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## The Ventilation-to-area Ratio and House Lighting Relate to the Incidence of Pulmonary Tuberculosis

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### Abstract

**Background:** Indonesia is one of the heavy burden countries with high pulmonary tuberculosis incidence in the world. The physical condition of houses is one of the environmental factors on how the infection spreads. The objective of this study was to provide supporting facts between the physical environment of the houses and the incidence of pulmonary tuberculosis.

**Methods:** This was an observational analytic study with a case-control design, using checklists among pulmonary tuberculosis patients (n 32) and their healthy controls (n 32). Study subjects were chosen by simple random sampling. The study was performed from March to August 2019 at the Public Health Center (Pusat Kesehatan Masyarakat, Puskesmas) in Sawahan district, Surabaya. The incidence of pulmonary tuberculosis was related to various factors, including window existence, window opening habit, ventilation-to-area ratio, humidity, temperature, lighting, and occupancy density. The collected data were analyzed using the chi-square test to assess statistical significance with a p-value <0.05 was considered significantly related.

**Results:** The ventilation-to-area ratio (p<0.05) and house lighting (p<0.00) were related to pulmonary tuberculosis incidence, whereas other factors such as window existence, window opening habit, temperature, and occupancy density were not.

**Conclusions:** The ventilation-to-area ratio and house lighting have been proven to be related to pulmonary tuberculosis incidence. Government regulation on building permit needs to be encouraged to reduce the spreading and the incidence of pulmonary tuberculosis.

**Keywords:** House lighting, pulmonary tuberculosis, ventilation-to-area ratio

### 1 Introduction

Tuberculosis is an airborne disease caused by *Mycobacterium tuberculosis* and still a problematical disease for public health.<sup>1</sup> In Indonesia, East Java Province has a high prevalence of pulmonary tuberculosis, second after West Java Province.<sup>2</sup> The Sawahan Public Health Center (*Pusat Kesehatan Masyarakat*, Puskesmas) covers areas of Sawahan and Petemon Sub-district in Sawahan District, one of 31 districts in Surabaya, and being 3<sup>rd</sup> among the districts with a high number of incidence.<sup>3</sup>

There are many ways of prevention of tuberculosis, that have been conducted by the government and nonprofit organizations,

also directed by the local community groups. The prevention of tuberculosis that has been carried out includes a free obligatory BCG vaccination, free antituberculosis drugs and mask for the patients, and many other workshops to enhance the knowledge of tuberculosis infection. However, tuberculosis prevention of environmental and behavioral aspects seem to be lacking, especially when it comes to how to live healthy and have a healthy house. The criteria of healthy houses have been written in the Decree of the Ministry of Health of Indonesia, mentioning that a house has to be reviewed from the building material, components and layout, lighting, air quality, ventilation, water, food storage, waste, and also

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the occupancy density.<sup>4</sup> Therefore, this study was conducted to identify the relationship between the incidence of tuberculosis and the physical condition of houses, such as window existence, window opening habit, ventilation-to-area ratio, humidity, temperature, lighting, and occupancy density. The result of this study is expected to be able to assess the importance of the physical condition of healthy houses in reducing tuberculosis incidence.

## Methods

This was an analytic observational case-control study, conducted after obtaining approval from three authorities including the National Unity and Politics Agency (*Badan Kesatuan Bangsa dan Politik, Bakesbangpol*) Surabaya, the Surabaya Health Department, and the Health Research Ethics Committee of the Faculty of

**Table 1 Standard of the Healthy House According to the Decree of Ministry of Health of Republic of Indonesia<sup>5</sup>**

Variables	Standard
Window existence	Yes
Window opening habit	Yes
Occupancy density	>8m <sup>2</sup> /people
Ventilation-to-area ratio	10%
Humidity	40-60% Rh
Temperature	18-30°C
Lighting	>60 lux

Note: Rh: Relative humidity

Medicine, Universitas Airlangga, Surabaya. A total of 32 pulmonary tuberculosis patients of *Puskesmas* Sawahan from January 2018 to July 2019 were collected by simple random

**Table 2 House Condition among Pulmonary Tuberculosis Patients Compared to Controls**

Variable	Case		Control		OR (95% CI)	p-value*
	n(%)	mean±SD	n(%)	mean±SD		
Window existence						
Yes	25(78.1)		28(87.5)		2.778 (0.933-8.270)	0.320
No	7(22.9)		4(12.5)			
Window opening habit						
Yes	18(56.3)		25(78.1)		1.000 (0.060-16.713)	0.062
No	14(43.8)		7(22.9)			
Occupancy density (people/m <sup>2</sup> )		13.2±11		15.4±13.3		
≥8 people/m <sup>2</sup>	21(65.6)		23(71.9)		1.152 (0.405-3.275)	0.790
<8 people/m <sup>2</sup>	11(14.4)		9(28.1)			
Ventilation-to-area ratio (%)		4.3±4.4		7.4±6.7		
≥10%	2(6.3)		9(28.1)		5.870 (1.155-29.826)	0.020**
<10%	30(93.8)		23(71.9)			
Humidity (% Rh)		55.2±5.8		53.6±6.3		
40-60% Rh	25(78.1)		28(87.5)		0.802 (0.218-2.954)	0.740
<40% Rh or >60% Rh	7(22.9)		4(12.5)			
Temperature (°C)		33±0.8		33.1±1.1		
18-30°C	-		-			
<18°C or >30°C	32(100)		32(100)			
Lighting (lux)		30.8±27.9		75±41.1		
>60 lux	3(9.4)		22(68.3)		21.267 (5.222-86.601)	0.000**
<60 lux	29(90.6)		10(11.8)			

