Investigation of Airflow Movement towards Healthy Homes Requirement in The Post Pandemic Era

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Abstract. The Covid-19 pandemic has brought lessons, especially in terms of preparedness for a future pandemic. Hospitals are overflowing with infected patients. At the peak of the Covid-19 pandemic, homes became self-isolation facilities due to inadequate healthcare facilities. Therefore, it is crucial to conduct research to investigate and prepare homes that lack ventilation. This study investigated air movement through windows and their configuration. The investigation focused on air movement in space to reduce transmission rates and better prepare homes for future pandemics. This study used quantitative methods with statistical analysis of measurement results from several sample houses located in two urban villages in Jakarta. The study was conducted in small to medium-sized landed houses. The aim was to identify patterns of relationships between climatological elements and their influence on air movement in a room through windows. The research results indicate that no correlation between the variables has been found. Statistical analysis revealed that the data for several combinations of tested variables were not normally distributed. Therefore, this research is continue to find an appropriate analysis model.

Keywords: Ventilation, Windows Configuration, Airflow

1 Introduction

1.1 Background

The Covid-19 pandemic has brought about major changes to the function of homes. These changes include: changing spaces for working [1] or studying from home, creating healthier spaces for self-isolation, and adapting spaces to anticipate new needs. The pandemic has changed ways of life [2], further necessitating the need to adapt homes to respond to similar disasters in the future.

A home with good air circulation and sufficient sunlight meets the requirements for isolation during a pandemic [3]. However, special attention to the dimensions and position of openings is crucial, and the intensity of sunlight entering the room can be optimize [4]. Meanwhile, air exchange can reduce droplet concentration [5] and reduce humidity generated by room occupants [6]. This is also supported by statements that

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utilize the flow and supply of clean air into a room to suppress the spread of the virus [7], [8]. Therefore, openings in residential homes must meet these requirements.
When a house is in its original standard condition, the need for openings and air exchange within the building is still met. However, problems arise when the house is expanded. The expansion is carried out horizontally to maximize the land area, or vertically by adding more floors. The impact of this expansion is thought to be due to neglecting the openings in the house. This is because houses in a row layout have limitations in creating openings on the left and right sides of the building.
Research in tropical climate areas [9] shows that climate indicators (temperature, rainfall, RH, and wind) have a negative correlation, while poor indoor air quality is correlated with the increase in daily cases. Research in Brazil argues the opposite, that high rainfall increases the transmission rate [10]. Research in Singapore [11] shows that the presence of RH and water vapor increases the transmission rate, while ventilation and air speed help reduce transmission. In addition, the influence of climate interaction with openings is also closely related to the lighting aspect [12] and the influence of sunlight on health [13], [14].

Discussion on the interaction of natural ventilation and Covid19 transmission in addition to ventilation as a suppressant of transmission [15], [16], [17], [18], [19]. Residential homes become quarantine facilities that are quite equal to hospital quarantine facilities [20], so it is necessary to evaluate the openings of residential homes [21]. As the contribution of openings in order to improve health [22] both from the aspect of visual comfort and psychological aspects.

Research with a home locus in Jakarta, with an indoor air movement approach using climatological aspect parameters in tropical regions and health requirements in the post-pandemic era, processed into a model with opening scenarios and configurations to be better prepared for the possibility of similar incidents in the future.

1.2 Literature Review

Investigations were conducted on each residence, so that strategies for openings and their configurations could be developed. The home, as a means of self-isolation, plays a role in preventing the transmission of disease to all age groups within a family [23]. Frick stated that buildings in tropical regions should be constructed openly with sufficient space to allow for air movement, and this is starting to be overlooked[24]. Air movement is an important aspect for tropical regions to achieve thermal comfort. If air movement of 0.5 m/s occurs in a room with a temperature of 25°C, the body will feel 1°C cooler, if air movement of 1 m/s, the body will feel 3°C cooler.

The rate of air movement through natural ventilation is considered to have a positive impact in preventing transmission and is considered necessary for modeling the spread of the virus [25], [26]. Several studies have stated that as long as there is interaction with confirmed positive patients, transmission will continue [27], [28], [29]. However, the rate of air exchange generated by natural ventilation with a magnitude of 0.71 m/s - 1.172 m/s horizontally is able to reduce virus transmission [30].

