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Exploratory Study of Physical Environment Factors Affecting Tuberculosis Endemics Houses in Kebumen District, Indonesia

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ABSTRACT

According to prior researchs, the bacteria of Tuberculosis can spreads easily in an unhealthy environment influenced by several physical environment factors in a house. In Kebumen, where mostly classified as rural area, there are 3 sub-districts that is stated to be the most endemic area with hundreds of TB cases detected every year. By selecting 50 patients from 'Balai Pengobatan Paru-paru' (BP4)'s medical record, some physical assessments have been done on some indicators such as Residential Density, Ventilation system, Daylighting System, Temperature, Humidity, and also Material Quality. This quantitative research collected the existing physical variables through close-ended questionnaire and field measurements. Those data were later analyzed with distribution method by using digital data analysis software named JMP and compared them with the prevailing standard values. The result showed that eventhough all of 50 respondents have ideal Residential Density Percentage, their Ventilation and Daylighting System didn't conforming with the standard. Those houses also have high Humidity (> 60%) and high Temperature ($>30^0$ C) that may be caused by the poor air circulation system inside the house. However, almost all of the infected houses were found to use brick as their wall material with various quality and used ceramics or ram earth as their floor material.

Keywords: Tuberculosis, Physical Assessment, Quantitative Methods

1. Introduction

The latest data from WHO in 2012 [1] shows that there are still 700,000 TB cases found in Indonesia. The mortality rate caused by TB reaches 27 per 100,000 population and the incidence rate is 185 cases per 100,000 population. Rural areas, in particular, become one of the determinants of TB incidence because the proportion and level of risk of TB sufferers in rural areas is higher than in urban areas [1, 2].

According to John Gordon's triangle epidemiology theory, the emergence process and spread of Tuberculosis (TB) disease is influenced by the interactions between three main parameters, namely 'agents' (TB bacteria), 'hosts' (humans) and 'the environment' (houses and sites). Until today, TB prevalence rates tend to decrease but they're insignificant and slow. There have been many solution done by the government to reduce the TB cases each year. Unfortunately, most of the efforts to suppress TB prevalence are only focused on accurative programs than preventive one. The preventive program that is undergoing lately is to improve the quality of the residential and the environment.

Environment could be divided into two categories, physical and non-physical. The physical environment is the part of the environment surrounding humans that contains only physical elements, tangible, and may be more specific such as building, acoustic,

lighting, climate, infrastructure, size, etc. The physical factors that will be assessed in this research are Residential Density, Ventilation, Lighting, Temperature, Humidity, Materials, and other factors related to physical environment. Meanwhile, social or may be familiarly known as non-physical environment is not tangible and only can be felt by human itself. The health state that will be determined with the TB status is the non-physical environment facors that will be assessed in this research.

The incubation period of TB bacteria can be influenced by several things including the unhealthy condition of the house environment (physical environment factors) and the low immunity of the human body (non-physical environment factors). Many aspects related to physical environment has been proved influence the emergence of TB cases in dwellings [2-6] such as ventilation system, lighting system, humidity, temperature, and material quality. In addition to it, the Indoor Air Quality (IAQ) could affect the bacteria spreads inside the house. So, to enhance the quality of the physical environment, as the preventive step to decrease the TB incident rate, it is important to explore whether the same aspect can also affect the growth of TB cases in Kebumen, the main object of this research.

Kebumen is a regency in Central Java Province that is dominated by rural area. The southern part of Kebumen Regency is coast, the middle part of it is dominated by lowland, while in the northern part it is in the form of mountains and hills. These topographies make Kebumen has various micro climate, depend on which side the area is located. The physical conditions of the houses in those vilages also have different typologies which depend on each resident's economic ability and preferences. It leads to the diversity of form, material choice, building size, and the quality of building system.

Aside from the physical environment diversity, Kebumen has been known as the 'City Of Tile' since almost 30% its residents work as tile factory labor. The tile factory produces a lot of carbondioxide (CO^2) every hour from the combustion process and it becomes a serious air pollution source. Another air pollution threat came from the pet corral. The majority of resident in Kebumen's rural area still has livestocks that produces certain amount of animal waste. If the owner don't know how to treat the waste, the pollution that came from it could be dangerous for IAQ [13-14].

