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Prediction Model of Tuberculosis Transmission Based on Its Risk Factors and Socioeconomic Position in Indonesia

Abstract

Background: The current evidence shows that people in low socioeconomic positions tend to be at high risk for tuberculosis (TB) transmission. The main purpose of this research is to identify the significance of socioeconomic position and TB risk factors to TB transmission, particularly in Bandar Lampung, Indonesia.

Methods: This cross-sectional study, conducting in January – November 2017, included 183 samples of smear-positive TB patients collected from 30 primary health centers across the city that had implemented a directly observed treatment short-course strategy. The latent variables of this research was concerned with consist of determinants, namely, socioeconomic position, housing, nutritional, healthcare access, and TB transmission, each of which were measured through a corresponding indicator. The data was collected through in-depth interviews and then 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: The findings suggest that tuberculosis control program should be integrated with education improvement, a reduction of housing density index, and strengthened examinations of internal house contacts. These programs will support TB control programs in decreasing tuberculosis incidence, especially in low and middle income countries with high socioeconomic disparity.

Key-words: socioeconomic position determinants, risk factors, tuberculosis, prediction model

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 (1,2). Bandar Lampung, has been recorded as one of the cities, in Indonesia, with a high rate of TB incidence, with 2,056 cases in 2016 compared to the 1,195 cases in the year 2012 (3,4). Moreover, Bandar Lampung is located in the fifth poorest province in Indonesia (5). It is also well known that TB is highly correlated with poverty level (6).

The increasing of tuberculosis cases suggests that there are disease transmissions or contacts among closely related people in the community. Studies have shown that disease transmission or contact occur from inside the house, from surrounding homes, and from the working environment (7–9). The risk of transmission is higher for people with lower socioeconomic position compared to people with higher socioeconomic position (10). 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 (11). Moreover, research also showed that clustered TB incidences were located in area of Bandar Lampung with low socioeconomic position (12). 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 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 incidence.

Material 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 directly observed treatment short-course (DOTS) strategy, consisted of 635 smear-positive TB patients. This study used a sample of 183 smear-positive TB patients, which was the 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). TB transmission was measured by indicators: internal house transmission, surrounding house transmission, and working environment transmission (7–9). Socioeconomic position determinants were measured by indicators: education (i.e., uneducated, primary educated, higher educated), occupation (i.e., unemployed, temporary employee, permanent employee), per capita income (i.e., less than

US $1,495, US $1,495–2,989, more than US $2,989), and social class (i.e., having no productive assets, having one productive asset, having more than one productive asset) (13–15). Housing determinants were measured by indicators: housing density index (i.e., < 5.6 m^2, 5.6–< 8 m^2, ≥ 8 m^2); ventilation index (i.e., < 13.75%, 13.75– <20%, ≥ 20%); and indoor air pollution number (i.e., ≥ 2, 1, 0 indoor air pollution sources) (16,17). Nutritional determinants were measured by indicators: sufficiency (i.e., if the patient had ever missed meal time less than one week and ever reduced meal portions for one to four weeks, ever reduced meal portions for less than one week, and had never reduced meal portions); monthly personal food budget (i.e., < US $30, US $30–60, > US $60); and food diversity (i.e., 1, 2, 3, and > 3 types of food) (18). Health access determinants were measured by the following indicators: distance (i.e., > 5 km, 1–5 km, < 1 km) and transportation (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 by using the SmartPLS v.3. 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 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 on 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.

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 more than or equal to 0.70 shows that the indicator is suitably valid to explain its latent variable. A loading factor (λ) of $0.5 < \lambda < 0.7$ shows that indicator is moderately valid. Meanwhile, a loading factor of less than 0.5 indicates that it is poorly valid. Table 1 show 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 less than 0.5 were used for the model development due to the size of the sample; a model with more than 150 sample units can accept a minimal standardized loading factor of 0.20.

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 p value, and the structural path coefficient significance (γ). The p value of a structural equation indicates whether there is a certain correlation between latent variables. Furthermore, the γ 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.

