



Determinants of tuberculosis in countries of Latin America and the Caribbean

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ABSTRACT

Objectives. To explore the relationships among social, economic, environmental, and health services determinants of tuberculosis (TB) morbidity and mortality, and to identify the mechanisms that mediate such associations in countries of Latin America and the Caribbean (LAC).

Methods. This was an ecological study of 26 LAC countries that had accurate data available on 38 selected variables for the year 2010. The countries represented 99% of the TB burden in LAC. Multivariate linear regression was used to identify associations among determinants of health and TB morbidity and mortality.

Results. TB-HIV coinfection and multidrug resistant TB (MDR-TB) in previously treated cases were found to be positively associated to TB morbidity and negatively associated to improved basic sanitation and water coverage—pointing to an increase of TB morbidity in the first two variables and a decrease of TB morbidity in the last two. Regarding TB mortality, indigenous people and MDR-TB in previously treated cases were positively associated. In contrast, literacy among women, basic sanitation, water coverage, and nutritional status were negatively associated to mortality, denoting that improvements in these areas could reduce TB mortality.

Conclusions. The study findings support intersectoral actions that address social, economic, environmental, and health services determinants within the Stop TB strategy. The mechanisms by which social determinants of health affect current trend outcomes extend beyond medical interventions to control TB, but more research is needed to understand how and to develop actionable recommendations.

Keywords

Tuberculosis; social determinants of health; health inequalities; linear regression; Latin America; Caribbean Region.

There is more tuberculosis (TB) in the world today than at any other time in history (1, 2). TB remains a major, global, public health problem in Latin America and the Caribbean (LAC). In fact, global control of TB is far from complete. In 1993, when there were an estimated 7 – 8

million cases and 1.3 – 1.6 million deaths occurring annually, WHO declared TB to be a global public health epidemic. In 2010, the figures are higher, with an estimated 8.5–9.2 million cases and 1.2–1.5 million deaths annually, including deaths from TB in people living with the human immunodeficiency virus (HIV) (3).

The current threat of a TB emergency is of great concern for the international

community. It is the leading cause of death among people in the most economically-productive age groups, especially in developing countries. In this context, global targets were set for 2015, and to reach them WHO recommended the strategy “Stop TB,” launched in 2006 as an enhancement of the Directly Observed Therapy Short-term (DOTS) strategy. However, the Stop TB Strategy does not explicitly address the factors behind TB. The 2015 Millennium Development Goals (MDG) target 6.c called for reducing TB

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incidence and cutting TB prevalence and death rates by half of the 1990 levels (4, 5).

The Commission on Social Determinants of Health (CSDH), set up by WHO in 2005, has attempted to revitalize the debate and actions to improve health by addressing the “causes of the causes” of ill health. CSDH has developed action frameworks in several fields to address social determinants of health such as globalization, urbanization, living and working conditions, social exclusion, and more. The key message from CSDH is that public health achievements will largely depend on actions outside the health care sector (6, 7).

The aim of this article was to identify some of the social determinants that increase vulnerability associated to TB in Latin American and Caribbean countries. The term “determinant” has ample meaning, including health services as a social response for avoiding TB mortality.

MATERIALS AND METHODS

Study design and population

This was an ecological study of 26 LAC countries with accurate data available on the 38 selected variables for the year 2010. These countries represent 99% of the area’s TB burden. Some LAC countries were excluded due to their small size and subsequently small contribution to the burden of disease; others were excluded due to a lack of data, upwards of 20% in exploratory analysis.

Data collection and variables

All of the information reported and analyzed by this study was based on data registered and submitted to PAHO by its Member States, as well as: epidemiological estimates produced by PAHO from its ongoing TB control programs; PAHO basic health indicators published annually; and systematic, scientific, bibliographic reviews (3,4). In order to include all of the study variables, a database was compiled from the databases of the aforementioned PAHO programs, including those responsible for tobacco control, nutrition, alcohol and substance abuse, environmental health, chronic disease prevention and control, HIV/AIDS, and health analysis. Methods used by PAHO/WHO to estimate incidence, prevalence, and death rates,

and related data limitations, are described in detail elsewhere (2).

