The analysis of tuberculosis funds efficiency on high burden countries

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ABSTRAK

Tuberkulosis tetap menjadi masalah utama kesehatan global dan menempati urutan kedua sebagai penyebab kematian utama dari penyakit menular di seluruh dunia. Setiap negara berusaha mengeluarkan anggaran yang berbeda untuk mengatasi masalah tuberkulosis. Tingkat efisiensi penggunaan anggaran akan mengurangi jumlah kasus tuberkulosis dan memberikan dampak yang baik bagi perekonomian. Tujuan penelitian ini adalah memperkirakan skor efisiensi teknis dana tuberkulosis di negara-negara yang memiliki beban tuberkulosis tinggi dengan menggunakan metode Data Envelopment Analysis (DEA) dan menganalisis faktor lingkungan lain yang memainkan peran penting untuk meningkatkan skor efisiensi dengan menggunakan metode Tobit. DEA menunjukkan beberapa negara memiliki skor efisiensi yang tinggi dan beberapa negara memiliki skor rendah yang menunjukkan bagaimana negara tersebut menggunakan anggaran untuk mencapai output yang maksimum. Estimasi Tobit menunjukkan bahwa pajak rokok dan anggaran pengendalian tembakau memiliki efek marginal yang positif terhadap skor efisiensi teknis.

ABSTRACT

Tuberculosis remains a major global health problem and ranks as the second leading cause of death from infectious disease worldwide. Countries devote their budgets to overcome the tuberculosis problem. An efficient use of these budgets will arguably reduce the number of tuberculosis cases and eventually give a positive impact to the economy. This paper aims to estimate the technical efficiency scores of tuberculosis funds on high-burden countries by using Data Envelopment Analysis (DEA) method. Further, this study analyzes other environmental factors that are crucial to increase the efficiency scores by using Tobit method. DEA shows that some countries exhibit high efficiency scores while others exhibit low efficiency scores. It also informs how countries use funds to maximize their results. Meanwhile, the Tobit estimation shows that taxing cigarettes and

committing budgets to control tobaccos have positive marginal effects on technical efficiency scores.

INTRODUCTION

TB (tuberculosis) now ranks alongside HIV (Human Immunodeficiency Virus) infection as a leading cause of death worldwide. Global TB Report reported that in 2014, TB killed 1.5 million people; among them, 0.4 million are HIV positive. TB related mortality reached 890,000 men, 480,000 women, and 140,000 children. WHO (World Health Organization) also estimates that there are 9.6 million people suffered from TB in 2014 consisting of 5.4 million men, 3.2 million women, and 1.0 million children. Mortality causes great economic burdens due to large productivity loss (Hanly, Soerjomataram, & Sharp, 2015).

Most developing countries face significant health problems because of the high burdens of communicable diseases like malaria, tuberculosis, and HIV/AIDS (World Bank, 2006). TB is a contagious disease that becomes a major global health problem. Infectious diseases like TB cause significant economic losses (Fonkwo, 2008). The WHO reports that Afghanistan, Bangladesh, Brazil, Cambodia, China, DR Congo, Ethiopia, India, Indonesia, Kenya, Mozambique, Myanmar, Nigeria, Pakistan, Philippines, Thailand, Tanzania, Viet- Nam, and Zimbabwe were countries with the highest TB burden globally (WHO, 2015).

Table 1 shows the number of TB-related incidence and mortality. In 2017, India had the highest number of TB incidence in the world with 2.7 million people, followed by China with 0.889 million people and Indonesia with 0.842 million people. Meanwhile, the lowest number of TB incidence among high TB-burden countries was Congo with 20.000 people.

Indonesia had the third highest TB-related mortality after India and Nigeria. High TB mortality rates in India, Nigeria, and Indonesia created significant burdens on respective countries. The previous study also reports that the average cost per TB death was about \$ 66.872 in the Africa region (Kirigia & Muthuri, 2016).

Governments need fundings for preventing, diagnosing, and treating TB to overcome the problem. Optimal prevention policies will reduce TB incidences. Further, comprehensive diagnosis, effective treatment, and increased budgetary outlay result in significant improvements in TB cure rates (Khatri, 1996). The rapid growth of health expenditure has become a great concern for the governments, but health expenditure does not grow faster than GDP (Xu, Saksena, & Holly, 2011). Weak and underfinanced health systems create a heavier burden on health. In the case of TB, the low health government budgets imply that external donors must bear the lion share of the treatment costs (World Bank, 2006).