Based on Table 2, it can be seen that there are three significant paths among seven paths in the structural model evaluation, indicated by their p value which less than 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 p values of those significant paths are 0.005, 0.044, and 0.022 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. Additionally, socioeconomic position through housing determinants influences TB transmission with a significance value of 0.153 (0.375 * 0.409).

The structural model evaluation also produced R^2 values, as shown in Table 3. Based on Table 2 and Table 3, it can be seen that 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.

Discussion

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.

This result concurs with review stating that a disparity in socioeconomic positions tends some people to have lower education, work, income, and possession of goods than others. Moreover, people with low socioeconomic position determinants tend to have high-density houses with less ventilation and more air pollution, which are TB risk factors (6). This result also in line with review stating that poor quality and overcrowded housing related to poverty, which refer to indicators of low education, no occupation, low income as well as low social class (21). Previous research has also shown that people with lower social determinants tends to have poor housing conditions (11,22). This result also concurs with researches stating that a house with high density index, less ventilation index as well as more air pollution number; tends to have higher risk on TB transmission, especially internal house TB transmission (6).

In this study, 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 (23).

In this research, housing determinants, mainly explained by housing density index, which was the indicator with the strongest loading factor. The housing density index is the house area divided by the number of people who live in the house. Housing density index also significance factor on spreading *Mycobacterium tuberculosis*; when a TB patient cough or sneeze, *M. tuberculosis* will retain for certain time in the air. Therefore, the higher the house density index, the more person in the house will exposed with the bacteria (21).

The result also shows that internal house TB transmission was the strongest indicator in explaining TB transmission. This result supports by data reveal that among 183 respondents,

42.1% (77 respondents) have internal house transmission. It also concurs with the research founding that internal house transmission is more occurred in TB transmission (6).

Based on the findings, education, house index density and internal house transmission are variables that should be highlighted and included in TB control programs. 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 non-formal education, which can be done by providing education and work training that can be applied directly (24). 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 (25). Also, 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.

Efforts to improve socioeconomic position determinants and housing determinants require the support of other health-related sectors as well as other sectors beyond health (10). These efforts should also be supported by the government. Through the commitment of central and local governments, the support can be perform 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 (26,27).

Conclusions

This research shows that tuberculosis 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.

Table 1: Loading Factor of Indicators of PLS Path Model

Latent Variables	Indicators	λ
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

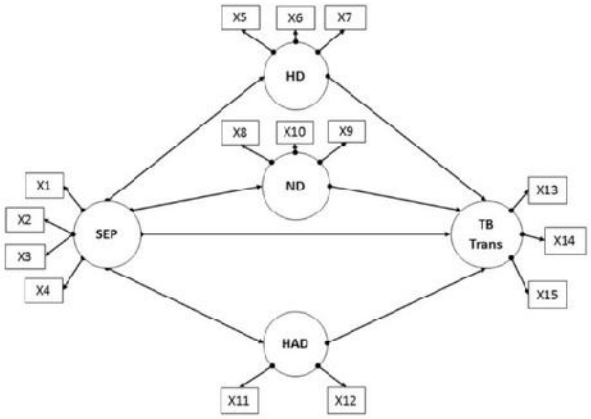
Table 2: p value, t value and γ value of Structural Equation of PLS Path Model

Path	p value	t value	γ values
Socioeconomic position determinants → housing determinants	0.005	2.796	0.375
Socioeconomic position determinants → nutritional determinants	0.022	2.296	0.274
Socioeconomic position determinants → health access determinants	0.591	0.538	0.109
Socioeconomic position determinants → TB transmission	0.312	1.013	0.093
Housing determinants → TB transmission	0.044	1.972	0.409
Nutritional determinants → TB transmission	0.158	1.415	0.256
Health access determinants → TB transmission	0.142	1.472	0.322

Table 3: R^2 Value of PLS Path Model

Latent Variables	R^2 Value
Housing determinants	0.134
Nutritional determinants	0.072
Health access determinants	0.003
TB transmission	0.423

Figure 1: Socioeconomic Position, Risk Factors and TB Transmission PLS Path Model



Legend:
SEF : Socioeconomic position determinants
HD : Housing determinants
ND : Nutrional determinants
HAD : Health access determinants
TB Trans: TB 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

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