In Kebumen, there is a local healthcare facility that becomes the main reference of TB patients, it's called as 'Balai Pengobatan Paru-paru' or abbreviated as BP4. BP4 has main role to treat every patients with lung problem, include TB. In this place, ever new patients will be ordered to do some tests and they will be observed by specialists doctor to make sure their status, whether the patients are positively infected or not. By compiling the patients' medical record from BP4 until mid-2014, this research is going to visit the selected patients' houses and do the physical assessment. Later, the existing data will be analyzed with some methods such as distribution, correlation, and regression in JMP Data Analysis program.

There are a lot of homework to do to achieve an ideal living environment. This research is trying to figuring out which physical environment factors that may have direct and big impact to determine the human health state, in this case will be seen from their TB status.

2. Material and Methods

Identification of the Health Status of TB Patients

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TB patients usually make early diagnoses with X-rays or sputum tests at the local healthcare facility namely 'puskesmas', hospital, or 'Balai Pengobatan Paru-Paru (BP4). After knowing their status, which can be negative or positive, TB patients will be treated intensively for 3 until 6 months. They have to intensively consume medication and improve their daily lifestyle.

According to WHO the severity of TB disease cannot be detected by an absolute count of time because the effects of treatment can vary by individual. Intensive treatment status can be calculated from the medication periods to the statement of recovery status from the local healthcare facility, which is 6 months.

However, the healing conditions that are felt by each individual are usually different. TB patients who are declared 'perfectly cured' can be seen from the results of chest x-ray, sputum re-test, and no further complaints after 6 months. But, there are also patients who have been undergoing 6 months treatment process but still feel some complaints of health problems, must continue the treatment again. This 'imperfectly cured' condition is known as TB obstruction, as been said by Dr. Imbar Sudarsono from Kebumen District Hospital.

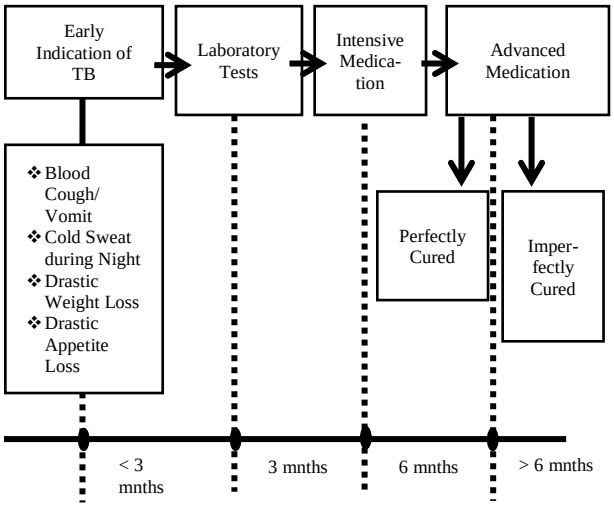

Diagram 1. Identification and Medication Level of

Methods of Sampling

The patients' who have been selected as this research's respondents are purposively chosen from BP4's medical record. We seized the data from 22 sub-district in Kebumen Regency to be 3 most endemic district that have different topographies. The final amount of the selected respondents were 50 patients or houses.

This research also requires special categorization to be able to determine the respondents' data, so it can be analyzed with some quantitative methods. Based on Diagram 1, the following are the TB status categories:

1. **The duration of TB patients is distributed in BP4 Kebumen (in a matter of months).** This is based on the calculation of the month from the respondents in the Kebumen BP4 until April 2014.
2. **Percentage of TB patients in one house**. The high rate of TB prevalence in residential environments, especially in a house, can also be calculated by the number of different people.
3. **The respondent's period becomes a TB patient.** The step of composting on the calculation results of point 1. This categorization occurs during the intensive TB treatment period which generally lasts for 6 months. The results of the calculation are then grouped into 3 categories of illness, which are <6 months, 6-12 months, and> 12 months.

Determining the Physical Environment Factors

Before deciding which factors that will be assessed in this research, some prior researches related to TB and Physical Environment Factors have been analysed and classfied into the table below.

