INVESTIGACIÓN ORIGINAL

HOME ENVIRONMENT AS A RISK FACTOR FOR INCREASED INCIDENCE OF TUBERCULOSIS: A CASE-CONTROL STUDY

AMBIENTE DOMICILIARIO COMO FACTOR DE RIESGO PARA AUMENTAR LA INCIDENCIA DE TUBERCULOSIS: UN ESTUDIO DE CASOS Y CONTROLES

AMBIENTE DOMICILIAR COMO FATOR DE RISCO PARA AUMENTO DA INCIDÊNCIA DE TUBERCULOSE: ESTUDO DE CASO-CONTROLE

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ABSTRACT

Objectives: This study aims to determine the differences in home physical conditions consisting of residential density, home ventilation, air humidity, room temperature and lighting, between TB and non-TB patients. Material and Method: This cross-sectional study used convenience sampling with 84 cases and 85 control group participants. The instruments used were an observation sheet, tape measure, digital thermohygrometer, and digital lux meter LX-90. Chi-square tests were used for data analysis. Results: Home environmental conditions were associated with the risk of TB transmission, namely residential density (p= 0.006/ OR= 3.811), house ventilation (p< 0.001/ OR= 51.066), air humidity (p= 0.001/ OR= 3.496), room temperature (p= 0.029/ OR= 3.046), and lighting (p< 0.001, OR= 54.175). Conclusions: The study found that all elements of the home physical environment have been shown to contribute significantly to tuberculosis transmission, so improving the home physical environment is necessary to control tuberculosis transmission.

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RESUMEN

Objetivos: Determinar las diferencias entre pacientes con y sin tuberculosis en las condiciones físicas de las residencias respecto a densidad residencial, ventilación residencial, humedad del aire, temperatura ambiente e iluminación. Material y Método: Este estudio transversal utilizó un muestreo intencional con 84 casos y 85 participantes del grupo control. Los instrumentos utilizados fueron hoja de observación, cinta métrica, termohigrómetro y luxómetro digitales LX-90. Se utilizaron pruebas de chi-cuadrado para el análisis de los datos. Resultados: Las condiciones ambientales del hogar están relacionadas con el riesgo de transmisión de tuberculosis, a saber: densidad residencial (p= 0,006/ OR= 3,811), ventilación de la casa (p< 0,001/ OR= 51,066), humedad del aire (p= 0,001/ OR= 3,496), temperatura ambiente (p= 0.029/ OR= 3,046) e iluminación (p< 0,001/ OR= 54,175). Conclusiones: Todos los elementos del entorno físico del hogar contribuyen significativamente a la transmisión de la tuberculosis, por lo que es necesario mejorar el entorno físico del hogar para controlar la transmisión de la tuberculosis.

RESUMO

O objetivo deste estudo é determinar as diferenças nas condições físicas das residências, consistindo em densidade residencial, ventilação residencial, umidade do ar, temperatura ambiente e iluminação entre pacientes com TB e não TB. Material e Método: Estudo transversal que utilizou amostragem intencional com 84 casos e 85 participantes do grupo controle. Os instrumentos utilizados foram folha de observação, fita métrica, termohigrômetro digital e luxímetro digital LX-90. Foram utilizados testes de qui-quadrado para análise dos dados. Resultados: As condições ambientais domiciliares estão relacionadas ao risco de transmissão de TB, nomeadamente densidade residencial (p= 0,006/ OR= 3,811), ventilação da casa (p <0,001/ OR= 51,066), umidade do ar (p= 0,001/ OR= 3,496), temperatura ambiente (p= 0,029/ OR= 3,046) e iluminação (p= <0,001/ OR= 54,175). Conclusões: O estudo concluiu que todos os elementos do ambiente físico da casa demonstraram contribuir significativamente para a transmissão da tuberculose, pelo que é necessário melhorar o ambiente físico da casa para controlar a transmissão da tuberculose.

INTRODUCTION

Even though data on the incidence of Tuberculosis (TB) in 173 countries from 2010 to 2019 shows an average decline of -27.48%, this infectious disease still requires special attention. Trends in decreasing incidence also vary by country type and stage of development, with low- and lower-middle-income countries remaining the most vulnerable to TB[1]. In 2021, the Southeast Asia, Africa and Western Pacific regions accounted for the highest numbers with 44%, 25% and 18% of new TB cases worldwide[2]. TB is still a global health problem, with an estimated 10.6 million people infected and 1.6 million of them dying in 2021[3]. The burden of TB is also high and increasing in vulnerable populations[4]. Indonesia is ranked second as the country with the most considerable TB disease burden in the world after India[2].