Table 1
Number of Tuberculosis Incidence and Mortality
In TB High Burden Countries in 2016- 2017

Country	Number of Incidences (People)		Number of Mortality (People)	
	2016	2017	2016	2017
Afghanistan	66,000	67,000	13,000	14,000
Bangladesh	360,000	364,000	66,180	59,170
Brazil	87,000	91,000	7,000	7,000
Cambodia	54,000	52,000	3,650	3,510
China	895,000	889,000	51,800	38,800
Congo	19,000	20,000	5,200	5,600
Ethiopia	182,000	172,000	30,000	28,600
India	2,790,000	2,740,000	435,000	421,000
Indonesia	1,020,000	842,000	123,000	116,400
Kenya	169,000	158,000	53,000	43,000
Mozambique	159,000	163,000	55,000	49,000
Myanmar	191,000	191,000	29,900	31,900
Nigeria	407,000	418,000	154,000	155,000
Pakistan	518,000	525,000	46,100	56,200
Philippines	573,000	581,000	22,300	26,380
Thailand	119,000	108,000	12,500	12,200
Tanzania	160,000	154,000	55,000	49,000
Viet Nam	126,000	124,000	13,850	12,800
Zimbabwe	34,000	37,000	5,600	8,300

Source: Global TB Report 2017 & 2018 (WHO, 2017, 2018)

Figure 1 shows that most of TB high burden countries use more international funding than local funding, with the exception for Brazil, China, Congo, India, and Indonesia.

Source: Global TB Report 2018 (WHO, 2018)

Figure 1
Source of Tuberculosis Funding in TB High Burden Countries in 2017

The amount of domestic and international funding will affect the flexibility of the governments to run a variety of TB related policies. WHO reports that, globally, as high as US\$ 4.8 billion is needed to overcome TB. However, in Nigeria, the previous study shows that government spending on health has been mostly inefficient (Olanubi & Osode, 2017).

Given the limited resources and a large financial needs to overcome TB, efficiency in using available resources is crucial. This study aims to analyze the efficiency in using TB related funds. In particular, this study answers the following research questions. First, what are the technical efficiency scores of TB funds in high burden countries? Second, what are the other environmental factors that play an essential role to increase efficiency scores? This research can be a recommendation for high burden countries to increase the TB budget and manage efficiently. Efficient uses of funds will potentially reduce the number of incidence and mortality caused by TB.

LITERATURE REVIEW

Tuberculosis

Tuberculosis is an infectious disease caused by a stem-shaped bacteria

(bacillus) known as *Mycobacterium Tuberculosis* (Manalu, 2010). Tuberculosis is recognized as one of the most ancient diseases of humankind and co-evolved for many thousands of years with human (Hirsh, Tzolaki, DeRiemer, Feldman, & Small, 2004). In spite of newer modalities for diagnosis and treatment of TB, unfortunately, millions of people are still suffering and dying from this disease and TB becomes one of the top three infectious killing diseases in the world (Sandhu, 2011). The incidence of Tuberculosis is caused by many factors such as individual characteristics, socio-economy, bad residential environment, and low quality of health care facilities (Ristyo, Iman Ali, & Nahariani, 2013). Rapid and appropriate treatment in patients with tuberculosis will affect the healing rate of tuberculosis patients. Tuberculosis overcoming becomes difficult because there are many challenges for diagnostic and treatment mostly in high burden countries. Many studies report barriers to overcome tuberculosis like financial barriers, physical barriers, health literacy, and provider barriers (Yang et al., 2014). Even gender-based analysis shows that men and women face different barriers when accessing TB diagnostic and treatment service (Hudelson, 1996). With all the obstacles that exist, the government must implement the best strategies to overcome tuberculosis.

The Economic Impact of Tuberculosis

Tuberculosis will automatically affect the economy in high burden countries. Many countries with high burden countries have spent many budgets to overcome tuberculosis (WHO, 2015). Tuberculosis will decrease productivity and create deaths. For example, 0.753 million tuberculosis deaths that occurred in the African Region in 2014 would be expected to reduce the future non-health GDP by International Dollars 50.4 billion (Kirigia & Muthuri, 2016). Previous studies also calculate the cost of tuberculosis. The mean cost of managing TB in Russia over 12 months was about US\$ 572 per cases (Atun et al., 2006). Meanwhile, the cost in Denmark is higher with direct cost per TB patient was about €10.509 (Fløe et al., 2015). High costs are also borne by immigrant patients in the Netherlands. It is estimated that the direct and indirect costs per TB patient are about €2.956 (Kik et al., 2009). Compared to some countries in Asia, the study also shows that total socio-economic cost of tuberculosis in India is about US\$171 per patient (Rajeswari et al., 1999) and in Malaysia US\$ 727.25 per patient (Atif, Sulaiman, Shafie, Asif, & Babar, 2014). All the previous studies show that tuberculosis creates adverse impacts on the economy.

Tuberculosis Funding

Tuberculosis financing can come from government or international funding such as The Global Fund. Besides giving funds to fight AIDS and Malaria, The Global Fund also provides significant funding to fight Tuberculosis (Bridge et al., 2016).

Founded in 2012, The Global Fund is a partnership between governments, civil societies, private sectors, and affected populations and become a leading international donor for harm reduction services (Bridge, Hunter, Atun, & Lazarus, 2012). From The Global Fund grants database, there was \$21.7 billion that was invested in 150 countries by the end of 2010 (Lee, Lal, Komatsu, Zumla, & Atun, 2012). Besides The Global Fund, some countries also can borrow funds from the IMF. The International Monetary Fund (IMF) as an international organization provides fund for financially ailing countries, including capital for health program (Stuckler, King, & Basu, 2008). TB Program fundings support for staff, drug-susceptible TB drugs, laboratories, patient support, community engagement, public-private mix surveys, and operational research (WHO, 2015).

