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RESEARCH

Incidence and pattern of tuberculosis treatment success rates in different levels of the human development index: a global perspective

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Background: Tuberculosis (TB) treatment success rate remains a public health challenge in many developed and developing countries. The correlation between the incidence and pattern of TB and the Human Development Index (HDI) has not been globally determined. This study aimed to determine the correlation between incidence and pattern of TB treatment success rates and HDI around the world.
Methods: In this global perspective, we used data on incidence and treatment success rates of TB and HDI from the World Health Organisation (WHO) and World Bank, respectively.
Results: The highest estimated incidence and lower treatment success rates of TB were restricted to countries with low HDIs. Life expectancy, education level, gross national income, HDI, and urbanisation were significantly associated with both TB incidence and treatment success rates.
Conclusion: Patterns in TB incidence and treatment success rates are correlated with Human Development Indices. In addition to following WHO strategies, policy makers need to focus on the social and environmental determinants in order to reduce the TB burden, particularly in low income countries.

Keywords: ecological study, human development index, incidence, tuberculosis

Introduction

Tuberculosis (TB) is still considered one of the major global threats to public health, despite promised targets of the Millennium Development Goals (MDGs). In 2014, about 9.6 million people were affected and 1.5 million people died due to this disease worldwide.[1] TB occurs in all regions; however, about 80% of new cases occur in 22 countries including India, Indonesia, Nigeria and Pakistan. In addition, in 2014, about 480 000 people around the world were diagnosed with multidrug-resistant TB (MDR-TB) among which more than half occurred in India alone.[2] The World Health Organisation (WHO) updated their TB program and now aims to completely eliminate TB by 2050. TB elimination means that the number of active smear-positive cases is less than one per one million people per year.[3] Achieving this goal requires a reduction in incidences of the disease of up to 16% per year, whereas the current reduction in incidence of TB is only 1% per year.[4]

About one third of the world's population is infected with a latent TB infection, and 10% of people may be infected with TB during their lifetime.[2] Co-infection with HIV, and the consequential weakening immune system, has become the most important risk factor known in recent years to activate latent mycobacterium TB infection.[5] The role of other risk factors such as diabetes mellitus, smoking, alcohol, malnutrition and silicosis have also been known to affect TB.[6–11] Also, exposure to the conditions associated with poverty, such as overcrowding, houses with poor ventilation, poor socio-economic status, homelessness, immigration, and being in a minority (in the less developed countries) or marginalised citizens (in developed countries) facilitate TB contraction.[8,12–14] The afore-mentioned factors are considered fundamental challenges in controlling TB.

The Human Development Index (HDI), which is a composite statistic of life expectancy, education, and per capita income, was introduced as a new indicator for comparing the human development of countries in 1990. This indicator is used to determine the relationship between social and economic development of countries, and incidence rate of diseases. This study aimed to determine the incidence and pattern of treatment success rate of TB in terms of different levels of HDI around the world.

Materials and methods

This is a global ecologic study to analyse the relationship of the age-specific incidence and treatment success rate (TSR) of TB, with the HDI. HDI has several main components such as: life expectancy at birth (LEB); mean years of schooling (MYS); and, gross national income (GNI) per capita. Some ancillary indices of HDI include: percentage of urbanisation, and percentage of childhood stunting. Data for 184 countries on incidence and TSR of TB for the year 2012 were obtained from WHO reports; and, data on the HDI and other indices were obtained from the World Bank Report 2013 available at http://databank.worldbank.org/data/reports.aspx.