Tarakan City, one of the cities in North Kalimantan Province, Indonesia, has set a target of 5,837 people suspected of having TB in 2022 and a minimum case detection rate of 95%, namely 1,081 cases per year. Tarakan City is a densely populated area compared to other cities in the same province, while the prevalence of pulmonary TB in this city is the highest in North Kalimantan Province, with 552 active cases in 2022. Handling of pulmonary TB is very intensive in addition to discovery of TB cases in the city as well and the prevention of transmission. One of the factors that increases the transmission of pulmonary TB is the physical environment. As of 2021, there are 4.49% of buildings in the city that have a floor area of ≤ 19m^2. Zinc is the type of top that dominated buildings in Tarakan City in 2020; the percentage reached 96.52%. As many as 61.92% of residents' houses have walls made of brick walls. A total of 10 sub-districts are classified as slum settlements, and in 2017, there were 60,941 uninhabitable houses in Tarakan City[5].

The bacteria that causes TB, namely *Mycobacterium tuberculosis*, is transmitted to other people through droplets containing TB bacilli when sufferers cough, sneeze or talk[6]. Other factors that are closely related to the spread of TB are the presence of a source of

transmission, the virulence of the germ, level of exposure, decreased body function, age, adequate nutritional requirements[7], gender, work environment, and physical environment at home[8]. Environmental conditions often act as intermediaries for the unconscious transmission of TB germs in the interaction process between individuals[9]. An increased risk of transmission can occur in conditions where the rooms are too crowded and the physical environment of the house does not meet health standards[10]. As a place to live, a house should meet safety and health requirements regarding building construction and environmental conditions. Several studies have proven that crowded housing and unhealthy physical conditions of homes are risk factors for the transmission of *Mycobacterium tuberculosis*[11].

TB is a social disease, and social and environmental factors play an essential role in the spread of TB apart from biomedical factors[12]. Research in South Korea shows that minor ecological factors are significant in the incidence of TB. The environmental factors studied were access to public health services, air quality, and climatic averages[13]. Furthermore, research in India shows that a contaminated home environment is associated with an increased risk of TB transmission. The home environment includes exposure to cigarette smoke, the condition of the house's walls, and the use of the toilet[14]. Environmental conditions are related to TB incidence in 31 provinces in China from 2002 to 2018; the environmental conditions in question are the general physical environment[15]. The results of another study also stated that temperature and humidity were factors in the presence of TB in Hong Kong based on data from 1997 to 2018[16].

TB transmission due to household contact is very high, according to research in India[17]. This finding aligns with review studies and meta-analyses showing increased TB transmission due to household contact[18]. Previous studies have examined environmental conditions related to TB incidence or transmission; the environment in question was primarily discussed in general terms. However, studies on the conditions of homes where TB patients live with the incidence of TB have yet to be widely explored, and if there are, they used small sample sizes[19].

Limited research on housing conditions as a factor in the spread of TB is the reason for conducting research. This study aims to determine differences in the physical conditions of residences consisting of residential density, residential ventilation, air humidity, room temperature and lighting between TB and non-TB patients. We hypothesized that people with poor home environments in terms of house density, ventilation, air humidity, room temperature and lighting have a higher risk of developing pulmonary TB compared to people who have good home environments.

MATERIAL AND METHOD

Type of study and location: This study was community-based, using a case-control design. The research was conducted at Tarakan City, North Kalimantan, Indonesia, from July to October 2022.

Sampling plan: The case group was non-inpatient TB sufferers who were recorded as undergoing standard treatment at the health service unit in Tarakan City. The control group did not have TB sufferers but lived in an environment quite close to TB sufferers. The population of the case group was 421 people, and the sample calculation using the Slovin[20] formula with a precision of 10%. After carrying out measures, the minimum number of case samples was 81 people. This study used a 1:1 ratio between the case and control groups: 84 people in the case group and 85 in the control group. The inclusion criteria for the case group were pulmonary TB patients being treated with standard anti-tuberculosis drugs, registered in the health service unit, and aged over 17. Exclusion criteria for the case group included patients living in long-term care facilities, such as hospitals or nursing homes; patients who live outside the study area or who do not have complete information about their home conditions. The inclusion criteria for the control group were not being a TB patient, living in a close environment to a TB patient, and being over 17 years old. Control group exclusion criteria include individuals who do not live in their own

homes, individuals who do not live in places that are not easily accessible, and individuals with cognitive or language impairments. The sample was selected using a convenience sampling. The sample determination process can be seen in Figure 1.

