




Social determinants of pulmonary tuberculosis in Argentina

Determinantes sociais da tuberculose pulmonar na Argentina

Fernando Andrés Hilal^I , María Belén Herrero^{II,III} ,
Elvira Maria Godinho de Seixas Maciel^I , Jose Ueleres Braga^{I,IV} 

ABSTRACT: *Background:* In Argentina, approximately 9,000 new cases of tuberculosis (TB) are recorded every year, representing an incidence rate of 22 cases per 100,000 inhabitants. There are no reported studies in Argentina examining the factors that influence the unequal distribution of the disease. The aim of the study was to identify the relationship between the distribution of social and economic factors and TB in Argentina between 2008 and 2012. *Method:* An ecologic study involving 525 departmental jurisdictions was conducted. Simple linear regression analysis was performed, followed by multiple linear regression for each group of determinants. A final model of determinants of TB's incidence was constructed from a model of multiple linear regression. *Results:* The following determinants explain 43% of the variability of TB's incidence rate among different jurisdictions: overcrowding, proportion of households with a sewage network, proportion of examined patients with respiratory symptoms and proportion of patients who discontinued treatment. *Discussion:* This study makes an important contribution to a better understanding of the factors influencing the TB occurrence in Argentina, which is the result of a multidimensional and complex process. These factors make part of this disease's social determination. *Conclusion:* TB incidence is associated with different determinants, from multiple levels. Inequalities in its distribution in Argentina are driven by the unequal distribution of key social determinants.

Keywords: Tuberculosis. Epidemiology. Socioeconomic factors.

^IDepartamento de Epidemiologia e Métodos Quantitativos em Saúde, Escola Nacional de Saúde Pública, Fundação Oswaldo Cruz – Rio de Janeiro (RJ), Brazil.

^{II}Departamento de Relaciones Internacionales, Facultad Latinoamericana de Ciencias Sociales – Buenos Aires, Argentina.

^{III}Consejo Nacional de Investigaciones Científicas y Técnicas – Buenos Aires, Argentina.

^{IV}Departamento de Epidemiologia, Instituto de Medicina Social, Universidade do Estado do Rio de Janeiro – Rio de Janeiro (RJ), Brazil.

Corresponding author: Jose Ueleres Braga. Rua São Francisco Xavier, 524, Pavilhão João Lyra Filho, 7º andar / blocos D e E, e 6º andar / bloco E, Maracanã, CEP 20550-013, Rio de Janeiro, RJ, Brazil. E-mail: ueleres@gmail.com

Conflict of interests: nothing to declare – **Financial support:** none.

RESUMO: *Introdução:* Aproximadamente 9 mil novos casos de tuberculose (TB) por ano são registrados na Argentina, representando uma taxa de incidência de 22 casos por 100 mil habitantes. Não há estudos publicados que avaliaram os fatores que influenciam a distribuição desigual da doença na Argentina. O objetivo deste trabalho foi identificar a relação entre a distribuição dos fatores sociais e econômicos e da tuberculose na Argentina entre 2008 e 2012. *Método:* Foi realizado um estudo ecológico envolvendo 525 departamentos. Na análise procedeu-se uma regressão linear simples, seguida de regressão linear múltipla para cada grupo de determinantes. Um modelo final com os determinantes da incidência de TB foi construído por meio de regressão linear múltipla. *Resultados:* Os seguintes determinantes explicam 43% da variabilidade da taxa de incidência de TB entre diferentes jurisdições: aglomeração intradomiciliar, proporção de domicílios com rede de esgoto, proporção de pacientes examinados com sintomas respiratórios e proporção de pacientes com tratamento descontinuado. *Discussão:* Este estudo contribui de maneira importante para uma melhor compreensão dos fatores que influenciam a ocorrência da TB na Argentina, resultado de um processo multidimensional e complexo. Esses fatores fazem parte da determinação social dessa doença. *Conclusão:* A incidência de TB está associada a diferentes determinantes, de múltiplos níveis. A heterogeneidade na distribuição da tuberculose na Argentina deve-se, entre outros fatores, pela distribuição desigual de determinantes sociais e de acesso às ações de saúde.

Palavras-chave: Tuberculose. Epidemiologia. Desigualdades.

INTRODUCTION

There is considerable evidence in the literature that the health status of individuals and populations is often influenced by social factors and by access and use of health services, as well as by factors outside the health sector, including social, economic, political, and environmental¹. These factors, which contribute directly to health and disease, as well as their interaction with biological factors, are known as the social determinants of health.

Although tuberculosis (TB) is a preventable and curable disease, it remains a major public health issue worldwide, with 10.4 million new cases happening and 1.3 million deaths every year². While, globally, the number of people with TB is declining, and the mortality rate has decreased by 47% between 1990 and 2015³, disease control strategies remain inadequate².