Inclusion for analysis was restricted to countries for which the epidemiologic data from the World Bank were available. In this study, we used the correlation bivariate method for assessment

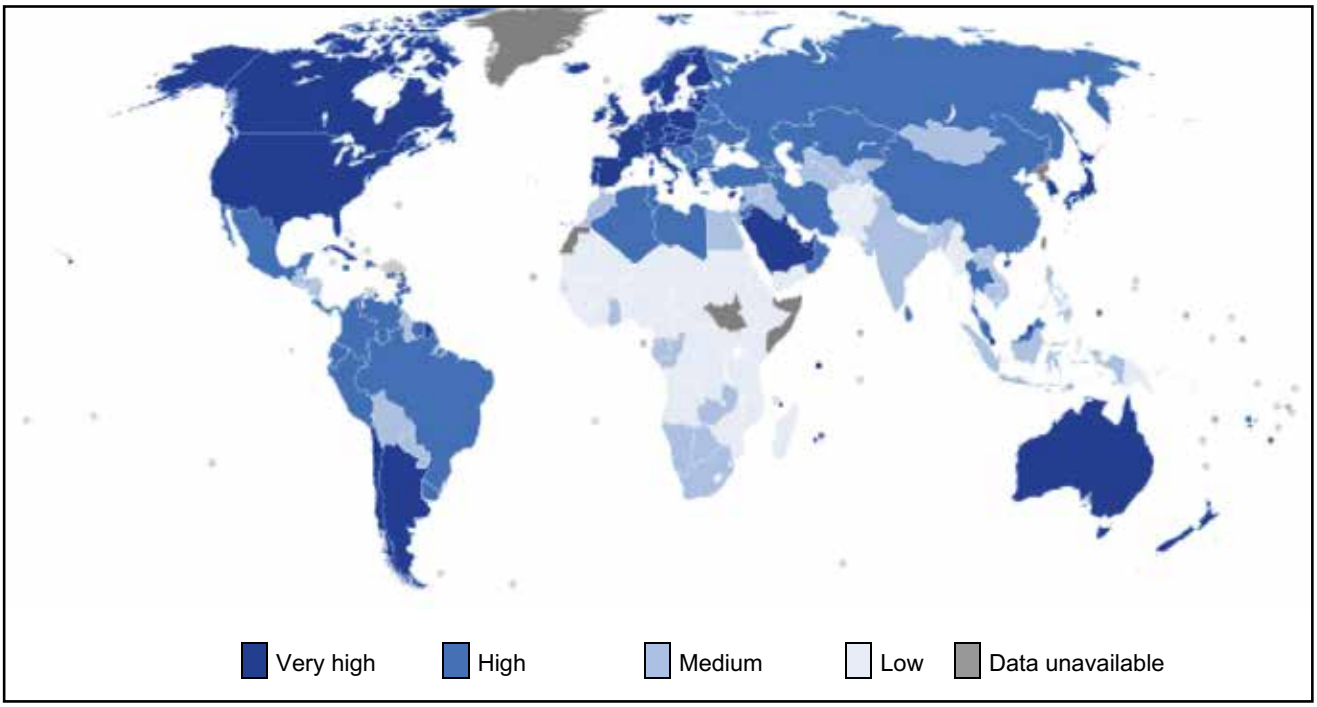

Figure 1: World map indicating the categories of Human Development Index by country (based on 2013 data).

