Abstract

Context: The current evidence shows that people in low-socioeconomic positions tend to be at high risk for tuberculosis (TB) transmission. Aims: The aim of this study is to identify the significance of socioeconomic position and TB risk factors to TB transmission, particularly in Bandar Lampung, Indonesia. Settings and Design: This cross-sectional study, conducting in January–November 2017, included 166 samples of smear-positive TB patients collected from 30 community health centers across the city that had implemented DOTS strategy. Subjects and Methods: The latent variables consisted of the following: socioeconomic position, housing, nutritional, healthcare access, and TB transmission, which was measured through corresponding indicators. The data were collected through in-depth interviews. Statistical Analysis Used: Data analyzed using the partial least square method. Results: Determinants of socioeconomic position through housing determinants significantly influence TB transmission with $R^2$ of 42.3%. They also show that education, housing density index, and internal house transmission are the strongest indicators in explaining their associated latent variables. Conclusions: TB control program should be integrated with education improvement, a reduction of housing density index, and strengthened examinations of internal house contacts. These programs should be supported by health institutions and other related institutions. The findings will improve TB control programs, especially in low- and middle-income countries with high-socioeconomic disparity.

Keywords: prediction model, risk factors, socioeconomic position determinants, tuberculosis

INTRODUCTION

Indonesia is a country with the third highest rate of tuberculosis (TB) incidence in the world. Indonesia has also struggled with an escalation of the rate of TB incidence. The number of incidences in 2016 was about twice the number in 2012. Bandar Lampung has been recorded as one of the cities, in Indonesia, with a high rate of TB incidence, and with 2056 cases in 2016 compared to the 1,195 cases in the year 2012. Moreover, Bandar Lampung is located in the fifth poorest province in Indonesia. It is also well known that TB is highly correlated with poverty level. The increasing of TB cases suggests that there are disease transmissions or contacts among closely related people in the community. Studies have shown that disease transmission or contact occurs from inside the house, surrounding homes, and the working environment. The risk of transmission is higher for people with lower socioeconomic position compared to people with the higher socioeconomic position. In addition, recent studies in Bandar Lampung showed that socioeconomic position in individual and community have potential role to TB incidence. The research showed that individual with low-socioeconomic position would have higher TB risk factors which then influenced to develop TB. Moreover, research also showed that clustered TB incidences were located in the area of Bandar Lampung with low-socioeconomic position. Therefore, knowledge of how socioeconomic position and TB risk factors influence TB transmission is required to support TB control program to decrease TB incidence. The research aims to develop a prediction model of TB transmission based on socioeconomic position determinants and TB’s risk factors determinants. Since these determinants are latent variables, the partial least square (PLS) method was used to analyze the data.
used to develop a model. By using the PLS method, both the determinants that significantly influence TB transmission and the indicators that best identify those determinants can be identified. The results of this model confirmed which determinants and which indicators should be considered as a basis for a suitable intervention strategy to decrease TB transmission.

**Subjects and Methods**

A cross-sectional study was conducted in Bandar Lampung from January to November 2017. Population in this study was all patients with smear-positive TB from January to June 2017 recorded in 30 community health centers (CHCs) that implemented the DOTS strategy, consisted of 635 smear-positive TB patients. This study used a sample of 166 smear-positive TB patients, which was the minimum sample size calculated using 80% power and 95% confidence intervals. The sampling technique in this research was simple random sampling.

The research variables consisted of independent latent variables, dependent latent variables, and their indicators. The dependent latent variable was TB transmission. The independent latent variables included socioeconomic position determinants and TB risk factor determinants (housing, nutritional, and health access). In this research, variables were measured in dichotomous rather than continuous. Using dichotomous variables based on theoretical cutoffs, we can build model regarding to both ideal and nonideal condition.