Variables and data collection: The independent variable was the home environment, which consists of house density, ventilation, air humidity, room temperature and lighting. Meanwhile, the dependent variable was the incidence of pulmonary TB. The research instruments consisted of questionnaires, observation sheets and measuring instruments. The research was conducted in 2022, which is still the time of the COVID-19 pandemic, so the entire data collection process complies with the guidelines for preventing and controlling COVID-19. Researchers visited participants' homes individually to carry out the data collection process. In this study there were no missing data.

The questionnaire was used to determine the respondents' demographic data, consisting of gender, age, education, marital status, and employment. We used an observation sheet to record measurement results from the physical environment of the house. The measuring instruments used vary according to the variable being measured. House occupancy density is calculated by comparing the bedroom floor area to the number of individuals sleeping in that room. Residential density is good if >8 m^2/person and poor if < 8 m^2/person. The ventilation area is measured using a rolling meter. House ventilation is good and meets health requirements if the site is >10% of the floor area. On the other hand, it is considered harmful and does not meet health requirements if the ventilation area is <10% of the floor area. Air humidity and room temperature are measured with the same tool, namely a calibrated digital thermohygrometer. Humidity is good at 40-60% and poor at <40% or >60%. Meanwhile, room temperature meets health requirements if it is 18-30°C and does not meet health requirements if <18°C or >30°C. Light intensity was measured using a calibrated LX-90 digital lux meter. Light intensity is good if > 60 Lux and poor if < 60 Lux. The house's physical condition is good by the characteristics of a healthy place according to the Decree of the Minister of Health of the Republic of Indonesia no. 1077/Menkes/Per/V/2011 concerning Guidelines for healthy indoor air at home.

Analysis of data: Categorical data are presented in numbers and percentages. Bivariate data were analyzed using the Chi-Square test with a confidence level of 95% and the Odds Ratio (OR) as the basis for estimating the risk.

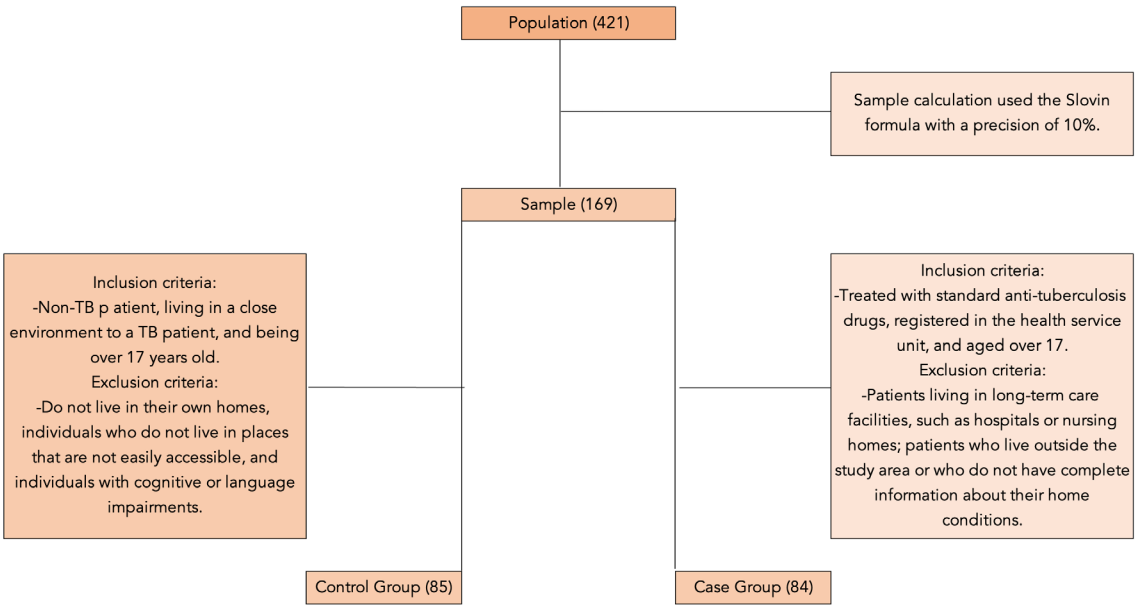

Figure 1. Flowchart of Research sample, Health service unit in Tarakan City, North Kalimantan, Indonesia, july to october 2022 (n=169).

Ethical aspects: This research has received an ethical certificate from the Ethics Commission of the Faculty of Health Sciences, University of Borneo Tarakan, with number 09/KEPK-FIKES UBT/VI/2022.