In Argentina, approximately 9,000 cases of TB are reported every year. In 2012, 9,070 cases of TB were recorded, with an incidence rate of 22 cases per 100,000 inhabitants. The disease's distribution is not uniform throughout the country. The difference in disease reporting rates between jurisdictions is noticeable, with some provinces that have significantly higher rates than the national average and others that do not exceed 10 cases per 100,000 inhabitants. Furthermore, localities with a high proportion of the population with unfavorable social determinants remain the most affected by TB⁴.

There is a consensus in the scientific community that TB is related to the social conditions of life⁵. Poor conditions affect nutritional status of the population, the likelihood of becoming infected with TB bacillus, and the ability of individuals to respond to infection. Some variables, together with biological factors, are responsible for the relative increase in TB's incidence^{4,6,7}.

Numerous studies worldwide have addressed the issue of multiple and diverse factors that influence TB occurrence. However, in order to implement fair strategies to reduce inequities and disease incidence, it is important to understand patterns of disease behavior in a territory and its determinants⁸. Some ecologic studies have sought to identify the relationship between the distribution of diseases and socio-economic factors, respecting the different hierarchical levels of these determinants⁹⁻¹¹.

A downward trend in reporting new cases has been observed in Argentina; however, this reduction has not helped to reduce inequality in TB distribution¹². Globally, TB is more common in jurisdictions with high proportions of substandard housing and illiteracy, and the decline in notification rates was lower in areas with greater needs⁶.

Inequality of living conditions and unequal access to health services affect TB occurrence in different ways; therefore, it is important to identify the determinants of the disease in order to develop control strategies that target specific affected groups¹. However, to the best of our knowledge, there are no published studies in Argentina examining the association between TB incidence, the characteristics of social groups and the geographical areas they live in.

The aim of this work is to identify the social determinants of pulmonary TB and its geographical distribution in Argentina between 2008 and 2012. This analysis aims to contribute to better understand the factors influencing TB occurrence and provides evidence for the development of disease control strategies. It also represents a novel approach to the study of incidence determinants by evaluating the characteristics of access to health services and conditions for disease diagnosis.

METHOD

An ecologic study involving 525 departments out of 24 provinces was conducted. The units of analysis were departments in Argentina. Two sources of secondary data were used for this study: the database and mapping data of the National Population and Housing Census (2010) of the National Institute of Statistics and Census (INDEC), from which information on population's socioeconomic living conditions was obtained; and the registry of the National Institute of Respiratory Diseases (INER Coni) data on the reported cases of pulmonary TB. The data used for the analysis are public and freely available.

This study is based on the Social Epidemiology perspective and models¹³. According to this perspective, the social determination of health states that the ways of getting sick are the result of patterns of production and reproduction determined by social class. Some social determinants are regarded as socioeconomic conditions, measurable through indicators, including employment status, employment type, income, housing characteristics, family nucleus, literacy and food consumption¹⁴. Three hierarchical levels of socioeconomic indicators' groups, constituting the independent variables of this study, were defined. The dependent variable was TB incidence rate.

Socioeconomic, cultural, and environmental conditions and TB incidence rate are closely related¹⁵⁻¹⁷. Among Level 1 determinants, the Unsatisfied Basic Needs Index (UBNI) was included as a reflection of the population's development level. The UBNI is a synthetic indicator, comprising social, economic, and health dimensions, and, therefore, may specially represent a population's life conditions.

Socioeconomic indicators associated with TB and considered markers of living conditions were selected among level 2 determinants. These indicators are (the proportion of households and persons according to) urbanization, illiteracy, unemployment, overcrowding (defined as 3 or more people per bedroom), poor housing, use of solid fuels for cooking, households with drinking water supply, and homes with sewer service.

Finally, Level 3 indicators include markers of access to health services and TB program performance. These are as follows: number of primary health care (PHC) units, proportion of private health coverage, number of laboratories performing smears, proportion of respiratory symptomatic patients evaluated, proportion of TB patients tested, proportion of cases of successful treatment, proportion of patients who discontinued treatment and proportion of patients with directly observed therapy (DOT's).

An exploratory analysis was performed and thematic maps were obtained in order to visualize the geographical distribution of these indicators. First, the existence of correlation between each independent variable and the dependent variable was evaluated, and then a multiple factor analysis was performed by linear regression. A bivariate analysis was conducted and variables that showed significant levels of correlation ($p < 0.2$) in all levels and those that were deemed essential for the explanatory model were included in the multiple regression analysis. A multiple linear regression (MLR) analysis was performed for all levels, and only variables with evidence of relationship with significant levels ($p < 0.05$) were retained. Finally, a unique MLR was performed, which included all significant variables according to level and all variables associated with a significance of 5% (backward stepwise method). Although the significance level of 5% is accepted as the most appropriate by researchers, the use of 20% in bivariate analysis is recommended in view of the need to include those variables that, although at the level between two variables could be influenced by confounding, they would represent "true" relationships in the multivariate analysis. The statistical exploratory data analysis and maps preparation were performed using the STATA® 13/SE and the GeoDA® 1.6.7 softwares, respectively.

