk of respiratory infections caused by bacteria or viruses.

Furthermore, in Table 3 it is known that the cigarette smoke variable has a significance value of 0.569. This significance value indicates that there is not enough evidence to reject the null hypothesis so there is no significant relationship between cigarette smoke and sick building syndrome experienced by building users or the null hypothesis fails to be rejected. In addition, based on Table 3 it is known that the value of the correlation coefficient of the airflow variable is 0.119. This shows that the cigarette smoke variable has a very weak correlation or relationship with the SBS symptoms experienced by the respondents. Passive smokers can be exposed to SBS like other people, depending on the environmental conditions in the building. However, passive smokers may not have a higher risk of developing SBS simply because they do not actively smoke.

In Table 3 it is also known that the sound level variable has a significance value of 0.903. This significance value indicates that there is insufficient evidence to reject the null hypothesis so that there is no significant relationship between sound level and sick building syndrome experienced by building users or the null hypothesis fails to be rejected. In addition, based on Table 3 it is known that the correlation coefficient value of the airflow variable is 0.051. This shows that the sound level variable has a very weak correlation or relationship with the SBS symptoms experienced by the respondents. Indoor sound level is not the main factor affecting SBS. However, sounds that are too loud can stress the nervous system and cause discomfort to people indoors, which can exacerbate existing SBS symptoms. In addition, a sound that is too loud can also interfere with the concentration and productivity of people in the room.

Furthermore, in Table 3 it is known that the results of the test show that the lighting variable has a significance value of 0.306, which means that this variable has no significant relationship with the occurrence of SBS and the null hypothesis fails to be rejected. In addition, based on Table 3 it is known that the correlation coefficient value of the airflow variable is 0.172. This shows that the lighting variable has a very weak correlation or relationship with the SBS symptoms experienced by the respondents. Indoor lighting factors can affect SBS because light can affect humans' psychological and physiological conditions. Although lighting levels do not directly affect SBS symptoms in all individuals, poor lighting conditions in the long term can harm the overall well-being and productivity of room users.

In addition, Table 3 also shows that the air pollution variable has a significance value of 0.997. This significance value indicates that there is not enough evidence to reject the null hypothesis so there is no significant relationship between air pollution and sick building syndrome experienced by building users or the null hypothesis fails to be rejected. In addition, based on Table 3 it is known that the correlation coefficient value of the airflow variable is 0.009. This shows that the air pollution variable has a very weak correlation or relationship with the SBS symptoms experienced by the respondents. It is possible that in a population, dust, and dirt do not affect SBS symptoms because there are respondents who do not feel the effects of SBS due to dust and dirt in the room because everyone has a different tolerance for these factors.

4 Conclusion

Based on data obtained from respondents' assessments or perceptions regarding IAQ and SBS symptoms in the Rectorate Building of State University of Malang, it is known that respondents are most disturbed by dry air conditions, indoor cigarette smoke, and noise levels

in the workspace. Furthermore, based on the results of cross-tabulation tests on the independent and dependent variables in this study, it is known that all independent variables have no significant relationship with the SBS symptoms experienced by the respondents and all independent variables have a very weak correlation or relationship with the SBS symptoms experienced by the respondents. In addition, from 80 respondents, 27 people (33.75%) experienced SBS and 53 people (66.25%) did not experience SBS.

The authors are very grateful and gives a great appreciation to the Institute of Research and Community Services (LP2M) *Universitas Negeri Malang* (UM) for providing fund support and administrative assistance for the research.

References

1. B. Talarosha and V. Rosardy, in (2018), pp. 137–144.
2. G.S. Graudenz, C. Oliveira, A. Tribess, C. Mendes Jr, M. Latorre, and J. Kalil, Indoor Air **15**, 62 (2005).
3. J.L. Brożek, J. Bousquet, I. Agache, A. Agarwal, C. Bachert, S. Bosnic-Anticevich, R. Brignardello-Petersen, G.W. Canonica, T. Casale, and N.H. Chavannes, Journal of Allergy and Clinical Immunology **140**, 950 (2017).
4. Z.A. Zainal, Z. Hashim, J. Jalaludin, L.F. Lee, and J.H. Hashim, Malaysian Journal of Medicine & Health Sciences **15**, (2019).
5. A. Cincinelli and T. Martellini, International Journal of Environmental Research and Public Health **14**, 1286 (2017).
6. S. Jafakesh, L. Mirhadian, Z. Atrkar Roshan, and M.J. Gol Hosseini, J. Holist. Nurs. Midwifery **29**, 23 (2019).
7. E. Tsantaki, E. Smyrnakis, T.C. Constantinidis, and A. Benos, International Journal of Environmental Health Research **32**, 595 (2022).
8. İ. Akova, E. Kiliç, H. Sümer, and T. Keklikçi, International Journal of Environmental Health Research **32**, 1204 (2022).
9. T.-Q. Thach, D. Mahirah, G. Dunleavy, N. Nazeha, Y. Zhang, C.E.H. Tan, A.C. Roberts, G. Christopoulos, C.K. Soh, and J. Car, Building and Environment **166**, 106420 (2019).
10. T. Lindgren and D. Norbäck, Indoor Air **15**, 65 (2005).
11. I. Arikan, Ö.F. Tekin, and O. Erbas, La Medicina Del Lavoro **109**, 435 (2018).