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Socioeconomic Determinants of Tuberculosis Cases in Indonesia, 2010–2013: An Ecological Study

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Abstract

BACKGROUND: Indonesia encounters a serious issue of disparity in tuberculosis cases among provinces. These disparities are crucial since they may reflect a macro-level factor that could be modified to further reduce the cases. Some factors are identified as contributing to this variation, including socioeconomic determinants.

AIM: This study investigated whether these socioeconomic determinants (i.e., poverty, unemployment, income inequality, and low education) can predict the variation of tuberculosis cases across provinces in Indonesia.

METHODS: We conducted an ecological analysis using public-use data files of the Annual Indonesian Health Profile Report and The Indonesian Social and Population Profile Report consisting of data from 33 provinces, 2010–2013. The main outcome measures were province-level tuberculosis notification cases for all form of tuberculosis cases and new smear-positive cases. The correlation between socioeconomic determinants and tuberculosis notification cases was analyzed with bivariate analyses and multivariate linear regression analyses.

RESULTS: This study showed that poverty was strongly and positively correlated with tuberculosis notification cases, either all form or new smear-positive cases. Unemployment was also positively correlated with tuberculosis notification cases, but the power was lower. In contrast, income inequality and low education level were not statistically correlated with tuberculosis notification cases. In multivariate linear regression analyses, poverty is the strongest predictor for tuberculosis notification cases. Poverty had a bigger impact than unemployment in the increased tuberculosis notification cases.

CONCLUSION: Findings from this study suggest that poverty has a profound influence on the variation in tuberculosis notification cases across provinces in Indonesia.

Introduction

In January 2014, the Ministry of Health of the Republic of Indonesia released data from The Indonesia Basic Health Research 2013 (Riset Kesehatan Dasar 2013, RISKESDAS 2013). It is the largest national representative health survey in Indonesia conducted by the Directorate General of Disease Control and Environmental Health, Ministry of Health. The report rose serious disparity issues that existed among 33 provinces with respect to tuberculosis notification cases [1].

Even though many studies have been devoted to the prevention of tuberculosis, the causes of disparities across provinces have not been the main concern and are frequently neglected [2]. Meanwhile, these disparities are a crucial issue since they may reflect a macro-level factor that could be modified to further lower tuberculosis cases [2], [3]. Macro-level factors such as economics, health system, social policies, built environment, and socio-cultural beliefs are well known as social determinants of health [4]. These factors fundamentally shape the micro-level ones such as biomedical aspects and health behavior, targeted by most interventions [5].

Prominent macro-level effects for the observed health disparities in Indonesia have been suggested, including socioeconomic and geographic aspects [3], [6]. The latter aspect is difficult to modify. In contrast, an increasingly important socioeconomic aspect that has a macro-level effect on health and is relatively more amenable to modification is poverty [7]. Recent social epidemiology studies described the beneficial effect of the intervention of poverty reduction among the poor on health outcomes. These studies demonstrated that social protection intervention such as a cash transfer program was associated with a reduction of several disease notification cases including leprosy, Human Immunodeficiency Virus (HIV) infection, and any other sexual-transmitted infections [8], [9]. Thus, poverty may exert its potential influence on health outcomes, especially in the context of infectious diseases.

The relationship between poverty and tuberculosis has been posited to be related or mediated by socioeconomic variables of unemployment, income inequality, and low education [7]. The previous ecological studies conducted in the United States and the United Kingdom found that poverty is a strong predictor of tuberculosis notification cases [10], [11], [12], [13], [14]. Furthermore, social epidemiology research investigating the variation in tuberculosis outcomes demonstrated that variables related to unemployment, income inequality, and low education are important macro-level predictors [15].