Outcome and independent variables

The outcome variables used in the analysis were TB incidence and TB mortality rates. The unit of analysis was the country level using the 26 LAC countries.

The links between each single outcome variable (TB incidence and TB mortality) and the independent variables that describe aspects of each country’s population were examined: social, economic, indigenous status, environmental, behavioral, biological, and health services factors—although not all data were available for all countries. As a step towards stabilizing the residual variation in regression analysis, a logarithmic transformation was used on some variables to get a normal distribution of data.

Some of the independent variables included in the analysis were: nutritional status; literacy rates of men and women; drinking water coverage; improved basic sanitation; life expectancy of men and women; literacy among men and women (measured as average years of schooling); public and private health spending; multidrug resistant TB (MDR-TB) cases treated; TB-HIV coinfection rate; purchase power parity (PPP\$); TB smear positive, relapse, retreatment, cured, failed, or death; TB patients with known HIV status; percent of tested TB patients who were HIV-positive; and so on.

Data analysis

The methodological approach used to analyze the study data consisted of three phases. The first phase was an exploratory analysis to verify compliance (or not) with certain assumptions in order to perform more robust statistical procedures later. The second phase consisted of a bivariate analysis to identify statistically significant associations and to control, as much as possible, the probability that chance would explain any observed association. Third and last, a multiple linear regression was applied to those variables found statistically associated in the bivariate analysis, plus some other variables of public health importance, even if they were not statistically significant on the bivariate analysis. This was done in order to identify the social determinants

associated to the outcome variable, in this case, TB incidence and mortality. TB incidence was based on pulmonary TB confirmed by positive smear, and TB mortality was based on death certificates. Numerical problems were checked, especially multicollinearity in order to avoid inaccurate estimates; one of the collinear variables was excluded to overcome this numerical problem. The collinearity was set up when the Pearson correlation coefficient was greater than 0.80, and the variable excluded was the one that showed the smallest association with the dependent variable.

During the multivariate analysis, independent variables were removed one by one, using the Stepwise procedure to generate a parsimonious model containing only variables that showed a significant value at $P < 0.10$ statistical level, in order to increase the power of detection of true association, beyond 80%. The alpha level used was 0.10, as previously stated, in order to increase the power detection of any association given the fixed sample size (8). The statistical analysis was done using IBM SPSS® Statistics software, version 20 (SPSS Incorporated, an IBM company, Chicago, Illinois, United States).

RESULTS

From 38 variables used, 24 were found to be associated to TB incidence in the bivariate analysis; 13 variables were eliminated because of numerical problems, especially multicollinearity; and finally, 11 variables remained statistically associated to TB incidence rate (Table 1).

The following variables were found to be statistically associated with the estimated TB incidence rate in the multivariate analysis: TB/HIV coinfection and MDR-TB cases previously treated showed a direct relationship (positive) with the outcome variable, TB incidence rate. In other words, as long as the number of TB/HIV coinfection and MDR cases treated increases, so will the TB incidence rate. On the other hand, water and basic sanitation coverage showed a negative relationship with the outcome variable; therefore, when water and basic sanitation coverage increases, TB incidence decreases (Table 2).