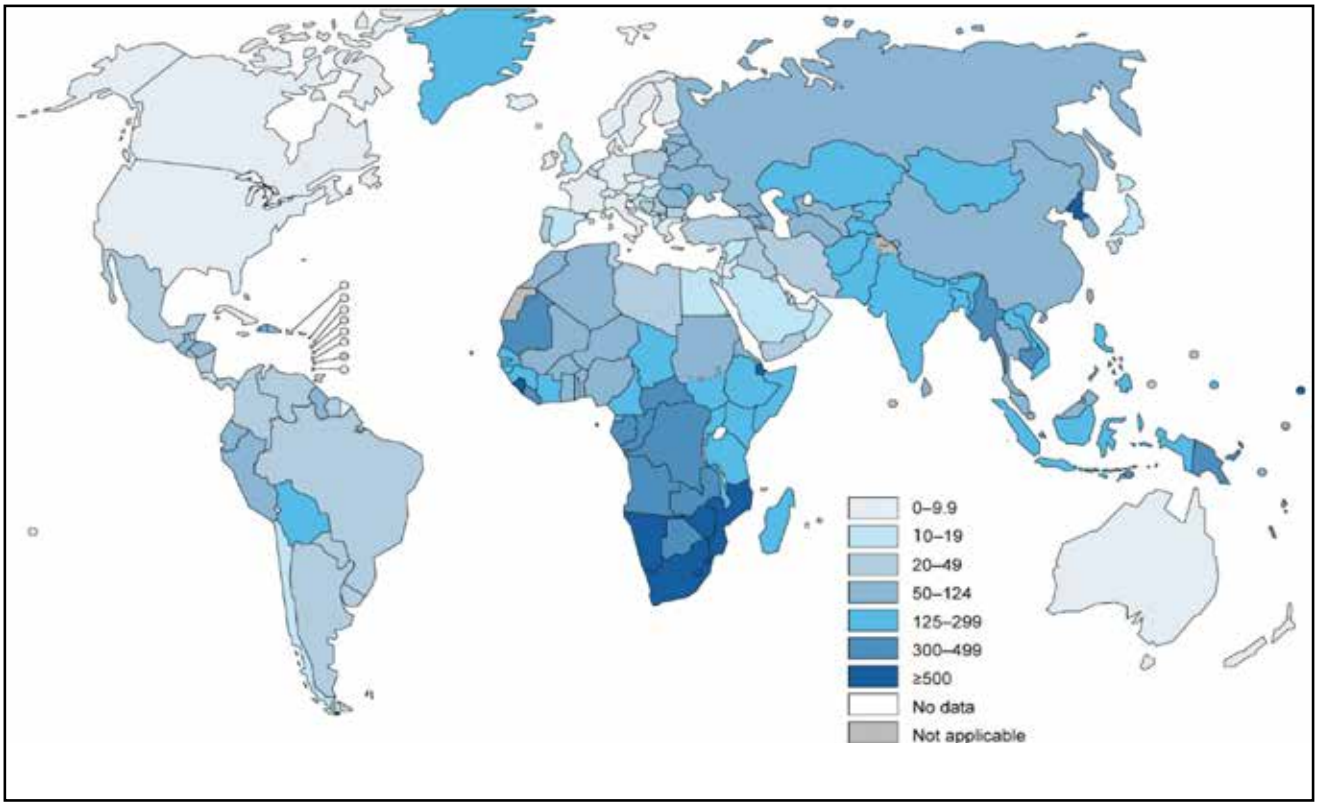

Figure 2: World map indicating the estimated TB incidence by country (based on 2013 data, Data source: Global Tuberculosis Report 2013, WHO).

of the correlation between the TB incidence rate and TSR with the HDI; we also used linear regression models for the assessment of effect of HDI on TB occurrence rates. Multiple linear regression models were ruled out due to extreme co-linearity of predictors. The level of significance was considered less than 0.05 for two-sided statistical tests. Data were analysed using Stata software version 12 (StataCorp, College Station, TX, USA).

Results

The results of this study showed that the highest HDI index values belonged to privileged countries such as USA, Canada, Australia, and Western Europe (Figure 1). In addition, Figure 2 shows the estimated TB incidence worldwide. Accordingly, TB incidence rates occurred most frequently in countries such as

Table 1: Tuberculosis incidence, treatment success rate and HDI component by different HDI regions in 2012

Region	TB Index		HDI component			
	EI	TSR	LEB	MYS	GNI	HDI
Very high human development	9.84	80.2	80.2	11.7	40,046	0.89
High human development	20.65	81.97	74.5	8.1	13,231	0.74
Medium human development	133.8	70.65	67.9	5.5	5,960	0.61
Low human development	237.1	76.82	59.4	4.2	2,904	0.49
p-value (F-test)	<0.001	<0.001	<0.001	<0.001	<0.001	-

Notes: EI: Estimated incidence (per 100,000 population), TSR: Treatment success rate (%), HDI: Human development index, LEB: Life expectancy at birth, MYS: Mean years of schooling, GNI: Gross national income per capita, TB: Tuberculosis.