The previous studies exploring the proposition were conducted mainly in developed countries. Meanwhile, tuberculosis is prone to find in developing countries. Thus, it is important to study the relationship between poverty to tuberculosis cases in developing countries including Indonesia. At present, there is no study exploring the provincial-level socioeconomic determinant of tuberculosis notification cases in Indonesia. Since the relationship between poverty and tuberculosis is closely related to other socioeconomic determinants, in this explanatory study, we also considered unemployment, income inequality, and low education as covariates using a complete provincial dataset. This ecological study explored the role of socioeconomic determinants mainly poverty as a predictor of disparities in tuberculosis notification cases across provinces in Indonesia, especially before Indonesia's 34th province was formally established in the year 2014.

Methods

Data sources and measures

Two measures of tuberculosis notification cases, that is, the total number of all form of tuberculosis cases and the total number of new smear-positive cases in 2010–2013 were obtained from a cross-sectional study in the Indonesia population conducted by the Directorate General of Disease Control and Environmental Health, Ministry of Health of the Republic of Indonesia. The data were published as public-use data files of the Annual Indonesian Health Profile Report [16], [17], [18], [19]. The detailed procedure for notification of tuberculosis cases in Indonesia was published previously [20]. Case notification is conducted according to The National Tuberculosis Manual. This manual is adapted from the World Health Organization guidelines through sputum smear examination of suspected patients with tuberculosis presenting to a health worker (clinicians or other medical practitioners) [21]. The diagnosis was carried out in selected health centers by sputum smear microscopy. The Ministry of Health of the Republic of Indonesia defines the total number of all form of tuberculosis cases as the total number of population with new and recurrent (relapse) the episode of tuberculosis notified in a given year, while the total number of new smear-positive cases as the total number of population with new tuberculosis diagnoses if one or more sputum smear specimens at the start of treatment are positive for acid-fast bacillus [16], [17], [18], [19].

The measures of predictors related to socioeconomic determinants such as poverty, unemployment, income inequality, and low education level for the year 2010–2013 were obtained from the Indonesian Social and Population Profile Report 2010–2013, on the official website of the Central Bureau of Statistics, Indonesia (Badan Pusat Statistik) [22]. Poverty is represented as the total population living below Indonesia's poverty line. The poverty line is defined by the Central Bureau of Statistics, Indonesia as the amount of expenditure required to obtain 2100 food calories per day, along with the amount of expenditure for other basic non-food items, such as housing, clothing, cost of formal education, and health cost [22]. Three covariates related to poverty and tuberculosis were also considered, that is, unemployment, income inequality, and low education [7], [15]. Unemployment is the percentage of the labor force that is unemployed per total population of each area in a given year. The Gini coefficient (Gini index), the most commonly used measure of income inequality, was applied in this study. This coefficient measures the distribution of income across the population. It varies from 0 (perfect equality) to 1 (perfect inequality). A higher Gini index indicates greater inequality, with high-income individuals receiving much larger percentages of the total income of the population [22]. A low education level is represented as the percentage of the population with less than 9 years of formal education.

All variables (the total number of all form of tuberculosis cases, the total number of new smear-positive cases, poverty, unemployment, income inequality, and low education) were obtained by province. These data were available for the 33 provinces from 2010 to 2013, before the 34th Province of Indonesia, the North Kalimantan, was formally established in 2014.

Data analysis

Data points for each variable were averaged (from the year 2010 to 2013) and represented as a continuous variable. Univariate analysis was performed across cases of one variable over observation years per province. We presented both mean and median for each variable, including standard deviation, and minimum and maximum values. Bivariate relationship between each explanatory variable (poverty, unemployment, income inequality, and low education) and outcome variables (the total number of all form of tuberculosis and the total number of new smear-positive cases) were assessed by calculating the Pearson Product Moment correlation coefficient (α = 0.05). The coefficient of determination or squared correlation coefficient (r^2) was obtained to