RESULTS

Table 1 shows that most respondents were male in both the case and control groups respectively (55.9% and 51.8%). The ages of respondents in the case and control groups were mainly in the late adult category (52.4% and 47.0%) and had junior high school education (42.9% and 41.2%). Marriage and employment data show that most respondents were married (60.7% and 65.9%) and fishermen (29.7% and 31.8%).

Table 2 shows that the case group and group have good category house density (63.1% and 68.2%). Other house conditions showed that the control group was in a better category than the case group: home ventilation (69.1% vs 41.2%), air humidity (72.6% and 73.8%), and lighting. Meanwhile, room temperature of both groups was equally poor (83.3% and 54.1%). The results of the analysis showed that there were significant differences between the case group and the control group in terms of residential density (p0.006, OR=3.811, CI=1.637-9.105), house ventilation (p<0.001, OR=51.066, CI=16.882-150.429), air humidity (p0.001, OR=3.496, CI=1.595-7.601), room temperature (p= 0.029, OR= 3.046, CI= 1.119-10.442), and lighting (p<0.001, OR= 54.175, CI= 20.361 -181,408).

Table 1. Distribution characteristics of respondents, Health service unit in Tarakan City, North Kalimantan, Indonesia, july to october 2022 (n= 169).

Variables		Case Group (n= 84)	Control Group (n= 85)	Total
		f (%)	f (%)	F (%)
Gender	Men	47 (55.9)	44 (51.8)	91 (53.8)
	Women	37 (44.1)	41 (48.2)	78 (46.2)
Age	Early adult	38 (45.2)	39 (45.9)	77 (45.6)
	Late adult	44 (52.4)	40 (47.0)	84 (49.7)
	Elderly	2 (2.4)	6 (7.1)	8 (4.7)
Education	No/Elementary	20 (23.8)	14 (16.5)	34 (20.1)
	Junior High School	36 (42.9)	35 (41.2)	71 (42.0)
	Senior High School	24 (28.6)	29 (34.1)	53 (31.4)
	Bachelor	4 (4.7)	7 (8.2)	11 (6.5)
Marrital Status	Married	51 (60.7)	56 (65.9)	107 (63.3)
	No	22 (26.2)	20 (23.5)	42 (24.9)
	Widow/Widower	11 (13.1)	9 (10.6)	20 (11.8)
Occupation	Government employees	1 (1.2)	4 (4.7)	5 (3.0)
	Self-employed	10 (11.9)	12 (14.1)	22 (13.0)
	Fisherman	25 (29.7)	27 (31.8)	52 (30.8)
	Farmer	16 (19,1)	19 (22,4)	35 (20.7)
	Labour	20 (23,8)	15 (17,6)	35 (20.7)
	No	12 (14,3)	8 (9,4)	20 (11.8)

Table 2. Home Physical Environmental Characteristics between Case (TB patient) and Control (Non-TB patient) Groups, Health Service Unit in Tarakan City, North Kalimantan, Indonesia, july to october 2022 (n= 169).

Variable		Case Group	Control Group	Total	*p*	OR
		f (%)	f (%)	F (%)		(95% CI)
House density	Good	53 (63.1)	58 (68.2)	111 (65.7)	0,006	3,811
	Poor	31 (36.9)	27 (31.8)	58 (34.3)		(1.637-9.105)
Ventilation	Good	26 (30.9)	50 (58.8)	76 (45.0)	<0.001	51,066
	Poor	58 (69.1)	35 (41.2)	93 (55.0)		(16.882-150.429)
Air humidity	Good	23 (27.4)	44 (51.8)	67 (39.6)	0,001	3,496
	Poor	61 (72.6)	41 (48.2)	102 (60.4)		(1.595-7.601)
Room temperature	Good	14 (16.7)	39 (45.9)	53 (31.4)	0,029	3,046
	Poor	70 (83.3)	46 (54.1)	116 (68.6)		(1.119-10.442)
Lighting	Good	22 (26.2)	60 (70.6)	82 (48.5)	<0.001	54,175
	Poor	62 (73.8)	25 (29.4)	87 (51.5)		(20.361-181.408)

CI=Confindent Interval; f=frequency; F=Total frequency; OR=Odd Ratio; p=p-value.