South Africa, Namibia, Zimbabwe, and Sierra Leone with a rate greater than 500 per 100 000 persons.

More specifically, in high or very high developed regions the highest value of LEB, MYS, GNI, and total HDI was estimated to be 80.2, 11.7, 40, and 0.89, respectively (Table 1). In contrast, the greatest incidence rates of TB occurred in less developed countries, whereas the highest success rate in TB treatment (81.97%) was achieved in countries with a high level of development.

According to Figure 3, global HDI has a negative correlation with both TB incidence (R = –0.51, $p < 0.05$) and treatment success rate (TSR) (R = –0.18, $p = 0.018$).

Linear regression models showed that all components of HDI were significantly associated with TB incidence (Table 2). On average, a unit increase in life expectancy, year of schooling, GNI, urbanisation and HDI can significantly decrease TB incidence. The impact of predictors on the TSR, however, was slightly different, and only significant for GNI, HDI and percentage of urbanisation. It was observed that a unit increment in these predictors, results in decrement of TSR by 0.16, 15.6 and 0.16, respectively.

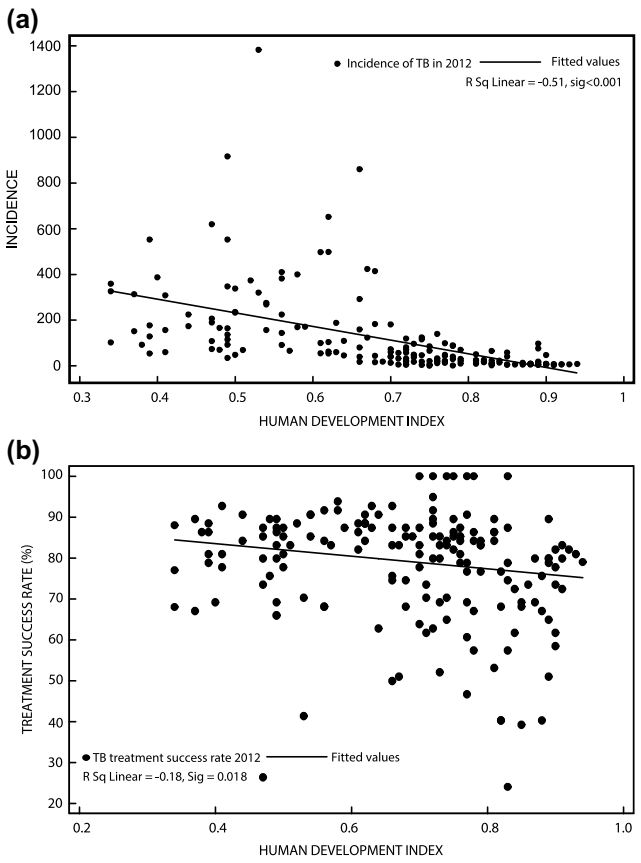

Figure 3: Correlation between the Human Development Index and TB incidence and treatment success rate in the world in 2012.

Discussion

Despite the importance and necessity of the directly observed treatment, short course (DOTS) strategy in reducing TB-related deaths, it seems that the national incidence rate of TB has a closer relationship with socio-economic factors such as the HDI.[15] In the present study, we used data from 184 countries to assess correlations between incidence of TB and TSR with HDI, a commonly used socio-economic index. Results from this study show that there is a significant correlation between the incidence of TB and TSR with the HDI, such that countries with better HDI have lower incidences of TB and higher TSRs. Previous studies have also shown that one of the effective factors on incidence rate and incidence trend of TB is HDI.[16,17] Previous research identifying trends in incidence of TB in 134 countries, and exploring the association between these trends and various indicators for development, found that HDI was inversely related to the incidence rate of TB. A similar finding from the Asia-Pacific region showed that socio-economic factors (such as HDI) are an