The same procedure was applied in order to identify the main determinants associated to TB mortality rate, as a single outcome variable. From 38 selected

TABLE 1. Bivariate analysis to determine variables associated to tuberculosis (TB) incidence in 26 countries of Latin America and the Caribbean, 2011

Model	Unstandardized coefficient		Standardized coefficient	90% Confidence Interval	
	β	Standard error		Lower bound	Upper bound
PPP\$ ^a	-0.005	0.002	-0.526	-0.007	-0.002
Coinfection TB-HIV rate	3.896	0.501	0.846	3.039	4.753
Multidrug resistant TB	2.947	1.285	0.424	0.748	4.753
Nutritional status	-0.104	0.022	-0.695	-0.142	-0.065
Literacy among women	3.318	0.669	0.707	1.990	4.286
Water coverage	-6.276	1.286	-0.721	-8.845	-4.067
Improved sanitation	-1.319	0.543	-0.468	-2.254	-0.383
Life expectancy of women	-10.435	1.416	-0.833	-12.857	-8.012
Average years of schooling	-14.072	6.567	-0.408	-25.327	-2.817
Public health spending	-11.973	5.293	-0.419	-21.029	-2.916
Private health spending	-18.179	8.371	-0.428	-32.584	-3.775

Source: prepared by the authors from the study results.

^aPurchasing Power Parity.

TABLE 2. Multivariate analysis to determine variables associated to tuberculosis (TB) incidence in 26 countries of Latin America and the Caribbean, 2011

Model	Unstandardized coefficient		Standardized coefficient	90% Confidence Interval	
	β	Standard error		Lower bound	Upper bound
Intercept	496.96	162.72		171.79	748.13
TB-HIV ^a coinfection rate	3.039	0.473	0.630	2.202	3.877
Multidrug resistant TB	1.456	0.527	0.296	0.523	3.877
Basic sanitation	-1.003	0.264	-0.398	-1.470	-0.536
Water coverage	-3.696	1.679	-0.232	-6.670	-0.722

Source: prepared by the authors from the study results.

^a Human Immunodeficiency Virus.

TABLE 3. Bivariate analysis to determine variables associated to tuberculosis (TB) mortality rate in 26 countries of Latin America and the Caribbean, 2011

Model	Unstandardized coefficient		Standardized coefficient	90% Confidence Interval	
	β	Standard error		Lower bound	Upper bound
PPP\$ ^a	-0.003	0.001	-0.439	-0.005	-0.001
Coinfection TB-HIV ^b rate	0.386	0.088	0.668	0.236	0.536
Multidrug resistant TB	0.308	0.167	0.353	0.023	0.593
Nutritional status	-0.013	0.003	-0.675	-0.018	-0.008
Literacy among women	0.393	0.083	0.709	0.250	0.536
Water coverage	-0.811	0.160	-0.733	-1.087	-0.536
Basic sanitation	-0.233	0.052	-0.703	-0.322	-0.144
Life expectancy of women	-1.292	0.183	-0.822	-1.605	-0.979
Indigenous people	0.147	0.085	0.333	0.002	0.293
Public health spending	-1.193	0.690	-0.334	-2.377	-0.018

Source: prepared by the authors from the study results.

^a Purchasing Power Parity.

^b Human Immunodeficiency Virus.

variables, 24 were found to be associated in the bivariate analysis; 14 variables were eliminated because of numerical problems, especially multicollinearity. The 10 variables statistically associated in the bivariate analysis are presented in Table 3.

The following 10 variables were also included in the multivariate analysis for TB mortality (Table 4): PPP\$, TB/HIV coinfection rate, MDR-TB cases previously treated, nutritional status, public expenditure on health, drinking water coverage, basic sanitation coverage, literacy among

women, indigenous population, and life expectancy at birth for women.

MDR-TB cases previously treated and indigenous population showed a direct relationship (positive) with the outcome variable, TB mortality rate. In other words, when the MDR-TB case previously treated or indigenous population increase, TB mortality rate will increase as well. On the other hand, water and basic sanitation coverage, nutritional status, and female literacy showed a negative relationship with the outcome variable, thus when these variables increase, the TB mortality rate decreases.

DISCUSSION

A more rapid and effective decline in TB cases could be achieved if in addition to pursuing better quality health services, a more pronounced effort were made to address and avert factors other than the biological ones (2). A stronger focus on TB control would imply more concentrated actions on social determinants, such as disadvantaged living and working conditions, malnutrition, lack of education, poverty, and other factors that may be contributing to a considerable proportion of the TB burden, especially among the most vulnerable population groups.