Table 1. Assessed Physical Environment Indicators and Variables Affecting TB in Prior Researches

Indicators	Variables	Prior Researches
Residential Density	Total Building Area per-Person	[2,3,4,5]
Ventilation	Ventilation Area Size	[2,3,4,5]
Lighting	Lighting Intensity in living room and bedroom	[2,3,4,5]
Temperature	Temperature in a room	[3,4]
Humidity	Humidity Percentage in a room	[3,4,5]
Material Quality	The type of Floor and Wall Materials	[5,6]

(Source: various sources)

Those mentioned indicators will be assessed in this research alongside 'site'. 'Site' become a critical concern in this case because of the condition in Kebumen, which is dominated by rural area, has been known for its air pollution that coming from tile factory. The presence of Tile Factory among the neighborhoods may trigger indoor air contamination along with other pollution sources such as transportation and corral.

Based on these considerations and looking into government standard of Healthy House [7-10] , it can be formulated the new Physical Environment Indicators and Variables Affecting TB as following:

Table 2. New Assessed Physical Environment Indicators and Variables Affecting TB

Indicators	Variables	Assessment Standard
Residential Density	Total Building/Floor Area per-person	m^2/person
	Total Land Area per-KK	m^2
	Building Coverage Ratio (BCR)	%
Natural Ventilation	Type	Based on drawing
	Amount	pcs
	Total Area	10% of Total Floor Area
	Direction	Based on drawing
Natural Lighting	Activity using Light	Hours
	Type	Based on drawing
	Amount	pcs
	Total Area	10% of Total Floor Area
	Daylight Factor (df)	2%-5%
	Windows-to-wall (WWR)	≥ 40%
Temperature	Temperature in a room	^{0}C
Humidity	Humidity Percentage in a room	%
Material Quality	The type of Floor and Wall Materials	Based on questionaire

Assessment of Physical Environment Factors in Tuberculosis Endemic Houses

The existing data collected will be analyzed using the distribution method in order to see the frequency of certain variables in the area of the research object and its comparison with the prevailing standard values. Distribution analysis aimed to find out the comparison of frequency distribution value in a group of variables divided by category of respondent to TB patient and total number of occupancy. The analytical process continued with correlation and regression methods so that it can be known the relationship of some of these indicators with the prevalence of TB that has been categorized into the old patients enrolled in BP4 Kebumen and the percentage of TB patients in a settlements.

3. Results and Discussions

a) Assessment of Occupancy Density Indicators in TB Infected Houses

One of the main indicators included in the group of physical factors in the settlement environment that affect TB prevalence is the indicator of occupancy density. The three main variables assessed in the indicator group are the per-life building area, the area per Head Of The Household or known as 'Kepala Keluarga' (KK) in Indonesia, and the percentage of Building Basic Coefficient

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(KDB). In Figure VI.1 can be seen the results of distribution analysis of these three variables in 50 homes of TB patients who became the object of research.

As seen in Figure 1, 92% of Tuberculosis Patients' houses had Total Building/Floor Area per-Person that fit with the standard. Then, 90% among 50 observed houses had Total Land Area per-KK above the minimum standard, 60 m^2. However, the negative result can be seen in the last variable of this indicator. The Building Coverage Ratio (BCR) of Tuberculosis Patient's houses shown that they are included in the high density area since more than half of their house have BCR more than 60%.

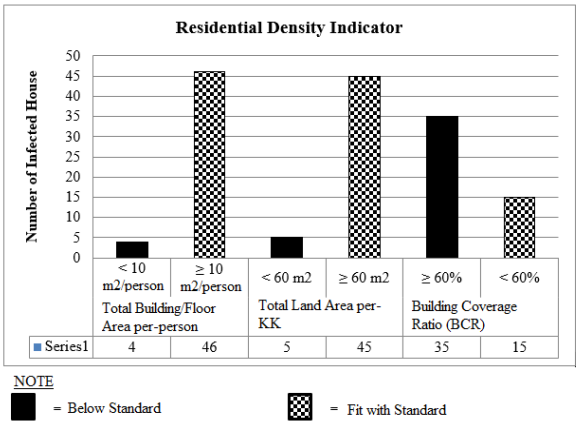

Figure 1. Distribution Analysis of Residential Density Indicator in TB Patients' Houses

b) Assessment of Ventilation Indicators in TB Infected Houses

The two main variables assessed in this indicator group are the broadest percentage of living room ventilation and the percentage of total ventilation area of the house as a whole. Calculation of the percentage of ventilation area is based on the ratio of the number of ventilation to the floor area. It can be seen in the Figure 2 The result of distribution analysis on the percentage of ventilation area in the living room and the whole house when compared with the standard percentage reference that is ≥ 10%.