Funds Efficiency

Funds Efficiency for tuberculosis deals with how governments use both types of existing budgets, which come from local and international budgets. Tuberculosis is the part of health expenditure, and health expenditure is part of government expenditure. Some previous studies that focus on the efficiency are Balaguer-Coll, Prior, & Tortosa-Ausina (2010); Afonso & Aubyn (2006); Jorge, Camões, Baptista, & Fernandes (2006); Afonso & Fernandes (2008); and Sihaloho (2018). These studies use Data Envelopment Analysis (DEA) to calculate the efficiency score of the government expenditure that can be implemented to calculate the efficiency score of tuberculosis expenditure. Simply increasing public expenditure in the health sector does not significantly affect health outcomes, thus indicating the low efficiency of health spending (Grigoli & Kapsoli, 2018). In a similar vein, when increased TB funds do not significantly reduce TB cases, this implies the low efficiency of TB spending. The efficiency of various expenditures is labeled as technical efficiency (Esanov, 2009).

Cigarette Tax and Tobacco Control Funds

Many factors cause tuberculosis infection. Latent Tuberculosis Infection (LTBI) is defined as the presence of Mycobacterium tuberculosis protein that is difficult to detect because of the absence of the clinical symptoms of active diseases. LTBI will potentially become TB disease depending on high-risk groups and other factors (Feng et al., 2014). Feng et al. (2014) find that cigarette smoking is a risk factor that is associated with a higher prevalence of LTBI. Cigarette smoke has a negative impact on respiratory immune function and is associated with increased respiratory infections, including Tuberculosis (Garmendia, Morey, & Bengoechea, 2012). Hence, governments must control cigarette consumption, such as by implementing a high cigarette tax and raising tobacco control funds. Increasing cigarette tax likely reduces

cigarette consumption (Showalter, 1998). Besides levying cigarette tax, numerous countries have started to control tobacco consumption in cooperation with scholars and activists (Hoang et al., 2016). Higher tobacco control funds facilitate governments to launch innovative programs to control tobacco/ cigarette consumption. An example of tobacco control programs is the prohibition of cigarette advertisements and promotion. Another study also finds that smoke-free air regulation as a tobacco control policy strongly affects adults' smoking behavior (Mader, Lapin, Cameron, Carr, & Morley, 2016).

RESEARCH METHODS

Data Description

This study uses secondary data from the Global TB Report 2009-2018. This research focuses on measuring the TB funds efficiency and analyzes the environmental factors that can increase technical efficiency scores in 19 TB high burden countries. This study uses the period of 2011-2017. Ideally, the inputs are all the resources used by the health system to increase the health status of the population (Behr & Theune, 2017). Cetin and Bache (2016); Behr and Theune (2017); Sun, Ahn, Lievens, and Zeng (2017); Ibrahim and Daneshvar (2018) use kind of health budget as input for DEA measurement (Behr & Theune, 2017; Cetin & Bahce, 2016; Ibrahim & Daneshvar, 2018; Sun, Ahn, Lievens, & Zeng, 2017). Based on previous studies, this study uses the following health budget as inputs: domestic fundings and international fundings. Whereas the outputs are the total value of health goods and services produced (Behr & Theune, 2017). Asandului, Roman and Fatulescu (2014); Behr and Thune (2017) use life measurement as output (Asandului, Roman, & Fatulescu, 2014; Behr & Theune, 2017). WHO has a target to decrease the incidence number and the death number of Tuberculosis (WHO, 2018).

This study uses the following health budget as outputs: the number of decreased TB deaths, the number of reduced TB incidences, and the number of new SMEAR laboratory. This study use a Tobit analysis to identify some factors that affect efficiency. Kolappan and Gopi (2002); Hassmiller (2006); Lin, Murray, Cohen, Colijn, and Ezzati (2008); Leung et al. (2010); Basu, Stuckler, Bitton, and Glantz (2011) study the association between tuberculosis and smoking (Basu, Stuckler, Bitton, & Glantz, 2011; Hassmiller, 2006; Kolappan & Gopi, 2002; Leung et al., 2010; Lin, Murray, Cohen, Colijn, & Ezzati, 2008). Showalter (1998) report that more tax of cigarette will decrease cigarette consumption and Mader et al. (2016) report tobacco control has a strong influence on cigarette consumption (Mader et al., 2016; Showalter, 1998). This study aims to estimate tax of cigarette and budget of tobacco control as environmental

factors that can affect the efficiency scores.