Regarding this research's ethical features, the study used non-nominal, secondary data of unrestricted access, thus being dispensed from the evaluation by the Committee of Ethics in Research of the National School of Public Health Sergio Arouca-Oswaldo Cruz Foundation.

RESULTS

From the results presented in the maps (Figure 1), it is possible to observe important differences in TB geographical distribution and in socioeconomic determinants.

The highest rates of TB were found in the departments of northern Argentina's provinces. High rates were also detected in the departments close to Buenos Aires and the southernmost departments of the Patagonian region. Although Buenos Aires Province does not have the greater incidence rate, its suburbs concentrate half of the national cases. In a number of provinces, there was coexistence of departments with high rates and of negligible rates (Figure 1).

SLR analysis revealed a statistically significant association ($p < 0.05$) between TB incidence rate and UBNI, corresponding to the level 1 variables (Table 1). This means that those departments with a higher proportion of UBNI had a higher TB incidence rate.

SLR analysis showed a statistically significant association ($p < 0.2$) between TB incidence rate and the following level 2 variables: illiteracy, overcrowding, unemployment, poor housing, use of solid fuel and service of sewage network (Table 1). However, using the MLR model, only the association with overcrowding and the service of sewage network was statistically significant ($p < 0.05$) (Table 1).

We found statistically significant associations ($p < 0.2$) between TB incidence and the proportion of respiratory symptomatic patients examined, patients evaluated, treatment success rate, treatment dropout rate, the proportion of patients with DOT, and the proportion of the population with private health coverage. MLR analysis showed significant

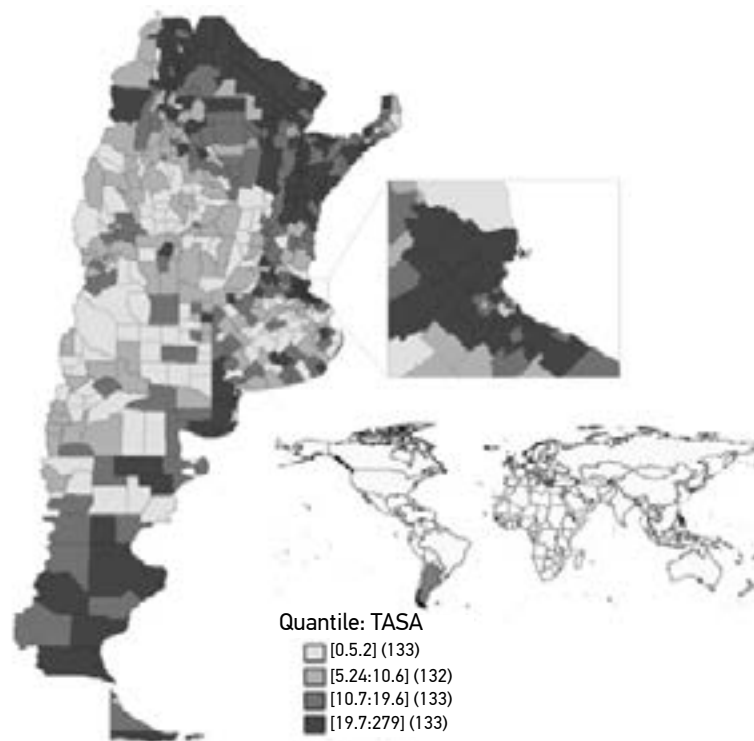


Figure 1. Map of tuberculosis notification rate by department of residence, Argentina, 2008–2010.

associations ($p < 0.05$) between TB incidence and respiratory symptomatic patients, treatment dropout rate, and proportion of the population with private health coverage (Table 2).

Table 3 shows the results of MLR's final model using all variables found to be significantly associated with TB incidence in the models shown by hierarchical groups. A statistically significant association was found between TB incidence rate and the following variables:

Table 1. Level 1 and 2 socioeconomic factors related to incidence of tuberculosis, department of Argentina, 2008–2012.

Determinants	Average	Regression coefficient ¹	95%CI	p-value	Regression coefficient adjusted ²	95%CI	p-value
Level 1							
Proportion households with Unsatisfied Basic Needs Index (UBNI)	12,3	0,828	(0,637 – 1,019)	0,000	0,828	(0,637 – 1,019)	< 0.001
Level 2							
Proportion of illiterates	8,4	1,329	(0,801 – 1,856)	0,000			
Proportion of households with overcrowding	4,9	2,431	(1,993 – 2,870)	0,000	3,010	(2,552 – 3,468)	< 0.001
Proportion of population with unemployment	5,1	0,699	(-0,199 – 1,958)	0,127			
Proportion of urban population	75,0	0,019	(-0,074 – 0,112)	0,688			
Proportion of substandard housing	7,3	0,612	(0,426 – 0,798)	0,000			
Proportion of households using solid fuels	7,7	0,295	(0,189 – 0,402)	0,000			
Proportion of households with drinking water	77,6	-0,037	(-0,122 – 0,046)	0,381			
Proportion of households with sewer service	35,7	0,039	(-0,015 – 0,094)	0,160	0,169	(0,117 – 0,221)	< 0.001

¹Regression coefficient obtained as a result of univariate models; ²coefficient obtained as a result of model variables by group; 95%CI: confidence interval of 95%; UBNI.