2 Method

This study used quantitative methods to identify variables that influence indoor air exchange. Measurement samples were taken in homes used for self-isolation. As a limitation, the residences used in the measurement samples were small to medium of house type. The east-west orientation of the houses becomes the limitation of this study. Data collection was conducted between 8:00 a.m. and 4:00 p.m. Western Indonesian Time (WIB), when the ventilation was open. Temperature, relative humidity, wind speed, and the area and configuration of openings were collected from the research units. The research steps were as follows:

1. Data on temperature, relative humidity, wind speed, and opening area and configuration were collected from the research units.
2. The data generated through the measurement process was then organized into research variables.
3. The collected variables were analyzed using two-way ANOVA.
4. Statistical analysis aimed to identify patterns of relationships between variables. Statistical analysis was performed using SPSS 26.

The research instruments used in this study include:

a. Hotwire anemometer Lutron AM-4234SD, for indoor data collection.
b. Anemometer Lutron AM-4207SD, for outdoor data collection.

Outdoor measurements were conducted by placing an anemometer in front of a window (Figure 1(a)). The goal was to collect air velocity and temperature data from outside the building. The sensor was placed on a tripod perpendicular to the horizontal wind direction. The device was set to record measurements every 10 minutes from 8:00 AM to 4:00 PM WIB. Each house under study was measured for two days. The measuring device recorded 49 data points per day.

Fig. 1. (a) Anemomoter Sensor Position, and the data recorder, (b) Anemometer Hotwire Sensor Position and the data recorder

Indoor measurements are taken by placing a hotwire anemometer inside the room, near a window (Figure 1(b)). The goal is to collect air velocity and temperature data inside the room. The sensor is placed where the wind enters the room through the window. Here's the scheme of the research (Figure 2):

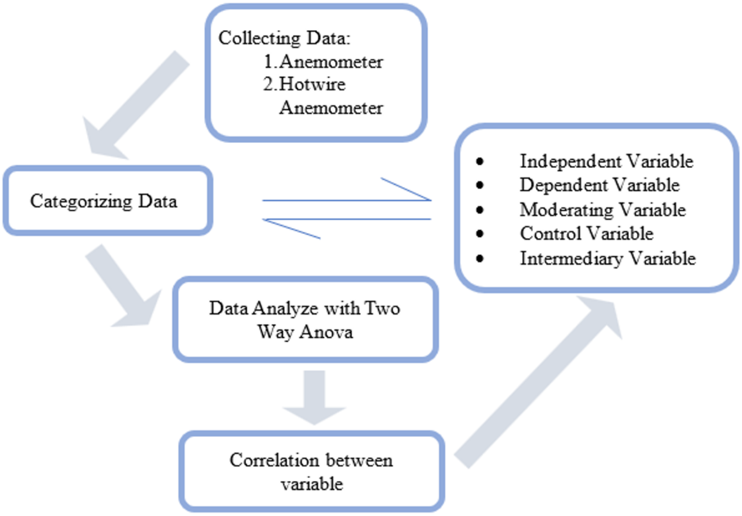


Fig. 2. Schematic overview of research implementation

3 Result and Discussion

Physical data from the six sample houses include: bedroom area, opening area, bedroom volume, house orientation, window type, door type, and ventilation configuration (Table 1). Two types of windows are found in the samples: top-hinged windows and side-hinged windows. Two types of doors are found in the samples: sliding doors and side-hinged doors.

Table 1. The physical data of the sample.

	Orientation	Room Area (m2)	Room Volume (m3)	Window Type	Window Size	Door Type	Door Size	W-D Configuration
A	West	7.50	22.50	Side-Hinge Window	0.97	Sliding Door	1.89	L Config.
B	West	9.00	27.00	Side-Hinge Window	3.63	Side-Hinge Door	1.98	Parallel Config.

C	East	6.71	18.79	Up-Hinge Window	0.51	Side-Hinge Door	1.70	Parallel Config.
D	West	8.26	24.87	Up-Hinge Window	2.03	Side-Hinge Door	1.84	Parallel Config.
E	East	18.20	50.96	Up-Hinge Window	0.72	Side-Hinge Door	1.49	L Config.
F	East	8.16	22.85	Up-Hinge Window	1.16	Side-Hinge Door	1.68	Parallel Config.

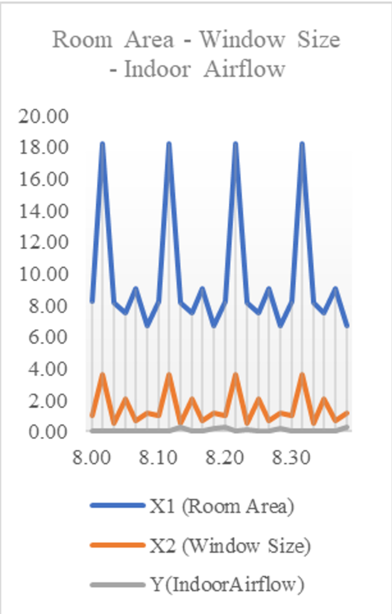
The total number of data recorded for one house per day is 49. For a two-day measurement period, the total is 98. Therefore, the data is presented in each combination of variables suspected to be related.