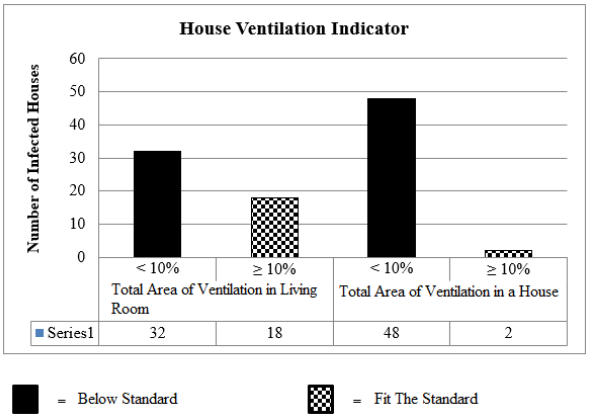

Figure 2. Distribution Analysis of House Ventilation Indicator in TB Patients' Houses

The percentage of ventilation area shown in Figure VI.2 shows that both the ventilation in the living room and the whole room of the TB patient house has not met the standard or is below the standard value. 64% occupancy has a living room venting area under 10% of living room floor area. Similarly, the ratio of the total area of house ventilation with total house area, where 96% of the occupancy of them have percentage value below 10%. Below are some examples of drawings of space in a TB patient's residence that has the number and total area of ventilation openings not in accordance with the minimum standard reference.

Figure 3 below shows the condition of a bedroom that does not have ventilation openings fit as the standard. The occupant only rely on the circulation that occured from the roof structure as shown in the figure.

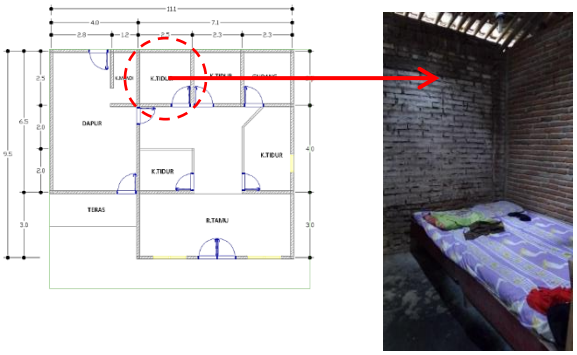

Figure 3. The Existing Room Condition Of a TB Patient's House

Similarly, the ventilation system in the living room is emblazoned in Figure 4. The room actually has 2 windows, but the occupants never open the window and they just rely on the bouvenlight above the door (Figure 4 no.3). While for natural lighting, the occupant usually turns on the lights during the day (figure 4 no.2) or at least they are satisfied with the amount of sunlight entered through the glass tile (figure 4 no.1).

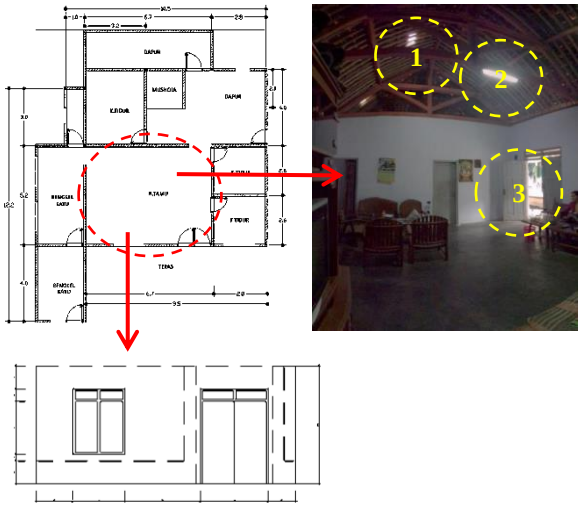

Figure 4. The Existing Living Room Condition Of a TB Patient's House

c) Assessment of Natural Lighting Indicators in TB Infected Houses

The natural lighting system is one of the important indicators in the building system, especially in cases of TB patients' houses because of the sunlight is needed to suppress the growth rate of TB bacteria in the house. As described in previous chapter, the quality of the natural lighting system of a dwelling is influenced by the quality of some varibles such as Daylight Factor (df) percentage in certain rooms and Windows-to-wall ratio (WWR). The following diagram is the result of the distribution analysis of those three variables in 50 TB patients' houses in Kebumen Regency.