Source: Reported cases of pulmonary TB 2008 - 2010 PNCTB. National Census of Population and Housing, INDEC, 2010.

proportion of overcrowding, proportion of households with waste disposal through a sewage network, proportion of respiratory symptomatic patients examined, and proportion of patients who discontinued treatment. This final model explains 43% of the variability in TB incidence rate among the different departmental jurisdictions of Argentina.

The distribution of TB indicators is rather heterogeneous (Figure 2). While overcrowding is more prevalent in the north of Argentina, poor sanitation occurs more frequently in the south. Abandonment of treatment is more frequent in the north and in the metropolitan

Table 2. Socioeconomic factors at level 3 related to tuberculosis incidence rate, department of Argentina, 2008-2012.

Determinants	Average	Regression Coefficient ¹	95%CI	p-value	Regression Coefficient adjusted ²	95%CI	p-value
Proportion of patients with respiratory symptoms	0,46	14,775	(12,050 – 17,500)	0,000	13,523	(10,965 – 16,081)	< 0.001
TB Proportion of patients evaluated	58,4	0,127	(0,085 – 0,170)	0,000			
Proportion of patients with successful TB treatment	57,5	0,130	(0,085 – 0,175)	0,000			
Proportion of patients TB abandoned treatment	8,5	0,410	(0,295 – 0,526)	0,000	0,379	(0,247 – 0,511)	< 0.001
Proportion of patients with TB TDO	49,5	0,099	(0,058 – 0,140)	0,000			
Proportion of population with private health coverage	56,6	-30,101	(-41,313 – -18,889)	0,000	-29,632	(-41,949 – 17,316)	< 0.001
Laboratories coverage per 10,000 population.	0,85	-0,869	(-3,543 – 1,844)	0,523			
APS coverage per 10,000 population	1,1	-0,157	(-1,252 – 0,937)	0,778			

¹Regression coefficient obtained as a result of univariate models; ²coefficient obtained as a result of model variables by group; 95%CI: confidence interval of 95%; TB: tuberculosis; directly observed therapy (DOT); primary health care (PHC): . Source: Reported cases of pulmonary TB 2008-2010 PNCTB. National Census of Population and Housing, INDEC, 2010.

area of Buenos Aires. Finally, respiratory symptoms are more frequently observed in both the north and the south of Argentina.

DISCUSSION

This study found that TB incidence is associated with the proportion of the population subject to overcrowding, the proportion of households with a waste disposal through sewerage network, the proportion of respiratory symptomatic patients examined, and the proportion of patients who discontinued treatment.

This study's results indicate that areas with low socioeconomic status have higher levels of disease incidence. The association between variables indicative of poverty and TB

Table 3. Socioeconomic factors related to tuberculosis incidence rate, department of Argentina, 2008-2012. Final model (level 1, 2, and 3).

