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Tuberculosis and its associated factors in a city in the metropolitan region of Rio de Janeiro

A tuberculose e seus fatores associados em um município da região metropolitana do Rio de Janeiro

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ABSTRACT: ***Introduction:*** The occurrence of tuberculosis has been related to the spatial organization and improvement of the living conditions of the population. However, this relationship is not directly related and tuberculosis illness involves processes at different levels of organization. ***Method:*** An ecological study analyzing the relationship between living conditions and tuberculosis in the city of Niteroi, Brazil. Two indicators, socio-environmental and programmatic, were created by factor analysis and analyzed by regression in the period of 2008 to 2012. Thematic maps were constructed to examine the distribution pattern of the incidence rate and indicators in the city. ***Results:*** The results showed a direct and significant association of the two indicators with the incidence rate of tuberculosis. A one-unit higher the programmatic indicator was associated with a 7% higher incidence rate. The socio-environmental indicator was associated with a 27% higher tuberculosis rate. ***Discussion:*** The results of the present study were consistent with the direct relationship between tuberculosis and living conditions in the city of Niteroi. ***Conclusion:*** We can conclude that the dynamics of tuberculosis transmission in Niteroi can be explained by the occurrence of the disease in areas of consolidated social periphery and by the social vulnerability of specific groups.

Keywords: Tuberculosis. Social conditions. Social inequity.

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RESUMO: ***Introdução:*** A ocorrência da tuberculose tem sido relacionada à organização espacial e à melhoria das condições de vida da população. Contudo, essa relação não é de forma direta, e o adoecimento por tuberculose envolve processos de diferentes níveis de organização. ***Método:*** Estudo ecológico que analisa a relação entre condições de vida e tuberculose no município de Niterói, Brasil. Foram criados dois indicadores, socioambiental e programático, por meio de análise fatorial e analisados por regressão no período de 2008 a 2012. Foram construídos mapas temáticos com os dados referentes à taxa de incidência e aos indicadores, para verificar o padrão da distribuição da taxa de incidência e desses indicadores no município. ***Resultados:*** Os resultados apontaram associação direta e significativa entre os dois indicadores com a taxa de incidência de tuberculose. O aumento em uma unidade no indicador programático esteve associado com um aumento na taxa de incidência em 7%. Já o indicador socioambiental associou-se com um aumento de 27% na taxa de tuberculose. ***Discussão:*** Os resultados do presente trabalho foram consistentes ao constatar relação direta entre tuberculose e condições de vida no município de Niterói. ***Conclusão:*** Podemos concluir que a dinâmica da transmissão da tuberculose no município de Niterói pode ser explicada pela ocorrência da doença em áreas de periferia social consolidada e pela vulnerabilidade social de grupos específicos.

Palavras-chave: Tuberculose. Condições de vida. Desigualdade social.

INTRODUCTION

The occurrence of tuberculosis (TB) has historically been related to the spatial organization of cities and to the improvement of living conditions of the population, considering that even before the advent of specific chemotherapy, a decrease in mortality was observed[1-3]. However, it is necessary to emphasize that this relationship is not established in a direct and linear way, TB illness involves biological and social processes at different levels of organization, which through a relationship of interdependence and dialogic interaction are responsible for the occurrence of the disease[4-6].

At the individual level, there would be associated behavioral variables, such as alcohol and drug use, nutritional status and co-infection with human immunodeficiency virus (HIV)[6]. At the collective level, the occurrence of the disease is understood through the process of social reproduction and organization of urban space[7-9].

Several studies have discussed the relationship between the particularities of a city's socio-spatial organization and the persistence of TB. Angelo[8] analyzed the process of producing urban space in the city of Juiz de Fora, Minas Gerais, by means of a set of social and economic indicators that enabled the creation of a typology of homogeneous regions that represented the process of residential segregation, which in turn was used to determine the association with the occurrence of TB in the urban space of the city of Juiz de Fora. San Pedro et al.[9] studied the occurrence of TB in the city of Itaboraí, Rio de Janeiro State (RJ), characterized by substantial changes in recent years, mainly due to the implementation of the Rio de Janeiro State Petrochemical Complex, RJ, and pointed out that the occurrence of TB in the city was associated with the indicators related to the living conditions of the population.

Niterói is a medium-sized city located in the metropolitan region of RJ. Despite registering the best Human Development Index (HDI) in the state and the seventh in Brazil, it is among the 14 municipalities in the metropolitan region, where priority is being given to strengthening the TB control plan. In 2010, the population was 487,562 inhabitants, making up 100% of the urbanized municipality[10,11].