TB transmission was measured by indicators: internal house transmission, surrounding house transmission, and working environment transmission. Internal house transmission was a transmission from family members of the respondent who lived in the same house. Surrounding house transmission was a transmission from neighbors who lived surrounding the respondents. Meanwhile, working environment transmission was a transmission from employees who worked in the same workplace.\[7\] Smear-positive TB of a family member, neighbors, and employees, recording from previous period, was used as an evident of those related transmissions.

Socioeconomic position determinants were measured by the following indicators: education, occupation, per capita income, and social class. Education was indicated by period that the respondents had been spent for their formal education (i.e., uneducated: <6 years, primary educated: 6–12 years, and higher educated: >12 years).\[13\] Occupation was the employment status of respondents in the last 12 months (i.e., unemployed, temporary employee, and permanent employee). Per capita income was indicated by per capita income for Lampung Province in 2016 with exchange rate IDR 12,000 for US $1 (i.e., poor sufficient: <US $1,495, less sufficient: US $1495–2989, and sufficient: >US $2,989).\[14\] Social class was specified by productive assets ownership of respondents (i.e., having no productive assets, having one productive asset, and having more than one productive asset).\[15\]

Housing determinants were measured by indicators as follows: housing density index, ventilation index, and indoor air pollution number. Housing density index was categorized by housing area divided by a number of people living in the house (i.e., poor sufficient: <5.6 m², less sufficient: 5.6–<8 m², and sufficient: ≥8 m²).\[16\] Ventilation index was identified by ratio (in %) between ventilation area and floor area (i.e., poor sufficient: <13.75%, less sufficient: 13.75–<20%, and sufficient: ≥20%).\[16\] Indoor air pollution number was indicated by a number of indoor air pollution sources, such as the number of smoking person in the respondent’s house and polluting solid cooking fuel (i.e., ≥2, 1, and 0 indoor air pollution sources)\[17\].

Nutritional determinants were measured by the following indicators: sufficiency, monthly personal food budget, and food diversity. Sufficiency was categorized by the nutritional sufficiency of the respondents (i.e., if the patient had ever missed meal time <1 week and ever reduced meal portions for 1–4 weeks, ever reduced meal portions for <1 week, and had never reduced meal portions).\[18\] Monthly personal food budget was identified by amount of individual food budget for Lampung Province in 2016 with the exchange rate IDR 12,000 for US $1 (i.e., poor sufficient food budget: <US $30, less sufficient food budget: US $30–60, and sufficient food budget: >US $60).\[14,18\] Food diversity was categorized by number of food’s type mostly consumed by the respondent (i.e., 1, 2, 3, and >3 types of food).\[19\]

Meanwhile, health access determinants were measured by indicators of both distance and transportation. The distance was indicated by how far the CHC from respondents’ house (i.e., >5 km, 1–5 km, and <1 km). Transportation was indicated by the type of transportation required by respondents to reach CHC (i.e., public, private, no transportation needed).\[19\]

The data collection in this research was performed through both observation and in-depth interviews following a questionnaire. An analysis of the collected data was performed using the smart pls v. 3, a software with graphical user interface for variance-based structural equation modeling (SEM) using PLS path method, developed by Ringle, Wende and Becker, in Bömmingstedt, Germany. An evaluation was conducted for both the measurement model and the structural model. Measurement model evaluation was done to evaluate goodness of indicators to represent their latent variable signified by loading indicator values. Meanwhile, structural model evaluation was performed to evaluate goodness of relationship between an independent latent variable and dependent latent variable signified by value of $R^2$ and path coefficient.\[11,20\]

Ethical clearance for this research was obtained from the Faculty of Medicine, University of Lampung. All involved respondents in this research were asked to participate on a voluntary basis and were provided with sufficient information during the interview and observation processes.

**Results**

This research’s results consisted of a measurement model.
evaluation and structural model evaluation. The PLS path model is shown in Figure 1. This model is the first and the only one trying model.