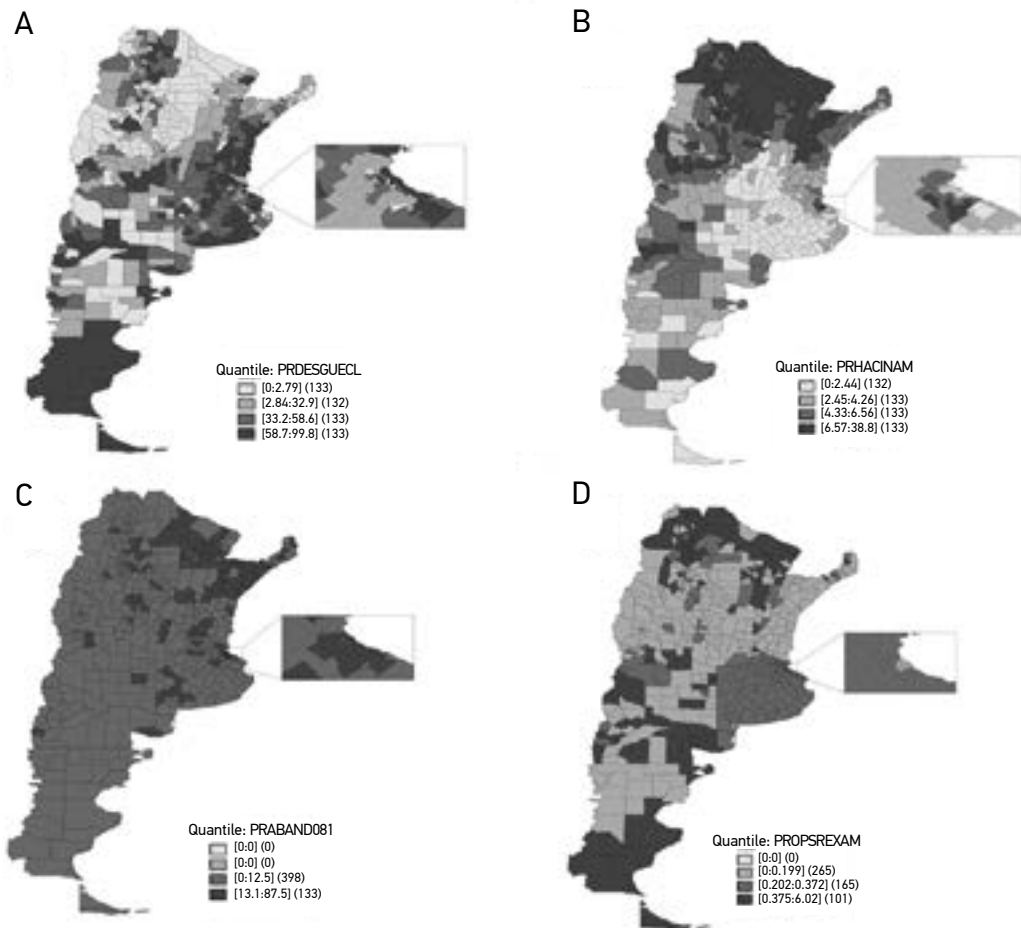
Determinants	Average	Regression Coefficient ¹	95%CI	p-value	Regression Coefficient adjusted ²	95%CI	p-value
Proportion households with UBNI	12,3	0,828	(0,637 – 1,019)	0,000			
Proportion of households with overcrowding	4,9	3,010	(2,552 – 3,468)	0,000	2,372	(1,875 – 2,869)	< 0.001
Proportion of households with sewer service	35,7	0,169	(0,117 – 0,221)	0,160	0,091	(0,031 – 0,151)	0,003
Proportion of patients with respiratory symptoms	0,46	13,523	(10,965 – 16,081)	0,000	10,611	(8,114 – 13,108)	< 0.001
TB proportion of patients who left treatment	8,5	0,379	(0,247 – 0,511)	0,000	0,363	(0,242 – 0,484)	< 0.001
Proportion of population with private health coverage	56,6	-29,632	(-41,949 – -17,316)	0,000			

¹Regression coefficient obtained as a result of multivariate models groups of variables; ²regression coefficient obtained as a result of the model made with the variables that were significant in the models by groups of variables; 95%CI: confidence interval of 95%; UBNI: Unsatisfied Basic Needs Index; TB: tuberculosis.

Source: Reported cases of pulmonary TB 2008 - 2010 PNCTB. National Census of Population and Housing, INDEC, 2010.

incidence is widely documented^{6,12,16}. A study conducted by Bossio et al. in Argentina found an association between increased prevalence, TB incidence and poor social and economic conditions¹². Our study corroborates these findings, showing an association between the proportion of households with UBNI and TB incidence in the univariate model. In Argentina, this variable is considered an indicator of the households' socioeconomic status, allowing for the definition of groups according to structural poverty, a more complex notion of poverty, which goes beyond insufficient income¹⁸. However, this association was not statistically significant in the MLR model. This may happen due to inherent limitations of this socioeconomic indicator's composition¹⁹.

Other variables related to socioeconomic status (particularly relevant to Level 2 of the selected variables) remained significant in the final regression model. An example is the proportion of households with overcrowding, which is one of the UBNI components. This study



A: Proportion of poor sanitation; B: proportion of overcrowding; C: proportion of abandonment of treatment; D: proportion of presence of respiratory symptoms.

Figure 2. Map of the proportion of tuberculosis indicators, Argentina, 2008–2010.

corroborates existing research showing a significant association between the occurrence of pulmonary TB and overcrowding^{20,21}. This may be explained by the fact that the association between overcrowding and TB incidence is stronger than the relationship between its incidence and the variable proportion of households with UBNI, thus leaving it displaced in the final model. This association may be explained in terms of the disease's mode of transmission²². TB is transmitted by air and overcrowding facilitates greater transmission. This risk can increase among people living in adverse socioeconomic conditions where the possibilities of adequate ventilation are reduced. Souza et al.²³ conducted a study in the city of Olinda, Brazil, constructing an index of social deprivation. This included the "average number of people per bedroom", a factor strongly related to TB transmission. The authors concluded that there was a strong association between social deprivation and TB emergence, highlighting the priority groups and areas requiring intervention. In a literature review, Lönnroth et al. suggested that overcrowding was associated with a high risk of TB transmission⁷. The evidence indicates that this association is influenced by other factors linked to housing conditions and to the characteristics of individuals, such as malnutrition and socioeconomic disadvantages²².