calculate the proportion of each measure of tuberculosis notification cases that were explained by each predictor variable. If more than one significant bivariate predictor was identified, then forward stepwise multivariate linear regression was performed (using all bivariate-significant predictors as candidates to enter the multivariate regression equation). A candidate predictor variable could enter and remain in the multivariate equation if the p-value associated with its multivariate regression coefficient was < 0.05. The forward stepwise selection was used because it provides the significant bivariate predictors that have the greatest utility in accounting for variance in the outcome variable in the regression model. It also accounts for the possible inherent collinearity between predictor variables. In ecological studies, where area-level aggregated data are used, the distributional assumptions of linear regression rarely hold. Therefore, all variables were transformed into a natural logarithmic scale to hold the parametric distributional form. Multivariate linear regression was performed for predicting both the total number of all form of tuberculosis cases and the total number of new smear-positive cases. The strength of association in linear regression analysis was appraised by the Beta value (a standardized coefficient ranging from -1 to 1). All analyses were performed by using the STATA statistical software package (version 12.0; STATA Corporation, College Station, TX, USA) with $\alpha = 0.05$.

Results

Univariate findings

Table 1 presents the descriptive statistics for all variables in the analyses. There is a considerable province-level variation with respect to tuberculosis notification cases in Indonesia, both for all form of tuberculosis cases (range from 1204 to 62563) and new smear-positive cases (range from 502 to 34301). Even though from the year of 2010 to 2013, it showed a downward trend in the socioeconomic variables, yet an upward one in tuberculosis notification cases. Complete data for all variables (tuberculosis notification cases and socioeconomic variables) in each province are available in the Appendix/Supplementary File.

Bivariate findings

Table 2 demonstrated bivariate analyses between each predictor and each outcome. Individually, poverty and unemployment were significantly correlated against tuberculosis notification cases. Poverty was strongly correlated with both measures of the total number of all form of tuberculosis cases (r = 0.842) and the total number of new smear-positive cases (r = 0.830), whereas unemployment had a moderate correlation with both measures (i.e., r = 0.466 and r = 0.410, respectively). In contrast, income inequality and low education levels were not correlated significantly with both measures of tuberculosis notification cases.

Table 1: Descriptive statistics of all variables

Variable	Year	Mean ± SD	Median (range)
Tuberculosis notification cases [16], [17], [18], [19]			
All form	2010	9177.61 ± 13172.77	4592 (1176–61010)
	2011	9592.79 ± 13686.71	4732 (1204–62563)
	2012	9820.79 ± 13597.33	4866 (1467–60801)
	2013	9911.94 ± 13607.98	5084 (1446–61721)
New smear-positive cases	2010	5556.54 ± 7156.38	3151 (635–32649)
	2011	5902.42 ± 7577.98	3328 (585–34301)
	2012	5983.24 ± 7486.73	3506 (502–33479)
	2013	5948.79 ± 7342.21	3424 (736–33460)
Socioeconomic variables[22]			
Poverty	2010	940109.10 ± 1431550	428800 (67800–5529300)
	2011	909664.50 ± 1377881	380110 (72060–5356210)
	2012	882793.90 ± 1322761	363300 (71400–5071000)
	2013	850502.10 ± 1255042	369010 (69220–4771260)
Unemployment	2010	6.68 ± 2.57	6.02 (3.49–14.13)
	2011	6.09 ± 2.60	5.62 (2.67–13.50)
	2012	5.33 ± 2.47	5.17 (2.07–10.74)
	2013	4.97 ± 2.34	4.51 (1.81–9.77)
Income inequality	2010	0.36 ± 0.04	0.36 (0.29–0.43)
	2011	0.37 ± 0.04	0.37 (0.30–0.46)
	2012	0.38 ± 0.04	0.38 (0.29–0.44)
	2013	0.38 ± 0.03	0.37 (0.31–0.44)
Low education	2010	72.35 ± 7.16	73.18 (51.14–81.01)
	2011	68.30 ± 8.56	70.07 (44.25–79.32)
	2012	66.58 ± 8.53	68.84 (42.68–76.97)
	2013	66.64 ± 8.40	68.51 (42.22–76.93)

Table 2: Pearson product-moment correlation between socioeconomic variables and measures of tuberculosis notification cases across 33 provinces in Indonesia between 2010 and 2013

Socioeconomic variables	r	Tuberculosis notification cases	
		All form	New smear-positive cases
Poverty	r	0.842***	0.830***
	r^2	0.709	0.688
Unemployment	r	0.466**	0.410*
	r^2	0.217	0.168
Income inequality	r	0.226	0.152
	r^2	0.051	0.023
Low education	r	0.030	0.169
	r^2	0.000	0.028

*p < 0.05; **p < 0.01; ***p < 0.001.