The evaluation of the measurement model identified the validity of each indicator, which is represented by a loading factor as shown in Table 1. A loading factor of a particular indicator, that is, $\geq 0.70$, shows that the indicator is suitably valid to explain its latent variable. A loading factor ($\lambda$) of $0.5 < \lambda < 0.7$ shows that indicator is moderately valid. Meanwhile, a loading factor of $<0.5$ indicates that it is poorly valid. Table 1 shows that all indicators of TB transmission, socioeconomic position, housing, nutritional, and health access determinants are suitably or moderately valid, except for the surrounding house transmission, social class, and indoor air pollution indicators. In this study, indicators with a loading factor of $< 0.5$ were used for the model development due to the size of the sample; a model with $>150$ sample units can accept a minimal standardized loading factor of 0.15.

Based on the loading factors, one can identify which indicator most significantly explains its latent variable. Table 1 shows that education, housing density index, monthly personal food budget, transportation, and internal house transmission are indicators that most significantly describe their latent variables.

The structural model evaluation involves three main values, namely $R^2$, the $t$ value, and the structural path coefficient significance ($\gamma$). The $t$ value of a structural equation indicates whether there is a certain correlation between latent variables. Furthermore, the $\gamma$ value classifies the influence of the independent latent variables in regard to the concerned dependent latent variables. Meanwhile, the structural equation determination coefficient ($R^2$) indicates the influence of all independent latent variables on dependent latent variables.

As shown in Table 2, there are three significant paths among seven paths in the structural model evaluation, indicated by their $t$ value which higher than 1.96 (at 0.05 of significant level). The three paths of the connected nodes are from the socioeconomic position determinants node to the housing determinants node, from the housing determinants node to the TB transmission node, and from the socioeconomic position determinants node to the food determinants node. The $t$ values of those significant paths are 2.976, 1.972, and 2.296, respectively. In addition, the significance influences of the significant paths are 0.375, 0.409, and 0.274, respectively. Based on these results, socioeconomic position determinants influence housing determinants with a significance value of 0.375, housing determinants influence TB transmission with a significance value of 0.409, and socioeconomic position influence food determinants with a significance value of 0.274. In addition, socioeconomic position through housing determinants influences TB transmission with a significance value of 0.153 ($0.375 \times 0.409$).

**Table 1: Loading factor of indicators of partial least square path model (Bandar Lampung, 2017)**

| Latent variables                      | Indicators                          | $\lambda$ |
|--------------------------------------|-------------------------------------|------------|
| Socioeconomic position determinants  | Education                           | 0.857      |
|                                       | Occupation                           | 0.630      |
|                                       | Income per capita                    | 0.606      |
|                                       | Social class                         | 0.238      |
| Housing determinants                  | Housing density index                | 0.794      |
|                                       | Ventilation index                    | 0.543      |
|                                       | Indoor air pollution number           | 0.451      |
| Nutritional determinants             | Monthly-personal food budget         | 0.771      |
|                                       | Sufficiency                          | 0.641      |
|                                       | Food diversity                       | 0.679      |
| Health access determinants           | Distance                             | 0.868      |
|                                       | Transportation                       | 0.870      |
| TB transmission                       | Surrounding house transmission       | 0.303      |
|                                       | Internal house transmission           | 0.993      |
|                                       | Working environment transmission     | 0.718      |

TB: Tuberculosis

**Table 2: $t$ value and $\gamma$ value of structural equation of partial least square path model (Bandar Lampung, 2017)**

| Path                                              | $t$    | $\gamma$    |
|---------------------------------------------------|--------|-------------|
| Socioeconomic position determinants $\rightarrow$ housing determinants | 2.976  | 0.375       |
| Socioeconomic position determinants $\rightarrow$ nutritional determinants | 2.296  | 0.274       |
| Socioeconomic position determinants $\rightarrow$ health access determinants | 0.538  | 0.109       |
| Socioeconomic position determinants $\rightarrow$ TB transmission | 1.013  | 0.093       |
| Housing determinants $\rightarrow$ TB transmission | 1.972  | 0.409       |
| Nutritional determinants $\rightarrow$ TB transmission | 1.415  | 0.256       |
| Health access determinants $\rightarrow$ TB transmission | 1.472  | 0.322       |