In line with the above, this study also found an association between TB incidence and a higher proportion of households with a waste disposal system through a sewage network. This service is considered an indicator of the structural conditions of life, according to the INDEC linked to the urban development of health and sanitation. This study also supports another research performed in Argentina, examining factors associated with adherence to TB treatment^{24,25}. It appears that the availability of basic services is a determinant key of health and of health outcomes among patients of low socioeconomic status. Furthermore, patients who do not adhere to treatment also have poorer indicators of housing conditions, such as the type of sewage system and overcrowding. A possible explanation may be that in locations lacking a sewage service, there is also less access to health services and, consequently, TB diagnosis is less likely. In a study on the determinants of TB incidence and social inequalities in Latin America, researchers found that access to drinking water and sanitation was significantly associated with TB incidence rates, and that these higher incidence rates are disproportionately concentrated in the most socially disadvantaged countries²⁶.

The association between socioeconomic status and poor access to health services for TB diagnosis has been examined in numerous studies conducted in different countries and regions, using different methodologies and indicators. Hanif et al.²⁷ evaluated factors influencing adherence to antiretroviral treatment and concluded that socioeconomic factors were often a proxy for other barriers, such as the cost of transportation, lack of time, difficulties in obtaining information, and discrimination²⁷. A study conducted in the Dominican Republic²⁸ showed that the poorest patients experienced the greatest economic impact and identified the main direct and indirect costs as follows: necessary expenses for supplementary food during treatment, transportation costs to attend health services, loss of income due to the interruption of the working day, and loss of time incurred to attend health services and as a result of delays in care²⁸. The authors concluded that diagnosis and free treatment of TB were not sufficient to mitigate the financial constraints faced by vulnerable groups as a result of the disease.

Evidence indicates that individual characteristics of patients, such as socio-demographic characteristics, level of education and employment status influence the individual's health but also the access to health services for diagnosis and treatment. In our study, we did not detect an association between unemployment, illiteracy and TB incidence, maybe it could be due to poor statistical power. Despite this, these features reflect greater socioeconomic vulnerability and low level of education is directly related to the lack of information and the inadequate identification of the disease^{12,29}, thus prolonging the time between onset of symptoms and health center attendance and furthering disease transmission.

Inequalities in TB distribution are driven by the unequal distribution of key social determinants, such as income level, level of education, nutritional status, adequate housing, environmental conditions and access to employment^{4,30}. In turn, these unequal social conditions facilitate TB transmission in the community^{4,31}. TB appears to be a disease of large urban centers³², although our study did not identify this association. This may be due to the fact that TB patients living in rural areas have difficulties in travelling to health centers for diagnosis, treatment, and follow up, thereby increasing the disease transmission. Moreover, the results of our study show that TB incidence was significantly associated with the proportion of patients who discontinued treatment. Discontinuation of treatment increases the likelihood of failure to cure the disease and also increases the chance of relapses. Furthermore, cessation of treatment is one of the main factors associated with the continuous transmission of the disease in the community. Studies have also found that approximately half of patients with a previous abandonment of TB treatment are more likely to be non-adherent, which increases the risk further for development and transmission of multidrug-resistant strains³³⁻³⁵.

Several studies, including a research conducted in Argentina, have shown that the probability of abandoning treatment is related to unfavorable socioeconomic indicators²⁹. Our study found that the population with the greatest risk of disease incidence was also affected by an unfavorable economic situation. These findings are therefore particularly relevant to the issue of disease control. Our results indicate that the incidence of pulmonary TB is higher in those departments with a higher proportion of respiratory symptoms. Of course, health teams working in departments where TB prevalence is higher are already sensitized to this issue and, therefore, the search for new TB cases is conducted with greater care and more efficiently. Conversely, the assessment of respiratory symptoms is not adequate in departments where the incidence of TB is negligible.

Finally, this study has some limitations that must be mentioned. First, we analyzed the reporting of cases, and not the incidence of the disease. It is postulated that underreporting of cases, which occurs in Argentina and worldwide, affects the most vulnerable groups of the population. This is due to several factors, including barriers to access to health services for diagnosis. The effect is an underestimation of the association of determinants in the disease's development, which negatively influences the study's results. One can argue the presence of an ecological fallacy, but we do not intend to make inferences at the individual level and thus do not become a problem.

Despite these limitations, this study makes an important contribution to a better understanding of the factors influencing the occurrence of tuberculosis in Argentina, which is crucial for developing strategies aimed at decreasing the disease's incidence.

CONCLUSIONS

We conclude that in Argentina, inequalities in TB distribution are driven by the unequal distribution of key social determinants. What is more, TB incidence is associated with social conditions like overcrowding, sewage network and with surveillance performance, like respiratory symptomatic examination and non-compliance TB treatment. To our knowledge, this is the first study in Argentina to analyze socioeconomic factors associated with the incidence of TB. The key contribution of this study is the evaluation of TB's unequal social distribution in Argentina, its associated social determinants, and, particularly, barriers to health services access, the assessment of the disease's diagnosis as one of the levels influencing TB occurrence. These findings support the development of strategies for disease prevention, diagnosis, and control.