Data Envelopment Analysis (DEA)

DEA evaluates the performance of a set of peer entities that converts multiple inputs into multiple outputs called Decision Making Units (DMUs). The definition of DMU is generic and flexible to evaluate the performance of many different types of entities in many countries (Cooper, Seiford, & Zhu, 2011). Data Envelopment analysis evaluates the performance and produces a relative efficiency score. This study uses STATA 12 to calculate the DEA process:

$$\text{Max } \theta \dots\dots\dots 1$$

Subject to:

$$\sum_{j=1}^n \lambda_j X_{ij} \leq X_{i0} \quad i = 1, 2, \dots, m \dots\dots\dots 2$$

$$\sum_{j=1}^n \lambda_j Y_{rj} \leq \theta Y_{r0} \quad r = 1, 2, \dots, s \dots\dots\dots 3$$

$$\sum_{j=1}^n \lambda_j = 1 \quad \lambda_j \geq 0 \quad j = 1, 2, \dots, n \dots\dots\dots 4$$

Source: Banker, Charnes, and Cooper (1984)

The DEA process shows that θ is the efficiency score with value $0 < \theta < 1$. X_{i0} and Y_{r0} are the i^{th} input and r^{th} output for DMU and $j = 1, 2, \dots, n$ represents the number of DMUs (Chan & Karim, 2012). For data processing, the selected countries classified as DMU. The DEA measures the relative efficiency score by comparing the multiple inputs and multiple outputs for each DMU. Table 2 shows the selected countries as DMU.

Table 2
Decision-Making Unit (DMU)

DMU	Country	DMU	Country
1	Afghanistan	11	Mozambique
2	Bangladesh	12	Myanmar
3	Brazil	13	Nigeria
4	Cambodia	14	Pakistan
5	China	15	Philippines
6	Congo	16	Thailand
7	Ethiopia	17	Tanzania
8	India	18	Viet Nam
9	Indonesia	19	Zimbabwe
10	Kenya		

Tobit Analysis

“Tobit analysis, a model which assumed that the dependent variable has a number of its values clustered at a limiting value” (McDonald & Moffitt, 1980). We use zero value (discrete) and continuous data to analyze Tobit regression. Tobit estimation evaluates the importance of environmental or non-discretionary inputs to the output efficiency scores on a set of possible explanatory variables” (Afonso & Fernandes, 2008). The following is the Tobit regression model in this paper:

$$\theta_i = \beta_0 + \beta_1 \text{Tax_Cig} + \beta_2 \text{Tob_Con_Bud}_i + \mu_i \dots\dots\dots 6$$

The model shows that θ is the efficiency score of tuberculosis funds on high burden countries with range 0 and 1. Tax_Cig is the cigarette tax applied by the governments. Tob_Con_Bud is the budget of tobacco control spent by the governments in each country.

ANALYSIS AND DISCUSSION

DEA

DEA results in Table 3 show that the efficiency score of TB high burden countries in using their fund did not always increase from 2011 to 2017. DEA compared the input and output of all TB high burden countries per year. DEA generates annual efficiency score for each country. In 2011, there were six countries with an efficiency score of 1, and the number increased to seven countries in 2017. The efficiency score of one means that the use of domestic and international funding is optimum to reduce the number of TB-related incidence/death in that country.

Table 3
Efficiency Score of TB High Burden Countries in 2011-2014

DMU	Country	2011	2012	2013	2014	2015	2016	2017	Average
1	Afghanistan	1.000	0.567	1.000	0.871	0.468	0.524	0.383	0.689
2	Bangladesh	0.160	0.989	0.602	0.280	1.000	0.839	0.667	0.648
3	Brazil	0.207	0.548	1.000	1.000	1.000	1.000	0.767	0.789
4	Cambodia	0.263	0.586	0.791	0.733	0.671	1.000	0.431	0.639
5	China	1.000	0.110	1.000	1.000	1.000	0.117	1.000	0.747
6	Congo	0.129	1.000	1.000	0.415	0.367	0.464	1.000	0.625
7	Ethiopia	0.419	0.227	0.514	0.153	0.268	0.846	0.202	0.376
8	India	1.000	1.000	1.000	1.000	0.055	0.485	1.000	0.792
9	Indonesia	0.026	0.026	1.000	0.112	0.303	0.223	0.484	0.311
10	Kenya	1.000	0.080	0.426	0.426	0.582	0.191	1.000	0.529
11	Mozambique	0.036	0.146	0.524	1.000	0.552	0.847	1.000	0.587
12	Myanmar	0.150	0.635	0.758	0.238	0.390	0.245	0.099	0.359

DMU	Country	2011	2012	2013	2014	2015	2016	2017	Average
13	Nigeria	0.100	0.050	0.159	0.082	0.185	1.000	0.049	0.232
14	Pakistan	0.778	1.000	0.607	0.786	1.000	1.000	0.131	0.757
15	Philippines	1.000	0.383	1.000	0.841	0.199	0.180	0.078	0.526
16	Thailand	1.000	0.266	0.862	0.776	1.000	1.000	0.505	0.773
17	Tanzania	0.908	0.318	1.000	0.382	0.674	0.613	1.000	0.699
18	Viet Nam	0.921	0.378	0.451	0.327	0.709	0.563	0.329	0.525
19	Zimbabwe	0.482	1.000	0.496	1.000	0.582	0.756	1.000	0.759

Source: Data processing by STATA 12

The country with the lowest efficiency score differed yearly. In 2011 (0.026) and 2012 (0.027), Indonesia had the lowest efficiency score compared to the other TB burden countries. Further, Nigeria had the lowest efficiency score in 2013 (0.159) and 2014 (0.082), while India scored the lowest in 2015 (0.055), China in 2016 (0.118), and Nigeria in 2017 (0.049). The lowest efficiency score shows that the use of domestic and international funding was not optimum in reducing the number of TB-related incidence/death in that country.