TB: Tuberculosis

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**Figure 1: Socioeconomic position, risk factors, and tuberculosis transmission, 2017**

Legend: socioeconomic position determinants housing determinants nutritional determinants health access determinants tuberculosis trans: tuberculosis transmission, X1: Education, X2: Occupation, X3: Income per capita, X4: Social class, X5: House density index, X6: Ventilation index, X7: Indoor air pollution number, X8: Monthly-personal food budget, X9: Sufficiency, X10: Food diversity, X11: Distance, X12: Transportation, X13: Internal house transmission, X14: Surrounding house transmission, X15: Working environment transmission
The structural model evaluation also produced $R^2$ values, as shown in Table 3. As shown in Tables 2 and 3, socioeconomic position determinants can explain 13.4% of housing determinants variance and 7.2% variance of food determinants. In addition, socioeconomic position through housing determinants can explain 42.3% variance of TB transmission. The rest of the variance of housing determinants, food determinants, and TB transmission is explained by other variables that were not studied in this research.

**Table 3: $R^2$ value of partial least square path model (Bandar Lampung, 2017)**

| Latent variables                  | $R^2$ |
|----------------------------------|-------|
| Housing determinants             | 0.134 |
| Nutritional determinants         | 0.072 |
| Health access determinants       | 0.003 |
| TB transmission                  | 0.423 |

The structural model evaluation results show that socioeconomic position through housing determinants influence TB transmission. The result is supported by the influence of socioeconomic position determinants to housing determinants and housing determinants to TB transmission.

There is a disparity in socioeconomic positions where some people have lower education, work, income, and possession of goods than others. People with low-socioeconomic position determinants tend to have high-density houses with less ventilation and more air pollution, which are TB risk factors. Previous research has also shown that people with lower social determinants due to poor housing conditions are more at risk to have TB.

In this study, the disparity in socioeconomic position determinants was mainly due to education, which was the strongest indicator in explaining socioeconomic position determinants. Education is closely related to employment, income, and welfare. Higher educational attainment is related to better work and also healthier working conditions. Higher education also increases opportunities for greater income. In this research, the socioeconomic position determinants correlated to poor housing determinants, mainly the housing density index, which was the indicator with the strongest loading factor. In addition, housing determinants influence TB transmission, especially internal house transmission, which was the strongest indicator in explaining TB transmission. The housing density index is the house area divided by the number of people who live in the house. If there is a TB patient, who lives in a house with a large housing density index, the risk for internal house TB transmission increases.

Based on the findings, there are some recommendations for TB control programs, especially in Bandar Lampung, Indonesia. First, the TB control program should be accompanied by education improvement. Since most of the TB patients in Bandar Lampung are not at the school age, the appropriate education improvement is nonformal education, which can be done by providing education and work training that can be applied directly. These activities can be accompanied by a revolving loan to open businesses that match the learned skills. The project of improving social determinants, together with the TB control program, proved to be very useful in TB control in Lima, Peru. Furthermore, the TB control program should be accompanied by an improvement of housing determinants, especially for homes with a high-housing density index. The improvement can be performed by providing affordable, low-cost housing by public works institutions. This research also recommends that the TB control program should include a stronger examination of TB contacts, especially internal house TB contact. This recommendation is based on the finding that internal house TB transmission was the strongest indicator of TB transmission.

Efforts to improve socioeconomic position determinants and housing determinants require the support of other health-related sectors as well as other sectors beyond health. These efforts should also be supported by the government. Through the commitment of central and local governments, the support can be performed as economic development and social policies that favor the poor and pay attention to the inequalities of social determinants, strengthen health systems, and control the spread of TB.

**Conclusions**

TB transmission is closely related to poor socioeconomic position determinants, which then also influence housing determinants. The findings of the determinants’ significance can be used to support TB control programs in low- and middle-income countries that have poor socioeconomic position determinants as the main cause of TB transmission, including Indonesia.

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**Conflicts of interest**

There are no conflicts of interest.

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