ACKNOWLEDGEMENTS

We thank the National Institute of Respiratory Diseases "Emilio Coni" for providing data that made this study possible. The authors also thank Nicole Breanne Lesnar for the invaluable support in translating the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable for this study.

REFERENCES

1. Huda TM, Tahsina T, El Arifeen S, Dibley MJ. The importance of intersectoral factors in promoting equity-oriented universal health coverage: a multilevel analysis of social determinants affecting neonatal infant and under-five mortality in Bangladesh. *Glob Health Action* 2016; 9: 29741. <https://dx.doi.org/10.3402%2Fgha.v9.29741>
2. World Health Organization. Global tuberculosis control: WHO report 2015. Geneva: World Health Organization; 2017.
3. World Health Organization. Global tuberculosis control: WHO report 2011. Geneva: World Health Organization; 2015.
4. Hargreaves JR, Boccia D, Evans CA, Adato M, Petticrew M, Porter JD. The social determinants of tuberculosis: from evidence to action. *Am J Public Health* 2011; 101(4): 654-62. <https://dx.doi.org/10.2105%2FAJPH.2010.199505>
5. De Geest S, Sabaté E. Adherence to long-term therapies: evidence for action. *Eur J Cardiovasc Nurs* 2003; 2(4): 323. [https://doi.org/10.1016/S1474-5151\(03\)00091-4](https://doi.org/10.1016/S1474-5151(03)00091-4)

6. Creswell J, Jaramillo E, Lönnroth K, Weil D, Raviglione M. Tuberculosis and poverty: what is being done. *Int J Tuberc Lung Dis* 2011; 15(4): 431-2. <https://doi.org/10.5588/ijtld.10.0654>
7. Lönnroth K, Jaramillo E, Williams BG, Dye C, Raviglione M. Drivers of tuberculosis epidemics: the role of risk factors and social determinants. *Soc Sci Med* 2009; 68(12): 2240-6. <https://doi.org/10.1016/j.socscimed.2009.03.041>
8. Acosta L. O mapa de Porto Alegre e a tuberculose: distribuição espacial e determinantes sociais [dissertation]. Porto Alegre: Faculdade de Medicina, Universidade Federal do Rio Grande do Sul; 2008.
9. Barata RB. Epidemiologia social. *Rev Bras Epidemiol* 2005; 8(1): 7-17. <http://dx.doi.org/10.1590/S1415-790X2005000100002>
10. Diez Roux AV. A glossary for multilevel analysis. *J Epidemiol Community Health* 2002; 56: 588-94. <http://dx.doi.org/10.1136/jech.56.8.588>
11. Krieger N. A glossary for social epidemiology. *Epidemiol Bull* 2002; 23(1): 7-11.
12. Bossio JC, Arias SJ, Fernández HR. Tuberculosis en Argentina: desigualdad social y de género. *Salud Colectiva* 2012; 8(Suppl. 1): 77-91.
13. Breilh J. La determinación social de la salud como herramienta de transformación hacia una nueva salud pública (salud colectiva). *Rev Fac Nac Salud Pública* 2013; 31(Suppl. 1): S13-27.
14. Krieger N. Proximal, Distal, and the Politics of Causation: What's Level Got to Do With It? *Am J Public Health* 2008; 98(2): 221-30. <http://dx.doi.org/10.2105/AJPH.2007.111278>
15. Dean HD, Fenton KA. Addressing social determinants of health in the prevention and control of HIV/AIDS, viral hepatitis, sexually transmitted infections, and tuberculosis. *Public Health Rep* 2010; 125(Suppl. 4): 1-5. <https://dx.doi.org/10.1177%2F00333549101250S401>
16. Dye C, Lönnroth K, Jaramillo E, Williams BG, Raviglione M. Trends in tuberculosis incidence and their determinants in 134 countries. *Bull World Health Organ* 2009; 87(9): 683-91.
17. Sharpe TT, Harrison KM, Dean HD. Summary of CDC consultation to address social determinants of health for prevention of disparities in HIV/AIDS, viral hepatitis, sexually transmitted diseases, and tuberculosis. December 9-10, 2008. *Public Health Rep* 2010; 125(Suppl 4): 11-5. <https://dx.doi.org/10.1177%2F00333549101250S404>
18. República Argentina. Instituto Nacional de Estadística y Censos. Necesidades Básicas Insatisfechas [Internet]. Argentina: Instituto Nacional de Estadística y Censos; 2015 [cited on Apr 17, 2015]. Available at: https://www.indec.gov.ar/nivel4_default.asp?id_tema_1=4&id_tema_2=27&id_tema_3=66
19. República Argentina. Instituto Nacional de Estadística y Censos. Las necesidades básicas insatisfechas: sus deficiencias técnicas y su impacto en la definición de las políticas sociales [Internet]. Argentina: Instituto Nacional de Estadística y Censos; 2015 [cited on Apr 17, 2015]. Available at: <https://repositorio.cepal.org/handle/11362/31529>
20. Clark M, Riben P, Nowgesic E. The association of housing density, isolation and tuberculosis in Canadian First Nations communities. *Int J Epidemiol* 2002; 31(5): 940-5.
21. Hawker JJ, Bakhshi SS, Ali S, Farrington CP. Ecological analysis of ethnic differences in relation between tuberculosis and poverty. *BMJ* 1999; 319(7216): 1031-4.
22. de Lima ML, Ximenes RA, de Souza ER, Luna CF, de Albuquerque M de F. [Spatial analysis of socioeconomic determinants of homicide in Brazil]. *Rev Saúde Pública* 2005; 39(2): 176-82. <http://dx.doi.org/10.1590/S0034-89102005000200006>
23. Souza WV, Ximenes R, Albuquerque MFM, Lapa TM, Portugal JL, Lima MLC, et al. The use of socioeconomic factors in mapping tuberculosis risk areas in a city of northeastern Brazil. *Rev Panam Salud Pública* 2000; 8(6): 403-10.
24. Herrero MB, Arrossi S, Ramos S, Braga JU. Social determinants of nonadherence to tuberculosis treatment in Buenos Aires, Argentina. *Cad Saúde Pública* 2015; 31(9): 1983-94. <http://dx.doi.org/10.1590/0102-311X00024314>
25. Herrero MB, Arrossi S, Ramos S, Braga JU. Spatial analysis of the tuberculosis treatment dropout, Buenos Aires, Argentina. *Rev Saúde Pública* 2015; 49: 49. <https://doi.org/10.1590/S0034-8910.2015049005391>
26. Munayco CV, Mújica OJ, León FX, Granada M d, Espinal MA. Social determinants and inequalities in tuberculosis incidence in Latin America and the Caribbean. *Rev Panam Salud Pública* 2015; 38(3): 177-85.
27. Hanif H, Bastos FI, Malta M, Bertoni N, Surkan PJ, Winch PJ, et al. Individual and contextual factors of influence on adherence to antiretrovirals among people attending public clinics in Rio de Janeiro, Brazil. *BMC Public Health* 2013; 13: 574. <https://dx.doi.org/10.1186%2F1471-2458-13-574>
28. Mauch V, Melgen R, Marcelino B, Acosta I, Klinkenberg E, Suarez P. Tuberculosis patients in the Dominican Republic face severe direct and indirect costs and need social protection. *Rev Panam Salud Pública* 2013; 33(5): 332-9.
29. Salas Abarca P, Chamizo García HA. Determinantes sociales de la adherencia al tratamiento de la tuberculosis: una discusión desde la perspectiva heurística del riesgo. *Revistas de Ciencias Administrativas y Financieras de la Seguridad Social* 2002; 10(1): 67-78.