Data collection was carried out by placing the two measuring instruments as shown in the house plan below:

Fig. 3. Layout of the Research Object with Measurement Points, ● Position of Anemometer and ● Position of Hotwire Anemometer

This study involved nine variables suspected of influencing the rate of air movement within a space. These variables are room area, room volume, building orientation, door type, door size, window type, window size, door-window configuration, indoor temperature, and outdoor temperature. The nine variables were arranged in the following combinations:

a. Test the variables of Room Area as X1, Window Size as X2, and Indoor Airflow as Y (Fig. 4a). Research question of this combination: is there a difference in indoor airflow in the bedroom based on the room's area and window size?



Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Standardized Residual for Indoor Airflow	.126	588	.000	.884	588	.000

One-Sample Kolmogorov-Smirnov Test

		X1_RoomArea	X2_WindowArea	Y_IndoorAirflow
N		588	588	588
Normal Parameters[a,b]	Mean	9.6383	1.5193	.125428
	Std. Deviation	3.89652	1.07867	.1529217
Most Extreme Differences	Absolute	.398	.290	.208
	Positive	.398	.290	.158
	Negative	-.226	-.175	-.208
Test Statistic		.398	.290	.208
Asymp. Sig. (2-tailed)		.000[c]	.000[c]	.000[c]

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		588
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	.13890409
Most Extreme Differences	Absolute	.136
	Positive	.136
	Negative	-.085
Test Statistic		.136
Asymp. Sig. (2-tailed)		.000[c]

Fig. 4. (a) Graphic data of room area as X1, window size as X2, and indoor airflow as Y. (b, c, d) The result of room area, window size, and indoor airflow analysis.

In the Two-Way Anova test, data must pass the Normality Test. The results of the variable test above show a significance level of <0.05, indicating that the data is not normally distributed (Fig. 4b, 4c, and 4d). Data transformation can be performed by examining the histogram of each variable.

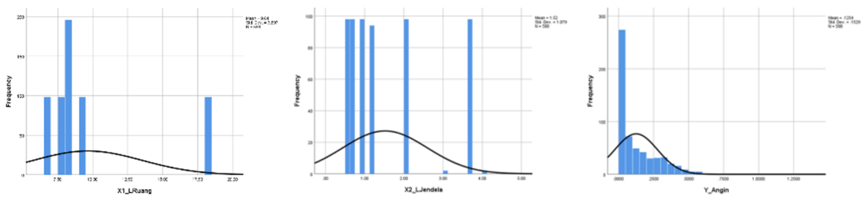


Fig. 5. (a) Histogram of room area (b) Histogram of window size, and (c) Histogram of indoor airflow.

The shape of the variable histogram graph shows a tendency towards the bottom left or moderate positive skewness (Fig. 5a, 5b, and 5c), so the transformation used is SQRT.

One-Sample Kolmogorov-Smirnov Test

		SQRT_X1	SQRT_X2	SQRT_Y
N		588	588	588
Normal Parameters[a,b]	Mean	3.0543	1.1645	.2812
	Std. Deviation	.55695	.40440	.21545
Most Extreme Differences	Absolute	.372	.245	.155
	Positive	.372	.245	.155
	Negative	-.202	-.137	-.125
Test Statistic		.372	.245	.155
Asymp. Sig. (2-tailed)		.000[c]	.000[c]	.000[c]

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.