Overall, the average efficiency score for all countries ranged between 0.232 – 0.792 in 2011-2017. It is likely that most of the countries did not use the budgets optimally. Nigeria had the lowest average score of efficiency (0.232), followed by Mozambique (0.587), Kenya (0.529), Philippines (0.526), Vietnam (0.525), Ethiopia (0.376), Myanmar (0.359), and Indonesia (0.311). These countries are most likely the worst in terms of allocating and managing the TB funding from 2011 to 2017. On the other hand, it seems that India was the most efficient country in allocating and managing the TB funding from 2011 until 2017.

Figure 3 shows the relation between efficiency score and international fund in 19 TB high burden countries from 2011-2017. From these data, India received the highest international funds in 2016 (US\$ 175 million) while Brazil received the lowest in 2013 and 2017 (US\$ 0.1 million). The figure also suggests that there was a negative relationship between the efficiency score and total international funds. The opposite applies to the relationship between efficiency score and domestic funds (Figure 4).

Source: Data processing by STATA 12

Figure 3
Efficiency and Total International Funding in TB High Burden Countries 2011-2017

Source: Data processing by STATA 12

Figure 4
Efficiency and Total Domestic Funding in TB High Burden Countries 2011-2017

Tobit

The Tobit estimation results show the influence of environmental factors as measured by the marginal effects on funds efficiency score of TB high burden countries. Many countries aim to reduce the number of smokers by increasing cigarette tax and establishing tobacco control frameworks. The taxation of tobacco products is always an important element of government policies toward smoking (Zimring & Nelson, 2012). The optimal framework of tobacco control will protect present and future generations from health problems, and other adverse social, environmental and economic consequences of tobacco consumption. The declining tobacco consumption will eventually decrease cigarette consumption.

Table 4
Tobit Result

	dy/dx	Std. Err.	z	P> z
Tax_Cig	0.005	0.006	0.81	0.428
Tob_Con_Bud	0.000	0.000	1.89	0.073

Source: Data processing by STATA 12

Table 4 shows that the cigarettes tax has a positive marginal effect of about 0.005 but not significant. The figure indicates low cigarette taxes in high TB burden countries. Low cigarette taxes only slightly increase cigarette prices and have no significant effect on the consumption of cigarettes. Previous studies show the negative association between cigarette taxes and smoking intensity although the effect is small and not usually statistically significant (e.g., Callison & Kaestner, 2014). The table also shows that tobacco control budget also has a positive marginal effect and significant at 0.000. Most of TB burden countries have a small amount of tobacco control budgets. Tobacco control has been one of the most successful public health endeavors in the past half of the century (Warner, Sexton, Gillespie, Levy, & Chaloupka, 2014). The Tobit regression can be a reference for TB high burden countries to increase tobacco control budgets. Higher funds will make it easier to implement tobacco control frameworks. A significant cigarette tax will also increase cigarette prices and eventually reduce cigarette consumptions (Callison & Kaestner, 2014).

CONCLUSION, LIMITATION, AND SUGGESTION

DEA process shows that there were countries that have not optimally used the existing budgets to resolve the TB problem, as indicated by the low efficiency score. These conditions were mostly caused by a small allocation from the local government. Most of the high burden countries received more fundings from the international source, and our DEA analysis suggests that large international fundings likely leads to

lower efficiency score. The inconsistent number of international funding and low local budgets create a funding gap between the expected budgets and the actual budgets. Funding gap decreases the quality of TB prevention program, diagnosis programs, and treatment programs. It delays governments' efforts in reducing the number of TB-related incidence and mortality. On the contrary, there is a positive relationship between the efficiency score and total domestic fundings. Therefore, governments need to allocate more domestic budgets and do not depend on international fundings. Further, our Tobit analysis shows that the marginal effects of cigarette taxes and tobacco control budgets. These results indicate that governments in TB high-burden countries have to increase cigarette taxes significantly to make cigarette prices very expensive and reduce consumption. Governments also need to increase the number of tobacco control budgets to ensure that the planned framework is implemented. In short, higher cigarette taxes and more tobacco control budgets will reduce cigarette consumption and eventually reduce TB cases.