DISCUSSION

The study results showed significant differences in all home environment characteristics, including residential density, residential ventilation, air humidity, room temperature, and lighting, between TB and non-TB participants. This shows that environmental factors are associated with an increase in TB incidence. In line with research, the risk of transmission of tuberculosis bacteria is 2-4 times higher in residents of crowded houses[21]. Residential density influences the spread of TB, considering how it is transmitted via droplets. If an active TB sufferer is in the same room, the droplets released when he sneezes, coughs or talks can be inhaled by other people in the same room[22]. The ideal number of people living in one room or house is determined by a limit of no less than 8m^2/person. Such a space is considered to meet health requirements, not only relating to freedom in daily activities but also affecting the quantity and quality of clean air breathed by all occupants of the room/house[23]. Individuals in an ample space will feel spacious and comfortable because of sufficient O2 levels in the range of 19.5-23.5%; in the opposite condition, they will feel uncomfortable because of increased CO2 levels[24]. The air exchange system cannot function perfectly in a narrow space, so that microorganisms easily enter the body through the breathing process.

Good air circulation is also influenced by ventilation. The research results align with Pele et al.[25], which states that minimal ventilation results in increased air humidity, a condition conducive to the life and reproduction of germs, including TB bacteria. Droplets released by TB sufferers can survive longer in rooms with high air humidity, thereby increasing the spread and incidence of TB. There are at least four essential roles of ventilation: filtering and cleaning the air from dangerous chemicals, reducing unpleasant odors from pets, reducing air pollution due to cigarette smoke, and helping maintain normal air humidity in the house[26]. Every home is expected to function correctly by periodically opening windows and doors[27].

Synonymous with ventilation, air humidity has a significant relationship to the incidence of TB transmission, strengthening the results of research in Ethiopia[28] and Singapore[29] that humidity factors contribute to the transmission of TB disease. *Mycobacterium tuberculosis*

likes home environments with high humidity levels because it can increase life[30]. On the other hand, there were significant differences in the air temperature conditions of the control group and cases; most of the case group had air temperatures that did not meet health requirements, while the control group had fewer numbers than the case group. This difference strengthens the suspicion of the critical role of air temperature in controlling TB transmission. The results align with previous research in Hong Kong using data from 1997 to 2018, showing that air humidity and temperature influence the incidence and spread of TB[16].

Furthermore, lighting is essential in maintaining a healthy home environment. The characteristics of a healthy home require exposure to sunlight in sufficient quantity, not less but not too much. The natural light from sunlight plays a role in controlling pathogenic microorganisms circulating in the house. The ultraviolet content in morning sunlight can kill tuberculosis bacteria at 60 lux or more light intensity within 2 hours[24]. Sunlight plays a role in preventing transmission and helps speed up the recovery process for TB sufferers. This is because the vitamin D content produced from exposure to sunlight can suppress the body's inflammatory response to infections and reduce the impact of damage to lung organs[31]. The study results showed a significant difference in lighting between the case and control groups; most of the case group had lighting that did not meet health requirements, in contrast to the control group, most of which had lighting that met health requirements. The study results differ from those found previously in that there was no difference in lighting between the TB and non-TB groups. This difference was probably caused by the inadequate number of samples in the previous study[19].

Regarding the limitations, the data collection technique in this study uses direct observation and measurement in participants' homes, thus providing more accurate data than self-report questionnaires, which tend to cause bias. Furthermore, this study has weaknesses, including not involving TB patients under 17 years of age or patients currently hospitalized, so the research results cannot be generalized to all TB patients.

CONCLUSION

All elements of the physical environment of the house have a significant relationship with the incidence of TB transmission in Tarakan City. The magnitude of the risk of transmission is related to the house's physical environment, starting from the largest to the most minor, namely lighting factors, house ventilation, residential density, air humidity and air temperature. TB transmission is very likely between close contacts and household contacts, triggered by physical environmental conditions at home that do not meet health requirements. Modifying the home's physical environment to meet healthy needs is essential to control TB transmission.

The government is expected to take on this vital role with the support of all elements of society. Health promotion regarding environmental risks within the home includes factors such as the effects of using wood fuel or oil, smoking behavior, as well as special attention to settlements near factory industrial areas.

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Responsibility of the author

Silidah: Conception and design work, collection/data collection, analysis and interpretation of results, drafting of the manuscript, approval of the final version, advisory Statistics, other contributions (administrative).

Mihammad Irwan: Conception and design work, collection/data collection, analysis and interpretation of results, advisory Statistics, technical and methodological advice, other contributions (Logistic).

Elmania: Conception and design work, collection/data collection, analysis and interpretation of results, drafting of the manuscript, advisory Statistics.

Siti Fadlilah: Conception and design work, analysis and interpretation of results, drafting of the manuscript, critical revision of the manuscript, approval of the final version, advisory Statistics.

Nazwar Hamdani Rahil: Analysis and interpre-

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Ariyanto Nugroho: Analysis and interpretation of results, critical revision of the manuscript, approval of the final version, advisory Statistics, technical and methodological advice.

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