The strength of the correlation is shown in Figure 1. It depicts the positive correlation between significant socioeconomic variables (poverty and unemployment) and tuberculosis outcome measures. As noted by the r^2 values in Table 2, the variance of both measures of tuberculosis notification cases accounted by poverty was large by about 70%. Meanwhile, unemployment is explained roughly by 22% and 17% of the variance in both measures of tuberculosis outcomes, that is, the total number of all form of tuberculosis cases and the total number of new smear-positive cases, respectively.

Multivariate findings

The stepwise multivariate linear regression performed for two measures of tuberculosis notification cases (Table 3) revealed that both poverty and unemployment entered the regression model and achieved multivariate significance. The linear regression model using the total number of all form of tuberculosis cases was significant (p < 0.001) and explained

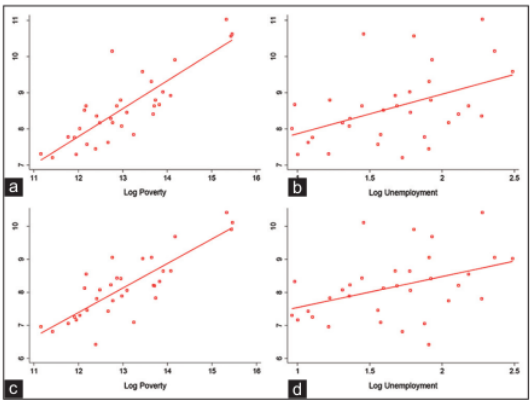

Figure 1: Ecological associations between bivariate-significant socioeconomic variables (log-poverty and log-unemployment) and log-tuberculosis notification cases for all form of tuberculosis cases (A and B) and new smear-positive cases (C and D) from 2010 to 2013 for all 33 provinces

approximately 77% of the variance (adjusted $r^2 = 0.768$). The model used the total number of new smear-positive cases as the outcome was significant ($p < 0.001$) and accounted for nearly 72% of the variance (adjusted $r^2 = 0.717$). As indicated by the *Beta* value listed in Table 3, poverty was a stronger predictor variable than unemployment for both measures of tuberculosis notification cases adjusting for the effect of each variable in the regression model. The more poverty and the more unemployment, the higher tuberculosis notification cases, given adjusting each covariate. When each covariate was adjusted, poverty will have more impact than unemployment in the increased tuberculosis notification cases in the multivariate regression model.

Table 3: Stepwise multivariate linear regression model predicting measures of tuberculosis notification cases across 33 provinces (during 2010–2013 period) based on predictor variables with bivariate statistical significance

Predictor	Tuberculosis notification cases	
	All form	New smear-positive cases
Poverty		
Beta value[a]	0.711***	0.696***
Partial R^{2b}	0.722	0.682
Unemployment		
Beta value[a]	0.654**	0.510*
Partial R^{2b}	0.253	0.150

[a]The Beta value is the increase in the measures of tuberculosis notification cases per unit increase in the predictor variable. For example, the log-all form of tuberculosis cases increased by 0.711 for every 1 unit increase in the log-poverty. [b]The partial R^2 is the increase in the model R^2 when the variable is added as the last variable in the model. For example, an additional 72.2% of the variation in the log-all form of tuberculosis cases among provinces was accounted for by the addition to the model of log-poverty.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Discussion

Provinces in Indonesia are heterogeneous in tuberculosis epidemiology which has important public health implications. Province was the unit analysis because it was the macro-level analysis that we sought to measure. The total number of tuberculosis notification cases was used in this study rather than the tuberculosis notification cases rate (tuberculosis cases per 100,000 people) since data on tuberculosis notification cases rate by province in Indonesia is not consistently reported by the Ministry of Health of Indonesia [16], [17].