Note: \*Pearson's chi-square, \*\*statistically significant, SD: Standard Deviation; OR: Odds Ratio; CI: Confidence Interval; Rh: Relative humidity

**Table 3 Humidity and temperature in Surabaya City from March to August 2017<sup>10</sup>**

Month	Perak I Measuring Station		Juanda Measuring Station		Average	
	Humidity (% Rh)	Temperature (°C)	Humidity (% Rh)	Temperature (°C)	Humidity (% Rh)	Temperature (°C)
March	75	33.3	55	34	65	33.7
April	71	33.5	56	34.4	63.5	34
May	62	33.8	46	34	54	33.9
June	64	32.7	46	34	55	33.4
July	65	33.1	46	33	55.5	33.1
August	31	33.5	42	32	36.5	32.8
		Average			54.9	33.5

Note: Rh: Relative humidity

sampling. Healthy controls were selected, recruited from one of the 3 houses next to the cases. Only those who agreed on being a study subject were included. Observational checklists were distributed to assess the various physical condition including window existence, window opening habit, and occupancy density. As for the ratio of ventilation-to-area, humidity, temperature, and lighting were measured by the researchers during house visits with meter roll, hygrometer, thermometer, and lux meter, respectively. The standard of a healthy house was defined according to the Decree of the Ministry of Health of the Republic of Indonesia (Table 1). The collected data were analyzed using the chi-square test to assess statistical significance with a p-value <0.05 considered as significantly related.

### Results

In total, houses of 32 pulmonary tuberculosis patients and their healthy controls were assessed, and compared to the standard of healthy house, defined according to the Decree of Ministry of Health of Republic of Indonesia (Table 1).

Most of the subjects were aware of window existence (53 of 64) in their homes and opened it frequently (43 of 64). However, most of the cases were not aware of the importance of ventilation (30 of 32) and lighting (29 of 32) in their house. Window existence, window opening habit, temperature, and occupancy density were not related to pulmonary tuberculosis incidence (p>0.05). Interestingly, the ratio of ventilation-to-area (p<0.05) and house lighting (p<0.00) were related to pulmonary tuberculosis incidence (Table 2).

Moreover, data on the temperature and humidity in Surabaya during the period of March and August 2019 were collected from two Measuring Stations in Perak I and Juanda, showing that most humid percentages was in March (65%) and the lowest was in August (36.5%); whereas the temperature was stable over time (Table 3).

### Discussion

This study has assessed the relationship between the incidence of tuberculosis and the physical condition of the houses such as window existence, window opening habit, occupancy density, ventilation-to-area ratio, humidity, temperature, and lighting. The majority of the pulmonary tuberculosis patients and the healthy controls from their neighborhood have been found to be aware of the need for every house to have a window and open it regularly. Although there is no relation between pulmonary tuberculosis incidence and window existence or window opening habit, this result is in line with another study in Surakarta city,<sup>6</sup> but not with a study in Puskesmas Pamulang.<sup>7</sup> Furthermore, our result has shown that the occupancy density is not related significantly to pulmonary tuberculosis incidence, conforming other studies.<sup>8,9</sup>

It is well known that tuberculosis is more active in an environment with warmer temperatures.<sup>11</sup> Humidity is also proven to be a factor that plays a role in tuberculosis infection.<sup>12</sup> However, humidity and temperature in this study have been found to be not related significantly to the incidence of pulmonary tuberculosis, in contrast with other studies.<sup>13</sup>



In Surabaya City, humidity as well as the temperature varies depending on the season. Compared to data from the Meteorological, Climatological, and Geophysical Agency (*Badan Meteorologi, Klimatologi, dan Geofisika*, BMKG) Surabaya in 2017, the average humidity and temperature are similar to our results in this study which is in the same month as the study conducted (Table 3). The average humidity and temperature in Surabaya City might thus affect the humidity and temperature in the houses.

The ratio of ventilation-to-area and house lighting has been found to be related to the incidence of tuberculosis.<sup>14</sup> This might be due to the low quality of building permit (*Izin Membangun Bangunan*, IMB) services in Surabaya City that does not mention a detailed important health factor of a building.<sup>15</sup> Although it is mentioned in the law of IMB that every building built must consider health factors, but there is no statement referred to the house criteria according to the Decree of the Ministry of Health.<sup>16</sup> Also, there is no obligation to have ventilation and lighting planning on simple buildings such as residential houses. The ventilation and lighting planning are only required for not-simple buildings such as office towers.<sup>17</sup>

The limitation of this study is that the houses of the pulmonary tuberculosis patients are similar, and the difference between cases and controls is not significant. Studies on the susceptibility and incidence of pulmonary tuberculosis based on environmental factors need further exploration, next to other factors related to the Mtb spreading.

In conclusion, there is no relationship between pulmonary tuberculosis incidence and various house and environment conditions such as the window existence, window opening habit, occupancy density. The humidity and temperature are also not related which may be due to the dry season. The relation with pulmonary tuberculosis incidence is more on the ratio of ventilation-to-area and house lighting. It is suggested that the quality of IMB service needs to be improved, including the integration service for health inspection. Therefore, government regulation on building permit needs to be encouraged to reduce the spreading and thus the incidence of pulmonary tuberculosis.

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