This study is subject to the following limitations. Due to data limitation for our DEA and Tobit analysis, we only use a limited set of variables in this paper. Previous DEA studies usually use the number of health workers and health facilities as inputs because these inputs affect the efficiency value. This study also only uses a reduction in mortality as one of the outputs of DEA. We advise further studies to use the cure rates from TB as the outputs because the declining mortality rate does not fully represent the cure rate for TB. Many tuberculosis patients may not have died, but they may not fully recover as well. Previous papers report that the number of HIV-AIDS cases correlates with the number of TB cases. For the Tobit analysis, it is suggested future studies to use the number of HIV-AIDS cases as the variable. It is also better to use the poverty rate and education indicators as environmental factors.

REFERENCES

- Afonso, A., & Fernandes, S. (2008). Assessing and explaining the relative efficiency of local government. *Journal of Socio-Economics*, 37(5), 1946–1979. <https://doi.org/10.1016/j.socec.2007.03.007>
- Afonso, A., & St. Aubyn, M. (2006). Relative efficiency of health provision: A DEA approach with non-discretionary inputs. *ISEG-UTL Economics Working Paper*, 33, 1–32. <https://doi.org/10.2139/ssrn.952629>
- Asandului, L., Roman, M., & Fatulescu, P. (2014). The efficiency of healthcare systems in Europe: A data envelopment analysis approach. *Procedia Economics and Finance*, 10, 261–268. [https://doi.org/10.1016/S2212-5671\(14\)00301-3](https://doi.org/10.1016/S2212-5671(14)00301-3)

- Atif, M., Sulaiman, S. A. S., Shafie, A. A., Asif, M., & Babar, Z. U. D. (2014). Resource utilization pattern and cost of tuberculosis treatment from the provider and patient perspectives in the state of Penang, Malaysia. *BMC Health Services Research*, 14, 353–363. <https://doi.org/10.1186/1472-6963-14-353>
- Atun, R. A., Samyshkin, Y., Drobniewski, F., Balabanova, Y., Fedorin, I. M., Lord, J., & Coker, R. J. (2006). Costs and outcomes of tuberculosis control in the Russian Federation: A retrospective cohort analysis. *Health Policy and Planning*, 21(5), 353–364. <https://doi.org/10.1093/heapol/czl023>
- Balaguer-Coll, M. T., Prior, D., & Tortosa-Ausina, E. (2010). Decentralization and efficiency of local government. *Annals of Regional Science*, 45(3), 571–601. <https://doi.org/10.1007/s00168-009-0286-7>
- Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science*, 30(9), 1031–1142. <https://doi.org/10.1287/mnsc.30.9.1078>
- Basu, S., Stuckler, D., Bitton, A., & Glantz, S. A. (2011). Projected effects of tobacco smoking on worldwide tuberculosis control: Mathematical modelling analysis. *BMJ (Online)*, 343–353. <https://doi.org/10.1136/bmj.d5506>
- Behr, A., & Theune, K. (2017). Health system efficiency: A fragmented picture based on OECD data. *PharmacoEconomics - Open*, 1(3), 203–221. <https://doi.org/10.1007/s41669-017-0010-y>
- Bridge, J., Hunter, B. M., Albers, E., Cook, C., Guarinieri, M., Lazarus, J. V., ... Wolfe, D. (2016). The global fund to fight AIDS, tuberculosis and malaria's investments in harm reduction through the rounds-based funding model (2002–2014). *International Journal of Drug Policy*, 27, 132–137. <https://doi.org/10.1016/j.drugpo.2015.08.001>
- Bridge, J., Hunter, B. M., Atun, R., & Lazarus, J. V. (2012). Global fund investments in harm reduction from 2002 to 2009. *International Journal of Drug Policy*, 23(4), 279–285. <https://doi.org/10.1016/j.drugpo.2012.01.013>
- Callison, K., & Kaestner, R. (2014). Do higher tobacco taxes reduce adult smoking? New evidence of the effect of recent cigarette tax increases on adult smoking. *Economic Inquiry*, 52(1), 155–172. <https://doi.org/10.1111/ecin.12027>
- Cetin, V. R., & Bahce, S. (2016). Measuring the efficiency of health systems of OECD countries by data envelopment analysis. *Applied Economics*, 48(37), 3497–3507. <https://doi.org/10.1080/00036846.2016.1139682>
- Chan, S. G., & Karim, M. Z. A. (2012). Public spending efficiency and political and