This province-level analysis discovered a strong relationship between poverty and tuberculosis notification cases. This exploratory study indeed requires a more intensive empirical study designed to identify causal mechanisms that may be presently reflected as the proxy of poverty. It is also important to explore the potential for confounding variables to explain the relationship between poverty and tuberculosis notification cases. Nonetheless, poverty is an important determinant of the observed disparities in tuberculosis notification cases across provinces Indonesia. Indeed, the power of the proxy (poverty) to account for such a large degree of the variance in the observed tuberculosis notification cases is noteworthy. In addition, the evidence is supported when considering the finding from the previous studies conducted in developed countries [10], [11], [12], [13], [14]. Specifically, the previous findings suggest that the higher poverty area is independently associated with an increased estimated probability of higher tuberculosis cases.

Considering the complex host-pathogen interplay at the population level, several causal mechanisms have been postulated for the linkage of poverty and tuberculosis. Poverty facilitates the transmission of *Mycobacterium tuberculosis*, mainly through its influence on living conditions (e.g., people living in overcrowded and poorly ventilated homes), a prolonged diagnostic delay, and an increased vulnerability due to malnutrition and/or HIV infection [14], [23], [24], [25], [26], [27].

A potential implication of the findings that reinforce a social protection intervention designed to reduce poverty and vulnerability among poor people may be an important endeavor for a macro-level approach to reduce tuberculosis cases. Although any strategy has not yet been developed, theory-based approaches have been described. Statistical modeling of cross-country analysis found that an increase in social protection spending was associated with a decrease in tuberculosis notification cases rates, estimated incidence rates, non-HIV-related tuberculosis mortality rates, and all-cause tuberculosis mortality rates [28]. This study done by Reeves *et al*. controlled other confounding factors for economic output, public health spending, and country-fixed effect. Another study proved that cash transfer and microfinance interventions can positively impact tuberculosis by controlling tuberculosis risk factors such as improving health-care access, economic-well-being, and food security [29]. Thus, investment in poverty reduction programs is likely to provide an effective complement

to tuberculosis prevention and treatment programs, especially for vulnerable groups.

In Indonesia, financial and economic support is a concerning issue in Tuberculosis management. The current level of social protection in Indonesia is insufficient to minimize the impact of socioeconomic factors on tuberculosis notification cases. Thus, it might need innovative social-protection policies and better levels of local and external funding [30]. In addition, the programs to encourage poverty reduction and tuberculosis prevention and treatment could involve a collaboration of multiple change agents including public health specialists, policymakers, physicians, allied health professionals, urban planners, non-governmental organizations, and other community leaders [31]. However, more evidence for poverty reduction and tuberculosis may be needed to promote bold and new policy recommendations.

Limitation

The study presented here is, however, subject to several limitations. Provincial-level measures fail to capture the potentially strong association at an individual level – a lower ecological hierarchy, due to aggregation bias inherited in all ecological studies. Besides, the association between poverty and other important socioeconomic variable such as social capital has not been described in the present study [10]. As a result, a confounding effect is observed when applying the findings to any given community and condition. Hence, the provincial level findings cannot be generalized to the lower ecological hierarchy and to a province that has more complex ecological factor interaction. However, the provincial-level findings suggest that further empirical study at the macro-level and using more controlled confounding variables is required. Finally, it should be noted that a causal explanation for the observed findings cannot be identified at this time. Taking into account the cross-sectional nature of the datasets drawn on, the likelihood of reverse causation is also necessary to consider as an explanation for some of these results. Nevertheless, given the strong association between poverty and tuberculosis notification cases across provinces in Indonesia, this study lends support to the idea of ensuring equality between the province as an important foundation for effective tuberculosis control.