One-Sample Kolmogorov-Smirnov Test

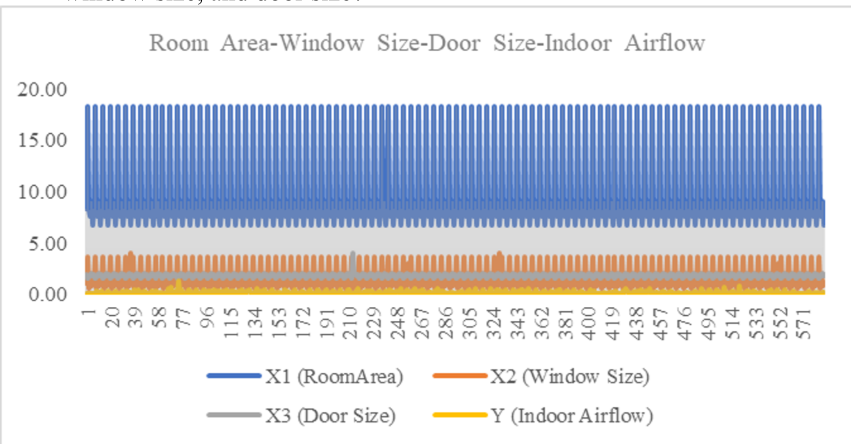
		Unstandardized Residual
N		588
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	.19018700
Most Extreme Differences	Absolute	.064
	Positive	.064
	Negative	-.047
Test Statistic		.064
Asymp. Sig. (2-tailed)		.000[c]

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.

Fig. 6. (a, b) The result of normality test after the SQRT data transform

The data normality test for the variables room area, window area, and indoor air temperature was stopped. The two-way ANOVA test must pass two tests: a normality test and a homogeneity test (Fig. 6a, 6b). Even after data transformation, the significance value remained < 0.05.

b. Test the variables of Room Area as X1, Window Size as X2, Door Size as X3, and Indoor Airflow as Y (Fig 7a). Research question of this combination: is there a difference in indoor airflow in the bedroom based on the room's area window size, and door size?



Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Standardized Residual for Y_IndoorAirflow	.126	588	.000	.884	588	.000

One-Sample Kolmogorov-Smirnov Test

		X1_RoomArea	X2_WindowSize	X3_DoorSize	Y_IndoorAirflow
N		588	588	588	588
Normal Parameters[a,b]	Mean	9.6383	1.5193	1.7633	.125428
	Std. Deviation	3.89652	1.07867	.16062	.1529217
Most Extreme Differences	Absolute	.398	.290	.183	.208
	Positive	.398	.290	.153	.158
	Negative	-.226	-.175	-.183	-.208
Test Statistic		.398	.290	.183	.208
Asymp. Sig. (2-tailed)		.000[c]	.000[c]	.000[c]	.000[c]

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		588
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	.13732967
Most Extreme Differences	Absolute	.133
	Positive	.133
	Negative	-.102
Test Statistic		.133
Asymp. Sig. (2-tailed)		.000[c]

Fig. 7. (a) Graphic data of room area as X1, window size as X2, door size as X3 and indoor airflow as Y. (b, c, d) The result of statistics analysis.

The results show that the significance level is <0.05, indicating that the data is not normally distributed (Fig. 7b, 7c, and 7c). Next, the diagrams for each variable are checked to proceed with the data transformation process:

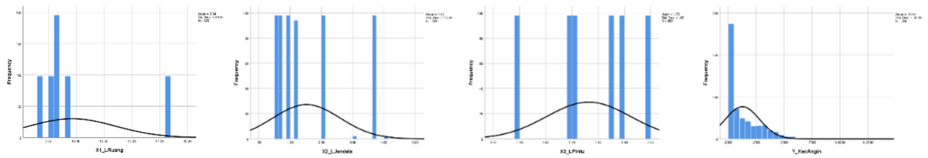


Fig. 8. (a) Histogram of room area (b) Histogram of window size, (c) Histogram of door size, and (d) Histogram of indoor airflow.

The histograms of each variable showed a tendency to the lower left, or moderate positive skewness (Fig. 8a, 8b, 8c, and 8d). Therefore, SQRT was used for transformation. The results were then tested for normality. After going through the normality test, the significance result remained zero (Fig. 9a, 9b).

One-Sample Kolmogorov-Smirnov Test

		SQRT_X1	SQRT_X2	SQRT_X3	SQRT_Y
N		588	588	588	588
Normal Parameters[a,b]	Mean	3.0543	1.1645	1.3265	.2812
	Std. Deviation	.55695	.40440	.06111	.21545
Most Extreme Differences	Absolute	.372	.245	.188	.155
	Positive	.372	.245	.145	.155
	Negative	-.202	-.137	-.188	-.125
Test Statistic		.372	.245	.188	.155
Asymp. Sig. (2-tailed)		.000[c]	.000[c]	.000[c]	.000[c]

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		588
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	.18852623
Most Extreme Differences	Absolute	.068
	Positive	.068
	Negative	-.049
Test Statistic		.068
Asymp. Sig. (2-tailed)		.000[c]

Fig. 9. (a, b) The result of normality test after the SQRT data transform

c. Test the variables of Outdoor Airflow as X1, Window Size as X2, and Indoor Airflow as Y (Fig. 10). Research question of this combination: Is there a difference in indoor airflow in the bedroom based on the outdoor airflow and window size?