- economic factors : Evidence from selected East Asian countries. *Economic Annals*, 57, 7–24. <https://doi.org/10.2298/EKA1293007C>
- Cooper, W. W., Seiford, L. M., & Zhu, J. (2011). Data envelopment analysis: History, models, and interpretations. In *International Series in Operations Research and Management Science* (Handbook o). Springer, Boston, MA. https://doi.org/10.1007/978-1-4419-6151-8_1
- Esanov, A. (2009). *Efficiency of public spending in resource-rich post-Soviet states. Public Spending in Resource-Rich Post-Soviet States*. Retrieved from https://resourcegovernance.org/sites/default/files/documents/rwi_esanov_efficiencyofpublicspending.pdf
- Feng, J. Y., Huang, S. F., Ting, W. Y., Lee, M. C., Chen, Y. C., Lin, Y. Y., ... Su, W. J. (2014). Impact of cigarette smoking on latent tuberculosis infection: Does age matter? *European Respiratory Journal*, 43, 630–632. <https://doi.org/10.1183/09031936.00118313>
- Fløe, A., Hilberg, O., Wejse, C., Løkke, A., Ibsen, R., Kjellberg, J., & Jennum, P. (2015). The economic burden of tuberculosis in Denmark 1998-2010. Cost analysis in patients and their spouses. *International Journal of Infectious Diseases*, 32, 183–190. <https://doi.org/10.1016/j.ijid.2014.12.021>
- Fonkwo, P. N. (2008). Pricing infectious disease. The economic and health implications of infectious diseases. *EMBO Reports*, 9(Suppl 1), 13–17. <https://doi.org/10.1038/embor.2008.110>
- Garmendia, J., Morey, P., & Bengoechea, J. A. (2012). Impact of cigarette smoke exposure on host-bacterial pathogen interactions. *European Respiratory Journal*, 39(2), 467–477. <https://doi.org/10.1183/09031936.00061911>
- Grigoli, F., & Kapsoli, J. (2018). Waste not, want not: The efficiency of health expenditure in emerging and developing economies. *Review of Development Economics*, 22(1), 384–403. <https://doi.org/10.1111/rode.12346>
- Hanly, P., Soerjomataram, I., & Sharp, L. (2015). Measuring the societal burden of cancer: The cost of lost productivity due to premature cancer-related mortality in Europe. *International Journal of Cancer*, 136(4), 136–145. <https://doi.org/10.1002/ijc.29105>
- Hassmiller, K. M. (2006). The association between smoking and tuberculosis. *Salud Publica de Mexico*, 48(Suppl 1), 201–216. <https://doi.org/10.1590/S0036-36342006000700024>
- Hirsh, A. E., Tsolaki, A. G., DeRiemer, K., Feldman, M. W., & Small, P. M. (2004).

- Stable association between strains of *Mycobacterium tuberculosis* and their human host populations. *Proceedings of the National Academy of Sciences*, 101(14), 4871–4876. <https://doi.org/10.1073/pnas.0305627101>
- Hoang, V. M., Tran, T. N., Vu, Q. M., Nguyen, T. T. M., Le, H. C., Vu, D. K., ... Kim, B. G. (2016). Tobacco control policies in Vietnam: Review on MPOWER implementation progress and challenges. *Asian Pacific Journal of Cancer Prevention*, 17(S1), 1–9. <https://doi.org/10.7314/APJCP.2016.17.S1.1>
- Hudelson, P. (1996). Gender differentials in tuberculosis: The role of socio-economic and cultural factors. *Tubercle and Lung Disease*, 77(5), 391–400. [https://doi.org/10.1016/S0962-8479\(96\)90110-0](https://doi.org/10.1016/S0962-8479(96)90110-0)
- Ibrahim, M. D., & Daneshvar, S. (2018). Efficiency analysis of healthcare system in Lebanon using modified data envelopment analysis. *Journal of Healthcare Engineering*, 2018(2060138), 1–6. <https://doi.org/10.1155/2018/2060138>
- Jorge, S., Camões, P., Baptista, J., & Fernandes, M. (2006). *Portuguese local government relative efficiency: A DEA approach. The 8th CIGAR Workshop on Performance Measurement and Output Based Budgeting in the Public Sector, Hamburg, Germany, September 14-15, 2006*. Retrieved from <https://core.ac.uk/download/pdf/55609200.pdf>
- Khatri, G. R. (1996). National tuberculosis control programme. *Journal of the Indian Medical Association*, 94(10), 372–384.
- Kik, S. V., Olthof, S. P., De Vries, J. T., Menzies, D., Kincler, N., Van Loenhout-Rooyackers, J., ... Verver, S. (2009). Direct and indirect costs of tuberculosis among immigrant patients in the Netherlands. *BMC Public Health*, 9(1), 283–291. <https://doi.org/10.1186/1471-2458-9-283>
- Kirigia, J. M., & Muthuri, R. D. K. (2016). Productivity losses associated with tuberculosis deaths in the World Health Organization African region. *Infectious Diseases of Poverty*, 5(43), 1–12. <https://doi.org/10.1186/s40249-016-0138-5>
- Kolappan, C., & Gopi, P. G. (2002). Tobacco smoking and pulmonary tuberculosis. *Thorax*, 57(11), 964–966. <https://doi.org/10.1136/thorax.57.11.964>
- Lee, D., Lal, S. S., Komatsu, R., Zumla, A., & Atun, R. (2012). Global fund financing of tuberculosis services delivery in prisons. *Journal of Infectious Diseases*, 205(Suppl 2), 274–283. <https://doi.org/10.1093/infdis/jis042>
- Leung, C. C., Lam, T. H., Ho, K. S., Yew, W. W., Tam, C. M., Chan, W. M., ... Au, K. F. (2010). Passive smoking and tuberculosis. *Archives of Internal Medicine*,