Conclusion

Findings from this province-level analysis suggest that poverty is a strong predictor of disparities in tuberculosis notification cases across provinces in Indonesia. Thus, poverty alleviation may play an important role in the management of tuberculosis for effective disease control. Merging individual tuberculosis care and poverty alleviation approaches at the macro-level and micro-level with the public health may have an impact on the future burden of the disease and be measurable. This exploratory study also requires subsequent empirical studies designed to spot many strategies (e.g., social protection interventions such as cash transfer programs and microfinance programs) that can be taken to reduce poverty for further lowering tuberculosis cases and disparities across provinces in Indonesia.

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Appendix

Supplement 1: The averaged of the total tuberculosis notification cases (all form and new smear-positive cases) as outcomes, and the socioeconomic variables (poverty, income inequality, unemployment, and low education) as predictors, by province in Indonesia from 2010 to 2013

	Province	Tuberculosis notification cases		Socioeconomic variables			
		All form (n)	New positive (n)	Poverty (n)	Income inequality (Gini index)	Unemployment (%)	Low education level (%)
12	Aceh	4499	3672.75	876602.5	0.323	8.272	64.602
2	North Sumatra	20162.5	16181.25	1429643	0.346	6.897	63.335
3	West Sumatra	6625.75	4525	421065	0.351	6.837	66.555
4	Riau	4718.5	3158	483682.5	0.366	5.935	66.350
5	Jambi	3527.5	3212.25	263030	0.332	3.710	70.875
6	South Sumatra	8286.75	5665.75	1091970	0.366	5.905	72.915
7	Bengkulu	2049	1686	316887.5	0.366	2.927	68.245
8	Lampung	7506.25	5721	1298868	0.361	5.345	75.407
9	Bangka Belitung	1495.25	1051.75	70120	0.301	3.372	72.870
10	Riau Islands	2387.5	1160	129282.5	0.330	6.542	48.592
11	DKI Jakarta	25592.25	8602.75	348252.5	0.413	10.627	45.072
12	West Java	61523.75	33472.25	4549218	0.398	9.767	72.185
13	Central Java	38850.75	20052.25	5046728	0.372	6.085	77.407
14	D.I. Yogyakarta	2550.5	1203.5	563417.5	0.420	4.832	56.542
15	East Java	41015.75	24675	5181943	0.358	4.297	74.902
16	Banten	14534	8293	689432.5	0.402	12.035	66.160
17	Bali	3009.25	1487	168110	0.403	2.617	61.572
18	West Nusa Tenggara	5647.75	3645.5	896902.5	0.368	5.405	75.797
19	East Nusa Tenggara	5856	4142	1008265	0.363	2.667	78.447
20	West Kalimantan	5622	4592.5	385305	0.386	4.245	77.877
21	Central Kalimantan	2349.25	1407.5	149015	0.330	3.015	74.022
22	South Kalimantan	5002.5	3377.75	187065	0.370	4.927	74.007
23	East Kalimantan	4266.75	2460.25	245540	0.370	9.722	59.892
24	North Sulawesi	5642	5165.5	193775	0.403	8.872	63.487
25	Central Sulawesi	3222.75	2666	430662.5	0.390	3.890	72.682
26	South Sulawesi	11061	8600.75	839945	0.412	6.755	70.032
27	Southeast Sulawesi	3977.5	3734	337177.5	0.414	3.910	68.500
28	Gorontalo	1949.5	1734	196912.5	0.442	4.745	75.920
29	West Sulawesi	1478.5	1289	155167.5	0.340	2.722	76.947
30	Maluku	3556	2307.5	352740	0.372	7.732	62.472
31	North Maluku	1348.75	908.5	90912.5	0.332	5.615	68.552
32	Papua	6623.5	2511	922587.5	0.428	3.402	76.207
33	West Papua	1712.75	614.5	240102.5	0.410	6.745	61.020

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