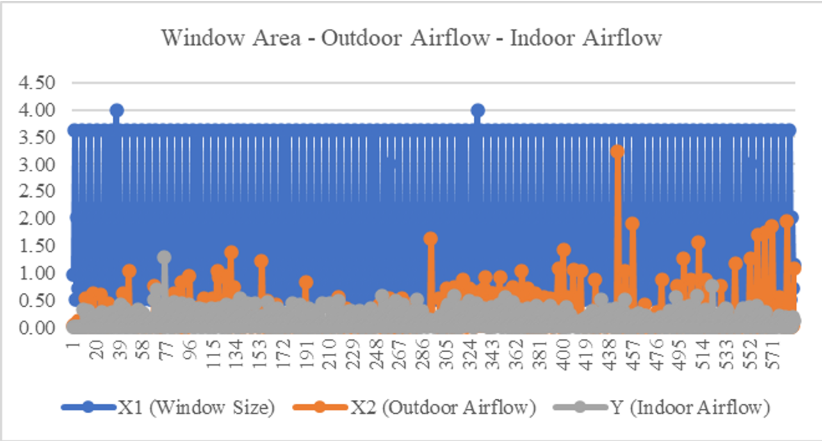


Fig. 10. Graphic data of window size as X1, outdoor airflow as X2, and indoor airflow as Y.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Standardized Residual for Y_Angin	.412	588	.000	.412	588	.000

One-Sample Kolmogorov-Smirnov Test

		X1_SuhuDalam	X2_SuhuLuar	Y_Angin
N		588	588	588
Normal Parameters[a,b]	Mean	30.6663	31.2451	.125428
	Std. Deviation	2.76591	3.36719	.1529217
Most Extreme Differences	Absolute	.096	.071	.208
	Positive	.096	.071	.158
	Negative	-.047	-.029	-.208
Test Statistic		.096	.071	.208
Asymp. Sig. (2-tailed)		.000[c]	.000[c]	.000[c]

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		588
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	.14529194
Most Extreme Differences	Absolute	.159
	Positive	.159
	Negative	-.127
Test Statistic		.159
Asymp. Sig. (2-tailed)		.000[c]

Fig. 11. (a, b, and c) The result of normality test.

The test data did not pass the data normality test (Fig. 11a, 11b, and 11c), then the variable histogram graph was checked.

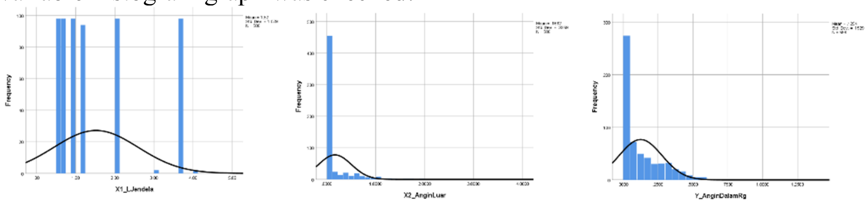


Fig. 12. (a) Histogram of window size; (b) Histogram of outdoor airflow; and (c) Histogram of indoor airflow.

From the histogram graph (Fig. 12a, 12b, and 12c), it shows a tendency to the lower left or moderate positive skewness, so the data is transformed using SQRT.

One-Sample Kolmogorov-Smirnov Test

		SQRT_X1	SQRT_X2	SQRT_Y
N		588	588	588
Normal Parameters[a,b]	Mean	1.1645	.2974	.2812
	Std. Deviation	.40440	.27908	.21545
Most Extreme Differences	Absolute	.245	.333	.155
	Positive	.245	.333	.155
	Negative	-.137	-.170	-.125
Test Statistic		.245	.333	.155
Asymp. Sig. (2-tailed)		.000[c]	.000[c]	.000[c]

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		588
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	.18180398
Most Extreme Differences	Absolute	.056
	Positive	.056
	Negative	-.030
Test Statistic		.056
Asymp. Sig. (2-tailed)		.000[c]

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.

Fig. 13. (a, b) The result of normality test after the SQRT data transform.

The significance results show that the data are not normally distributed (Fig. 13a, and 13b), because the value is <0.05.

d. Test the variables of Indoor Temperature as X1, Outdoor Temperature as X2, and Indoor Airflow as Y (Fig. 14a). Research question of this combination: is there a difference in indoor airflow in the bedroom based on the outdoor temperature and indoor temperature?