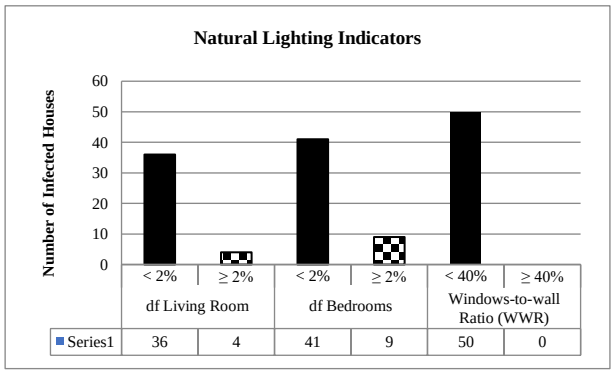

Figure 5. Distribution Analysis of Natural Lighting Indicator in TB Patients' Houses

Based on the results shown in Figure 5, more than 70% of TB patients have a percentage of the intensity of natural lighting in living rooms and bedrooms that do not meet the standards. Even the Percentage Of Windows-To-Wall Ratio (WWR) of 50 houses didn't fit with standard. It shows the factual condition of the TB patients' houses that are lack the natural light. In fact, some respondents chose to use artificial lighting even during the day (Figure 4).

From Figure 6, it can be seen that the four rooms didn't get proper natural lighting. Those rooms only rely on a roof gap, wind grid (Figure 6 C), and little bouvenlight above the door to enter the sunlight. In figure 6 D it appears that the room actually has a window,

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but residents tend to always close the window which leads to a dark room and less get air circulation.

Figure 7. Distribution Analysis of Humidity and Temperature in TB Patients' Houses

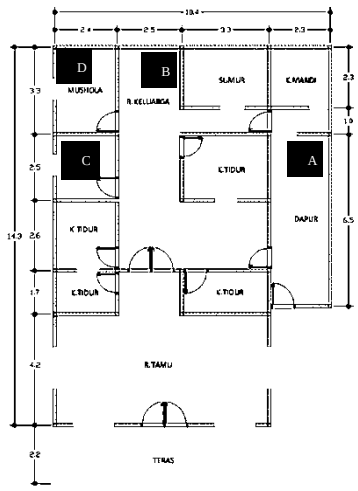
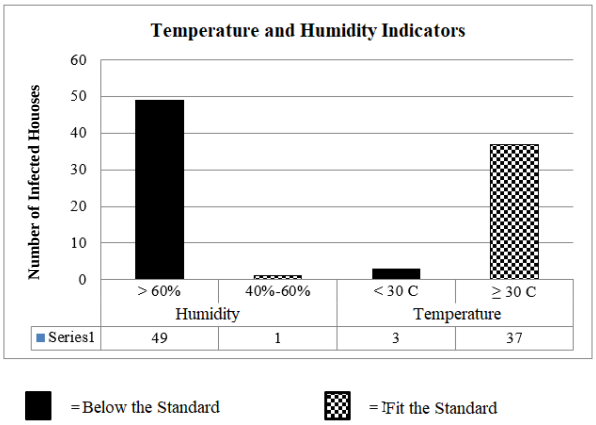


Figure 6. The Factual Condition of Some Rooms in the TB Patient's Houses

d) Assessment of Humidity and Temperature Indicators in TB Infected Houses

From the 50 infected houses, there is only 1 house that has humidity above the standard. Meanwhile on the temperature indicator, 74% of the infected houses with room temperature $\geq 30^0$C.



If we compared with standard references, these conditions actually in the ideal number since it fits the standards of the Decree of the Minister of Health of the Republic of Indonesia No. 829/Menkes/SK/VII/1999, which is more than 30^0C. But if it is linked to the calculation of the ventilation percentage in the room, this condition may occured due to lack of natural ventilation. As we can see from the ventilation indicators, the high temperature in the room can be caused by poor air circulation inside the measured room. The lack of air ventilation causes air circulation in the room to be hampered and the heat is trapped inside the house. The flow and air velocity inside the house definitely affects the temperature changes in the room [12].

e) Assessment of Material Quality in TB Infected Houses

On the Figure 8, it could be seen that the type of wall material that is mostly used in the respondent's houses is brick that got 98%. There is only 1 respondent in Alian sub-district whose walls use bamboo woven. However, there are several differences in the brick wall conditions found in the respondents' houses as can be seen in Figure 9. Although all of them use brick material, the condition of the existing walls in those houses are different. There are houses that still use non-plastered bricks as shown in Figure 9-A, a wall with a mixture of bricks as shown in Figure 9-B, and a brick wall that has been finished with paint like commonly as in figure 9-C .