30. Odone A, Crampin AC, Mwinuka V, Malema S, Mwaungulu JN, Munthali L, et al. Association between socioeconomic position and tuberculosis in a large population-based study in rural Malawi. *PLoS One* 2013; 8(10): e77740. <https://doi.org/10.1371/journal.pone.0077740>
31. Kamper-Jorgensen Z, Andersen AB, Kok-Jensen A, Kamper-Jorgensen M, Bygbjerg IC, Andersen PH, et al. Migrant tuberculosis: the extent of transmission in a low burden country. *BMC Infect Dis* 2012; 12: 60. <https://doi.org/10.1186/1471-2334-12-60>
32. World Health Organization. Urbanization and health. *BLT WHO* 2010; 88: 245-6.
33. Lienhardt C, Fielding K, Sillah JS, Bah B, Gustafson P, Warndorff D, et al. Investigation of the risk factors for tuberculosis: a case-control study in three countries in West Africa. *Int J Epidemiol* 2005; 34(4): 914-23. <https://doi.org/10.1093/ije/dyi100>
34. Balasubramanian R, Garg R, Santha T, Gopi PG, Subramani R, Chandrasekaran V, et al. Gender disparities in tuberculosis: report from a rural DOTS programme in south India. *Int J Tuberc Lung Dis* 2004; 8(3): 323-32.
35. Chang KC, Leung CC, Tam CM. Risk factors for defaulting from anti-tuberculosis treatment under directly observed treatment in Hong Kong. *Int J Tuberc Lung Dis* 2004; 8(12): 1492-8.

Received on: 11/16/2017

Final version presented on: 04/25/2018

Accepted on: 05/15/2018

Authors' contributions: We have participated in the study and concur with the submission and subsequent revisions of the manuscript. Fernando Andrés Hilal: Participation in protocol design and data analysis; primary responsibility for manuscript preparation. María Belén Herrero: Participation in the protocol design's review and manuscript preparation and writing. Elvira Maria Godinho de Seixas Maciel: Primary responsibility for the final protocol design's review and manuscript writing. Jose Ueleres Braga: Participation in protocol design, data analysis, and manuscript writing; primary responsibility for the manuscript's final review.