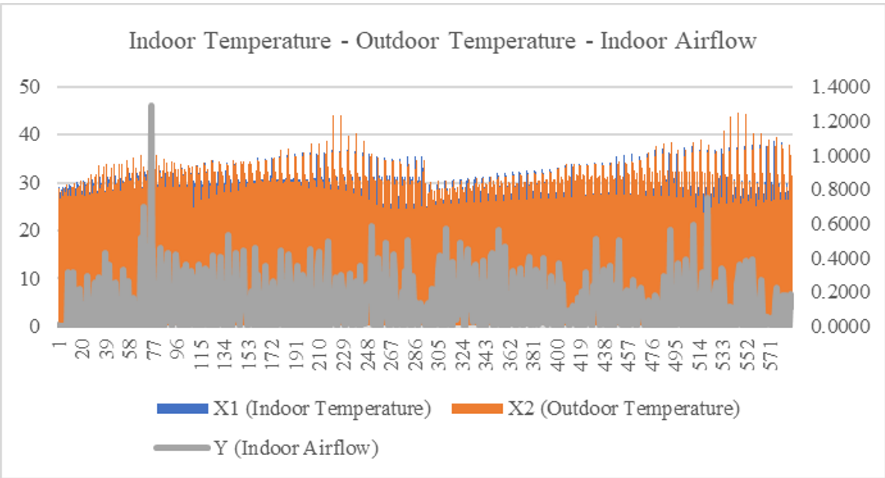


Fig. 14. (a) Graphic data of Indoor Temperature as X1, Outdoor Temperature as X2, and indoor airflow as Y. (b, c) The result of statistics analysis.

Since the data had not passed the normality test (Fig. 14b, and 14c), the histograms of each variable were examined. The histograms showed a substantial tendency for positive skewness (Fig 15a, 15b, and 15c), so the natural logarithm (LN) was used to confirm the data transformation.

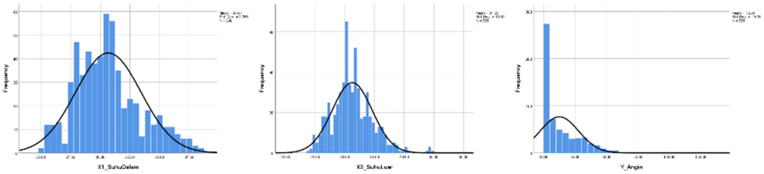


Fig. 15. (a) Histogram of indoor temperature; (b) Histogram of outdoor temperature; and (c) Histogram of indoor airflow.

One-Sample Kolmogorov-Smirnov Test

		LN_X1	LN_X2	LN_Y
N		588	588	588
Normal Parameters[a,b]	Mean	1.4849	1.4923	-1.4544
	Std. Deviation	.03858	.04595	.85920
Most Extreme Differences	Absolute	.079	.051	.158
	Positive	.079	.051	.158
	Negative	-.040	-.042	-.137
Test Statistic		.079	.051	.158
Asymp. Sig. (2-tailed)		.000[c]	.001[c]	.000[c]

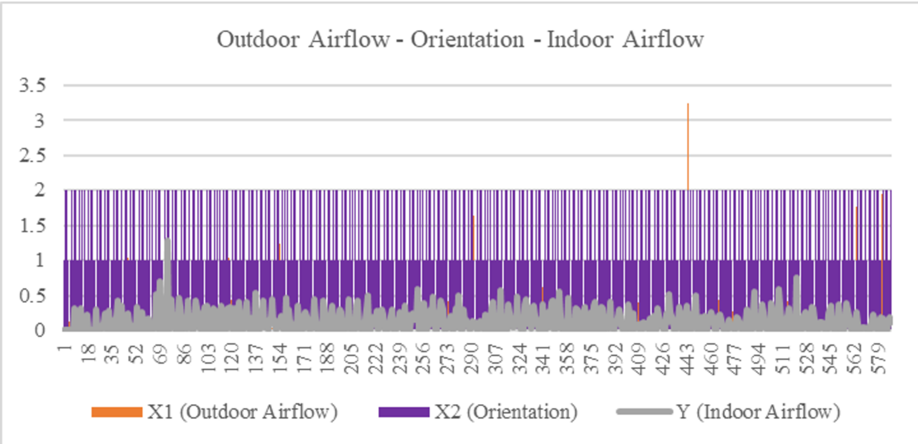
One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		588
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	.80369317
Most Extreme Differences	Absolute	.103
	Positive	.103
	Negative	-.102
Test Statistic		.103
Asymp. Sig. (2-tailed)		.000[c]

Fig. 16. (a, b) The result of normality test after the LN data transform.