The findings of this study highlight the importance of TB-HIV coinfection rates and MDR-TB cases as the two most significant health services-related factors that directly increase the risk of dying from TB in LAC. The two proxy indicators of good living conditions were improved sanitation and access to drinking water, both key environmental determinants for reducing TB morbidity. Such environmental determinants point to the importance of working in an intersectoral fashion to create healthy community environments for the most vulnerable populations, thereby closing the TB gap between the poorest and the richest.

In relation to TB mortality, literacy among women, basic sanitation, drinking water coverage, and nutritional status, at the population level, were found to be associated to mortality. In other words, by improving these four social and environmental determinants, TB mortality could be reduced at the community level. This association is mediated by poverty; thus, reducing poverty at the population level should help reduce TB mortality as well.

TABLE 4. Multivariate analysis of variables associated to tuberculosis (TB) mortality rate in 26 countries of Latin America and the Caribbean, 2011

Model	Unstandardized coefficient		Standardized coefficient	90% Confidence Interval	
	β	Standard error		Lower bound	Upper bound
Intercept	57.50	15.19		30.596	84.403
Literacy among women	-0.274	0.073	-0.489	-0.403	-0.144
Multidrug resistant TB	0.139	0.076	0.238	0.004	0.274
Basic sanitation	-0.118	0.042	-0.388	-0.192	-0.044
Water coverage	-0.336	0.161	-0.214	-0.621	-0.052
Indigenous population	0.119	0.045	0.412	0.040	0.198
Nutritional status	-0.004	0.002	-0.309	-0.008	-0.001

Source: prepared by the authors from the study data.

Additionally, members of the indigenous population and MDR-TB cases previously treated were found to be associated to increased TB mortality. It is well known that multidrug resistant and extensively drug-resistant cases are found all over the world. Therefore, if the emergence of drug resistance is reduced, the attributable fraction of this risk factor on TB mortality burden in LAC would be reduced.

Special mention should be made regarding indigenous peoples. There are some LAC countries where a significant percentage of the population is indigenous and living under the poorest social and economic conditions, making them particularly vulnerable to TB infection.

One of the lessons learned with this study is that although we need to continue researching effective public health interventions for TB control, more of the same medical interventions will not necessarily yield better results. This new knowledge justifies investing in a new TB control framework, moving from medical interventions to a more comprehensive and sustainable framework based on the social determinants and involving a range of government and social actors (9).

It is well known that people living under the poorest conditions have a higher risk of developing TB as a consequence of permanent exposure to some or all of the associated factors described in this study. Furthermore, inequalities in living conditions explain the unequal distribution of TB burden among different human groups. People at low socioeconomic levels have, on average, more frequent contact with active TB sources, due to more crowded and poorly ventilated houses, food insecurity, limited access to health services, and less power to

act on existing knowledge related to healthy behaviors (10).

The importance of socioeconomic determinants for TB control is doubly reinforced by the fact that many countries have experienced a rapid decline without broad access to high-quality TB treatment. Long before effective chemotherapy was available, TB morbidity and mortality declined in Europe and other countries, largely because of socioeconomic development, improved working and living conditions, better nutrition, and isolation of infectious sources in a sanatorium (11). The challenge ahead for countries in LAC will not be easy to meet—TB elimination and control requires a definitive focus on nutrition and access to better basic sanitation, clean water, and literacy, especially among the poorest women and indigenous people (12, 13).

Another challenge is that tuberculosis case-finding and diagnostics are far from perfect. Although the gold standard for tuberculosis diagnosis is sputum culture, which takes time and relies on a consistent power supply, many settings still depend on sputum-smear microscopy—a 125-year-old method that detects 50% of cases, or fewer if laboratory capacity is exceeded, as is often the case in low-resource settings. The worldwide case detection rate of tuberculosis has stagnated at around 60%, not reaching the target of 70% originally set for 2000, postponed to 2005, and later judged to be unreachable (14). For this reason, it is necessary to take into account some other factors related to social determinants, most of them outside the traditional “health sector,” that could help stop or slow the current TB trend more quickly and steadily (15).