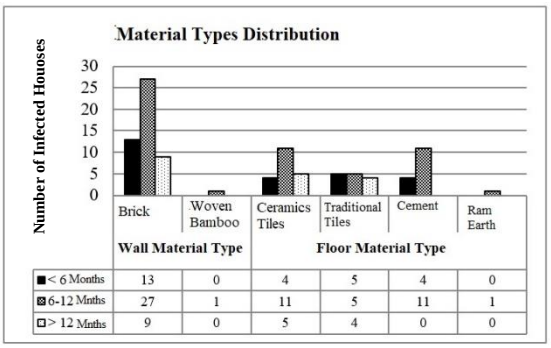


Figure 8. Distribution Analysis of Material Types in TB Patients' Houses

Figure 9. Different Types Of Brick Walls In TB Respondents' Houses In 3 Sub-Districts In Kebumen.

Most previous studies stated that TB patients usually have a low quality of brick, unplastered boards, or other poor quality material. Then for the type of floor material, most TB patients have houses with dirt floors and cement floors. Yet, the results of this study indicate that out of 50 respondents' houses in 3 sub-districts, 98% of their houses have medium-good quality of brick walls and 70% of the houses are already tiled and cemented. There is only one respondent who has a house with a woven bamboo wall and another one whose floor is still made from ram earth.

Because almost all of the respondent's houses have brick walls, it can be assumed that there is a relationship between the quality of the brick wall and the findings of TB cases in the neighborhood. Although there are several houses that are tiled and ground floors but the percentage of the most type of floor material in this study is ceramics and cement. When viewed from the quality of the two ingredients, ceramics and cement are materials that has low water absorption which can lower the humidity. This finding raises new considerations related to other physical and non-physical factors that can potentially lead to the growth of TB bacteria in the house not only limited on wall and floor material types.

After looking onto the previous explanations, it could be concluded that:

a) Since most TB infected houses have ideal number of Total Land Area per-KK, Total Building/Floor Area per-Person, and Building Coverage Ratio (BCR), the Residential Density may not be the cause of TB spreads. Yet, more advanced research should be conducted to prove this.
b) The ventilation system quality is so poor since almost all of the Total Area of Ventilation at the Living Room and Bedrooms in the infected houses didn't conforming the standard (< 10%).
c) The negative result also shown in the Natural Daylighting system quality. The Total Area of Ventilation at the Living Room and Bedrooms in the infected houses didn't conforming the standard (< 10%).
d) The indoor Humidity (in the Living Room) in the most infected houses was measured to > 60%. The Temperature in the same room was measured to be above 30^0 C. It means, the houses have high humidity and the temperature is warmer than the standard (27^0 C). Those conditions could be caused by the poor circulation system inside the house that leads to the humid and warmer indoor thermal environment.
e) However, in the material classification, most of the infected houses used brick as their wall material which has various finishing quality. The quality of brick finishing may have another correlation with the TB bacteria spreads inside the house, since in some prior researches, the brick wall seemed didn't have menaingful correlation with the TB incident.
f) The similar result also shown in the floor material type. Ceramics, which previously found to be the best material for healthy house in some referenced researches, was found to be used in the most of infected houses. Eventhough there was also a few of houses that still used Ram Earth, an advanced research relate to the quality of Ceramics should be conducted since the

human who live in the houses used this material still found to be TB infected.

4. Conclusion

Some of the indicators were found to be conformed with the standard, yet the other indicators that have poor quality such as ventilation and dayligthing system may be the main causes of the high humidity and temperature inside the house. Moreover, some advanced research related with TB should be conducted in Material Quality and Residential Density. Stakeholders should pay more attention to educate the resident for fixing their building system quality. Some improvements need to be done in order to enhancing the health state of the occupants and to prevent the spreads of some dangerous disease.

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