The analysis results show that the data is not normally distributed. However, there has been an increase in the significance value of 0.001 (Fig. 16a, 16b), although the value remains <0.05.

e. Test the variables of Outdoor Airflow as X1, House Orientation as X2, and Indoor Airflow as Y (Fig. 17a). Research question of this combination: is there a difference in indoor airflow in the bedroom based on the outdoor airflow and house orientation?



One-Sample Kolmogorov-Smirnov Test

		X1_AnginLuar	X2_Orientasi	Y_Angin
N		588	588	588
Normal Parameters[a,b]	Mean	.1662	1.50	.125428
	Std. Deviation	.33589	.500	.1529217
Most Extreme Differences	Absolute	.362	.341	.208
	Positive	.362	.341	.158
	Negative	-.311	-.341	-.208
Test Statistic		.362	.341	.208
Asymp. Sig. (2-tailed)		.000[c]	.000[c]	.000[c]

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Standardized Residual for Y_Angin	.335	588	.000	.617	588	.000

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		588
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	.14930278
Most Extreme Differences	Absolute	.164
	Positive	.164
	Negative	-.160
Test Statistic		.164
Asymp. Sig. (2-tailed)		.000[c]

Fig. 17. (a) Graphic data of Outdoor Airflow as X1, Orientation as X2, and indoor airflow as Y. (b, c, and d) The result of statistics analysis.

The results of the normality test indicate that the data is not normally distributed, as the significance value is <0.05 (Fig. 17b, 17c, and 17d). Next, data transformation is carried out based on the histogram graph of each variable.

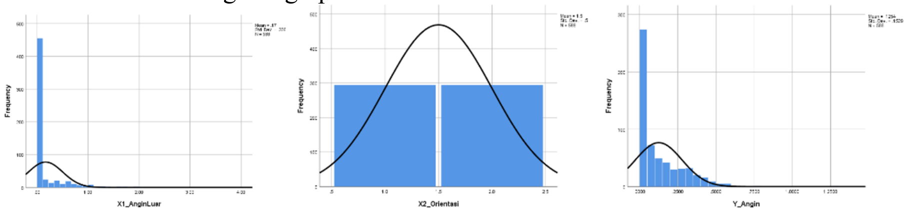


Fig. 18. (a) Histogram of outdoor airflow; (b) Histogram of orientation; and (c) Histogram of indoor airflow.

From the histogram graph (Fig 18a, 18b, and 18c), the transformation form used is SQRT, because the graph tends to have moderate positive skewness.

One-Sample Kolmogorov-Smirnov Test

		SQRT_X1	SQRT_X2	SQRT_Y
N		588	588	588
Normal Parameters[a,b]	Mean	.2974	1.2071	.2812
	Std. Deviation	.27908	.20728	.21545
Most Extreme Differences	Absolute	.333	.341	.155
	Positive	.333	.341	.155
	Negative	-.170	-.341	-.125
Test Statistic		.333	.341	.155
Asymp. Sig. (2-tailed)		.000[c]	.000[c]	.000[c]

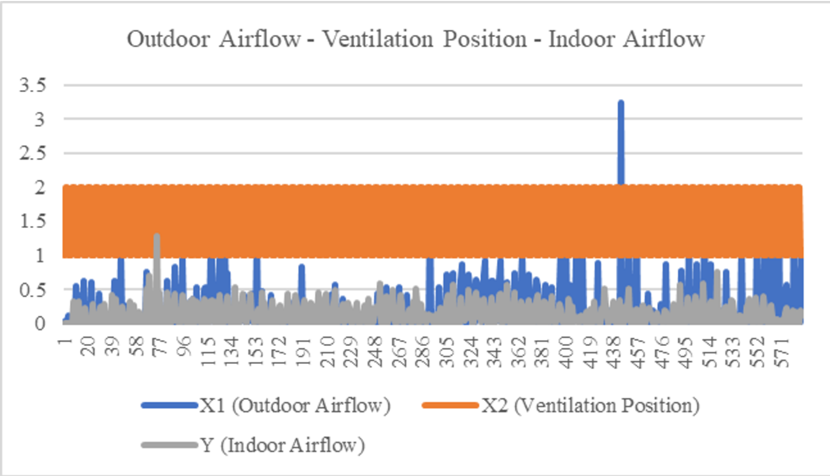
One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		588
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	.20559660
Most Extreme Differences	Absolute	.145
	Positive	.145
	Negative	-.097
Test Statistic		.145
Asymp. Sig. (2-tailed)		.000[c]

Fig. 19. (a, b) The result of normality test after the SQRT data transform.