Table 2: Effect of HDI components and demographic variables on TB incidence and treatment success rate by logistic regression

Variable	TB Incidence			Treatment success rate		
	B	95% CI	*p*-value	B	95% CI	*p*-value
Life expectancy at birth	–13.05	(–15.4, –1.7)	<0.001	–0.14	(–0.36,0.09)	0.230
Mean years of schooling	–22.4	(–31.7,–14.28)	<0.001	–0.64	(–1.3,0.001)	0.051
Gross national income per 1000 capita	–3.6	(–5,–2.17)	<0.001	–0.16	(–0.27,–0.04)	0.006
HDI	–597.2	(–746,–448)	<0.001	–15.4	(–27.95,–2.9)	0.016
Urbanisation (%)	–2.68	(–3.75,–1.63)	<0.001	–0.16	(–0.24,–0.08)	<0.001
Stunting in children*	5.8	(3.24,8.37)	<0.001	0.13	(–0.02,0.23)	0.085

*Children stunting moderate or severe (% under age 5), HDI: Human Development Index, TB: Tuberculosis, CI: Confidence Interval.

effective predictor of incidence and prevalence of TB.[18] Tuberculosis is a disease associated with poverty and factors, such as malnutrition, overcrowding and smoking, have a positive effect on increasing the incidence rate.[19] Therefore, incidence rates of TB in developing countries are affected by social and economic determinants more so than proper implementation and success of the DOTS program.[16]

Results of the linear regression model showed that all three HDI markers affect incidence and success rates of TB treatment. Results of a previous study that was conducted using data from 165 countries showed that the incidence rate of TB has reduced to 8.7 cases per hundred thousand people with an increase in life expectancy per year,[20] which is consistent with results from our study. Education can affect the incidence of disease and success rates of treatment through mechanisms such as promotion of healthy behaviors, adequate nutrition,[21] and the early diagnosis and treatment of TB.[22] Results of this study also show that TB incidence is associated with malnutrition. A previous study showed that malnutrition increases the susceptibility to infection and any delay in receiving therapeutic intervention can aggravate the infection.[23]

There is a significant correlation between the lack of success of TB treatment and increased patient age. Advanced age may be a contributing factor for the lack of success in TB treatment due to a higher life expectancy in countries with a high level of HDI compared to other countries with a lower HDI.[24] Another is the high number of immigrants and refugees in these countries who may not have proper access to health services.[24–26] Results from a study conducted in Europe showed that one of the reasons for the poor success rate of TB treatment in these countries is an uncertainty of outcome in the treatment of patients who are immigrants and from mobile populations in these countries, for whom there is no possibility of follow-up.[27]

Although urbanisation can increase the burden of TB through high population density and exposure to specific risk factors such as smoking and changes in lifestyle,[28] our study shows that there is an inverse correlation between urbanisation and the incidence of this disease. This may result from the impact of uncontrolled and confounding variables in the study. However, urbanisation is one of the fundamental obstacles in the implementation of TB control strategies and can reduce the success of treatment due to the lack of proper access to health services and a lack of proper supervision, and subsequently improper patient compliance.[29]

Some limitations and strengths should be noted in this study. We used data from the WHO and World Bank reports, which have consistent definitions and allowed us to compare standardised rates across several different regions and countries. This helped to minimise limitations associated with selection and information biases and sample size. Nevertheless, ecological fallacy plays an important role in ecological study with which one cannot produce inference about the nature of process affecting individuals using aggregated data. Another limitation in this global ecological study is the inability to fully control confounding factors.

Conclusion

Patterns in TB incidence and treatment success rates are correlated with Human Development Indices. In addition to following WHO strategies, policy-makers need to focus on social and environmental determinants to reduce the TB burden, particularly in low income countries.

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