There is growing consensus that progress in TB control in the low- and middle-income world will require not only investing in control programs, but

also action to impact its determinants. This timely shift in emphasis has been welcomed, but clearly, practical actions are lacking, highlighting the need to gain tangible support for these ideas. Notwithstanding, a focus on tackling the determinants of TB should not undermine other well documented ongoing efforts (16).

Gaps still exist in our understanding of the extent to which determinants drive the current TB epidemic, by what underlying process they are linked to TB, and how to best address them. A better grasp of the mechanisms that govern the relationships between TB and its determinants is imperative given that, according to WHO, the curative strategy has reached its maximum return. In fact, WHO has recommended a new strategy for case finding and treatment to be reached by the year 2050 (17, 18).

Limitations. This study was limited by weaknesses in the TB information systems and the variance among TB programs, which makes measuring impact within and between countries difficult. Even so, the study’s dependent variables were associated to numerous biological, health services, social, environmental, and economic determinants, suggesting that they do reflect the strength and complexity of the mechanism currently in place.

Conclusions

These study results lend evidence to the relationship between the TB situation and the determinants of health. In addition, the results point out that better living and working conditions will lead to morbidity decreases. To accurately measure the real contribution of determinants on TB control at the population level, more research is needed.

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RESUMEN

Determinantes de la tuberculosis en los países de América Latina y el Caribe

Objetivos. Explorar las relaciones que existen entre los determinantes sociales, económicos, ambientales y de los servicios de salud y la morbilidad y la mortalidad por tuberculosis, y examinar los mecanismos que median estas correlaciones en los países de América Latina y el Caribe.

Métodos. A partir de diferentes fuentes de datos del año 2010, se aplicó un análisis de regresión lineal multivariante con el propósito de revelar las asociaciones entre los determinantes de la salud y la morbilidad y la mortalidad por tuberculosis en 26 países de América Latina y el Caribe (99% de la carga de tuberculosis) que contaban con datos sobre las 38 variables escogidas.

Resultados. En el 2010, la coinfección por el virus de la inmunodeficiencia humana y *Mycobacterium tuberculosis* y la presencia de tuberculosis multirresistente en los pacientes previamente tratados mostraron una correlación positiva con la morbilidad por tuberculosis y una correlación negativa con el progreso del saneamiento básico y la cobertura de los servicios de agua; esta observación revela un aumento de la morbilidad por tuberculosis asociado con las dos primeras variables y una disminución de la morbilidad que se asocia con las dos últimas. Con respecto a la mortalidad por tuberculosis, la población indígena y los casos de tuberculosis multirresistente en los pacientes previamente tratados revelaron una correlación positiva. Por el contrario, el alfabetismo en las mujeres, el saneamiento básico, la cobertura de los servicios de agua y el estado nutricional se asociaron negativamente con la mortalidad, lo cual indica que al mejorar los cuatro últimos determinantes se puede obtener una disminución de la mortalidad por tuberculosis.

Conclusiones. Los resultados de este estudio respaldan las iniciativas intersectoriales que asocian los determinantes sociales, económicos, ambientales y de los servicios de salud a la estrategia Alto a la Tuberculosis. Los mecanismos que median la influencia de los determinantes sociales sobre la evolución actual de los resultados de salud trascienden las intervenciones médicas de control de la tuberculosis y se precisan nuevas investigaciones que mejoren la comprensión de estos mecanismos y contribuyan a formular recomendaciones prácticas.

Palabras clave

Tuberculosis; determinantes sociales de la salud; desigualdades en la salud; modelos lineales; América Latina; Región del Caribe.