From this combination of variable tests, it also has not passed the data normality test because the significance value after data transformation remains <0.05 (Fig. 19a, 19b).

f. Test the variables of Outdoor Airflow as X1, Ventilation Configuration as X2, and Indoor Airflow as Y (Fig. 20a). Research question of this combination: is there a difference in indoor airflow in the bedroom based on the outdoor airflow and ventilation configuration?



Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Standardized Residual for Y_Airflow	.327	588	.000	.609	588	.000

One-Sample Kolmogorov-Smirnov Test

		X1_AnginLuar	X2_Configuration	Y_Airflow
N		588	588	588
Normal Parameters[a,b]	Mean	.1662	1.5000	.125428
	Std. Deviation	.33589	.50043	.1529217
Most Extreme Differences	Absolute	.362	.341	.208
	Positive	.362	.341	.158
	Negative	-.311	-.341	-.208
Test Statistic		.362	.341	.208
Asymp. Sig. (2-tailed)		.000[c]	.000[c]	.000[c]

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		588
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	.14219349
Most Extreme Differences	Absolute	.163
	Positive	.163
	Negative	-.101
Test Statistic		.163
Asymp. Sig. (2-tailed)		.000[c]

Fig. 20. (a) Graphic data of Outdoor Airflow as X1, Ventilation position as X2, and indoor airflow as Y. (b, c, and d) The result of statistics analysis.

The results of the normality test indicate that the data is not normally distributed (Fig. 20b, 20c, and 20d). Another step is to transform the data by first observing the shape of the variable's histogram (Fig 21a, 21b, and 21c).

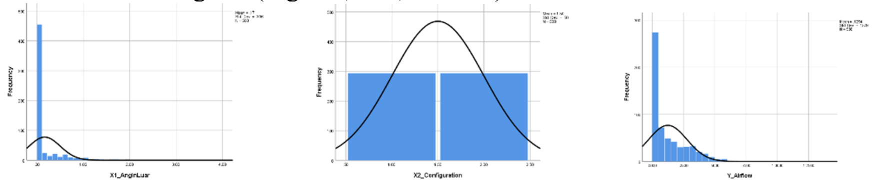


Fig. 21. (a) Histogram of outdoor airflow; (b) Histogram of ventilation position; and (c) Histogram of indoor airflow.

One-Sample Kolmogorov-Smirnov Test

		SQRT_X1	SQRT_X2	SQRT_Y
N		588	588	588
Normal Parameters[a,b]	Mean	.2974	1.2071	.2812
	Std. Deviation	.27908	.20728	.21545
Most Extreme Differences	Absolute	.333	.341	.155
	Positive	.333	.341	.155
	Negative	-.170	-.341	-.125
Test Statistic		.333	.341	.155
Asymp. Sig. (2-tailed)		.000[c]	.000[c]	.000[c]

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		588
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	.19406906
Most Extreme Differences	Absolute	.127
	Positive	.127
	Negative	-.060
Test Statistic		.127
Asymp. Sig. (2-tailed)		.000[c]

Fig. 22. (a, b) The result of normality test after the SQRT data transform.

The analysis results still show a significance value <0.05 or the data is not normally distributed (Fig. 22a, 22b).

The six variable combinations failed the data normality test. To determine the correlation between variables, a normality test and subsequent homogeneity test are required. However, the analysis above indicates that the data normality test was also unsuccessful. Then the following questions arise from the results of the statistical analysis:

1. Why the data did not pass the normality test?
2. Does the magnitude of the indoor airflow in the range of 0.03 - 0.1 affect the data testing process?
3. Are there any other test models that are capable of processing this data?

Thus, this research has not achieved its objectives. Further data analysis is still required. This research requires an analysis model that is appropriate to the data.

4 Conclusion

Based on the results of the Two-Way ANOVA analysis with a combination of variables suspected of influencing the rate of air movement in the room, the analysis stopped at the normality test stage. It is possible that the correlation test between variables failed due to data with values <0.01. This assumption is due to the predominance of Indoor Airflow (Y) measurement data below 0.01. The initial goal of this study was to identify variables influencing the rate of air movement in the room.

However, it could also mean that the data analysis model used may not be appropriate for data with values <0.01. In the future, this research needs to find an appropriate data testing method that can account for small data values.

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