- 170(3), 287–292. <https://doi.org/10.1001/archinternmed.2009.506>
- Lin, H. H., Murray, M., Cohen, T., Colijn, C., & Ezzati, M. (2008). Effects of smoking and solid-fuel use on COPD, lung cancer, and tuberculosis in China: a time-based, multiple risk factor, modelling study. *The Lancet*, 372(9648), 1473–1483. [https://doi.org/10.1016/S0140-6736\(08\)61345-8](https://doi.org/10.1016/S0140-6736(08)61345-8)
- Mader, E. M., Lapin, B., Cameron, B. J., Carr, T. A., & Morley, C. P. (2016). Update on performance in tobacco control: A longitudinal analysis of the impact of tobacco control policy and the US adult smoking rate, 2011-2013. *Journal of Public Health Management and Practice*, 22(5), 29–35. <https://doi.org/10.1097/PHH.0000000000000358>
- Manalu, S. P. (2010). Faktor-faktor yang mempengaruhi kejadian TB paru dan upaya penanggulangannya. *Jurnal Ekologi Kesehatan*, 9(4), 1340–1346. <https://doi.org/https://doi.org/10.1139/v74-288>
- McDonald, J. F., & Moffitt, R. A. (1980). The uses of tobit analysis. *The Review of Economics and Statistics*, 62(2), 318–321. <https://doi.org/10.2307/1924766>
- Olanubi, S. O., & Osode, O. E. (2017). The efficiency of government spending on health: A comparison of different administrations in Nigeria. *Journal of Policy Modeling*, 39(1), 79–98. <https://doi.org/10.1016/j.jpolmod.2016.12.002>
- Rajeswari, R., Balasubramanian, R., Muniyandi, M., Geetharamani, S., Thresa, X., & Venkatesan, P. (1999). Socio-economic impact of tuberculosis on patients and family in India. *International Journal of Tuberculosis and Lung Disease*, 3(10), 869–877. <https://doi.org/10.1063/1.1622109>
- Ristyo, S., Iman Ali, M., & Nahariani, P. (2013). Hubungan tingkat sosial ekonomi dengan angka kejadian TB paru BTA positif di wilayah kerja PKM Peterongan Jombang tahun 2012. *Stikes Jombang*, 2(3), 31–38.
- Sandhu, G. (2011). Tuberculosis: Current situation, challenges and overview of its control programs in India. *Journal of Global Infectious Diseases*, 3(2), 143–150. <https://doi.org/10.4103/0974-777X.81691>
- Showalter, M. H. (1998). The effect of cigarette taxes on cigarette consumption. *American Journal of Public Health*, 88(7), 1118–1119. <https://doi.org/10.2105/AJPH.88.7.1118>
- Sihaloho, E. D. (2018). Efficiency analysis of local government spending of regencies and cities in West Java, 2001-2010. *Review of Indonesian Economic and Business Studies*, 6(2), 111–126.
- Stuckler, D., King, L. P., & Basu, S. (2008). International monetary fund programs

- and tuberculosis outcomes in post-communist countries. *PLoS Medicine*, 5(7), 1079–1090. <https://doi.org/10.1371/journal.pmed.0050143>
- Sun, D., Ahn, H., Lievens, T., & Zeng, W. (2017). Evaluation of the performance of national health systems in 2004-2011: An analysis of 173 countries. *PLoS ONE*, 12(3), 1–13. <https://doi.org/10.1371/journal.pone.0173346>
- Warner, K. E., Sexton, D. W., Gillespie, B. W., Levy, D. T., & Chaloupka, F. J. (2014). Impact of tobacco control on adult per capita cigarette consumption in the United States. *American Journal of Public Health*, 104(1), 83–89. <https://doi.org/10.2105/AJPH.2013.301591>
- WHO. (2015). Global TB Report 2015. *WHO Library Cataloguing in Publication Data*. <https://doi.org/WHO/HTM/TB/2011.16>
- WHO. (2017). Global TB Report 2017. *WHO Library Cataloguing in Publication Data*.
- WHO. (2018). Global TB Report 2018. *WHO Library Cataloguing in Publication Data*.
- World Bank. (2006). Health transitions, disease burdens, and health expenditure patterns. *Health Financing Revisited*.
- Xu, K., Saksena, P., & Holly, A. (2011). *The Determinants of Health Expenditure : A Country-Level Panel Data Analysis. Working Paper of the Results for Development Institute*. <https://doi.org/BST0391061>
- Yang, W.-T., Gounder, C. R., Akande, T., De Neve, J.-W., McIntire, K. N., Chandrasekhar, A., ... Gupta, A. (2014). Barriers and delays in tuberculosis diagnosis and treatment services: Does gender matter? *Tuberculosis Research and Treatment*, 2014(1), 1–16. <https://doi.org/10.1155/2014/461935>
- Zimring, F. E., & Nelson, W. (2012). Cigarette taxes as cigarette policy. *Tobacco Control*, 4(Suppl 1), 25–33.