Considering the marked transformations in Brazil, the objective of this study was to determine the association between socio-environmental (SE) and programmatic (PR) indicators with the occurrence of TB in the period from 2008 to 2012. In addition, we sought to evaluate the relationships between the spatial pattern of TB and the socio-spatial organization of the city of Niterói in light of historical processes to understand the social production of TB in the city.

METHOD

An ecological study was carried out in Niterói, located in the metropolitan region of RJ, from 2008 to 2012. The boundaries are the municipalities of São Gonçalo and Maricá, and Baía de Guanabara Bay and the Atlantic Ocean[11].

Niterói is divided into 52 districts, distributed in 5 planning areas[11]. Due to inconsistencies in addresses and difficulties in estimating the population of neighborhoods officialized after 2003, the territorial division used considered 48 neighborhoods, defined before the Plano Diretor da Região Oceânica, instituted on April 4, 2002, when Itaipu and Piratininga were dismembered and formalized as the neighborhoods of Maravista, Serra Grande and Santo Antônio and Jardim Imbuí[11].

Data from the Information System for Notifiable Diseases (SINAN) provided by the State Department of Health of Rio de Janeiro and the Coordination of Epidemiological Surveillance of Niterói (COVIG) were used.

For this study, we considered the new cases of TB, including all forms of the disease (pulmonary and extrapulmonary) in patients living in Niterói.

Two indicators were constructed, SE and PR. The variables of the SE indicator come from the 2010 Demographic Census of the Brazilian Institute of Geography and Statistics (IBGE), and those used for the PR indicator were obtained from SINAN (Chart 1).

The Tuberculosis Control Plan (TCP) has eight units for outpatient treatment of TB and 31 modules of the Family Medical Program (FMP), which can diagnose, monitor and treat users in their respective areas[12].

There is a referral hospital, the Ary Parreiras State Institute of Chest Diseases (IETAP), which also houses the multidrug resistant (MDR) TB outpatient clinic. Hospital Estadual Azevedo Lima (HEAL) and Hospital Universitário Antônio Pedro (HUAP) diagnose and hospitalize people with TB for a short period of time, and in HUAP there is an Infectious and Parasitic Diseases (DIP) sector where patients can be referred. The present study was carried out in accordance with the Research Ethics Committee of Fluminense Federal University under approval No. 645.992.

SPATIAL ANALYSIS

We prepared the thematic maps of the distribution of the incidence rate in the city and the SE and PR indicators using as the analysis unit the neighborhoods of Niterói. The programs used for the mapping of the indicators were ArcGis 10 and Terraview 4.2.

The incidence rate map was corrected by the global Bayesian method. This method reduces the random fluctuations caused by the instability that gross rates express in areas with small populations, using information from neighboring areas around Niterói to minimize the effect of random fluctuations not associated with risk[13].

The class division used the natural break (Jenks Method), whose boundaries are defined where there are relatively large differences in the data values[14].

STATISTICAL ANALYSIS

The indicators were established by using the correlation matrix between eight exploratory variables described in Table 1. The indicators were constructed by factorial analysis with principal components estimation. The Kaiser-Meyer-Olklin statistic and the sphericity test were used to see if the data had sufficient correlation to perform the factorial analysis, and both results (Kaiser-Meyer-Olklin of 0.763 and sphericity test with $p < 0.001$) suggested

Chart 1. Variables selected to make up the socio-environmental and programmatic indicators.

Dependent variable
Incidence level was used as the dependent variable, the number of new cases of tuberculosis in the period of 2008 to 2012. In the regression model, the natural logarithm of the population of the middle of the period, year 2010, was used as offset.

Socio-environmental variables
Income: proportion of households with up to 1 MS, referring to the year 2010;
Proportion of households with more than 10 MS, referring to the year 2010;
Proportion of poor: proportion of heads of household with income up to 2 MS, referring to the year 2010;
Proportion of households with 7 or more residents;
Sanitation facility: proportion of households without sewage connected to general network or rainwater.

Programmatic variables
Treatment abandonment: "Number of tuberculosis cases whose closure was abandonment (individual who stopped coming to the basic treatment unit for more than 30 consecutive days after the expected day)".[16]
Retreatment: "Tuberculosis cases whose entry into the information system was due to relapse and re-entry after abandonment. Considering a recurrence, the patient who was discharged because of cure and diagnosed again with tuberculosis after a period of less than five years".[16]
TB/HIV co-infection: "Number of tuberculosis cases diagnosed positive for acquired immunodeficiency syndrome (AIDS)".[16]
MS: minimum salary; TB: tuberculosis; HIV: human immunodeficiency virus.

that the data were sufficiently correlated for such analysis[15]. Factors with eigenvalues above 1 were used to select the number of factors. Varimax rotation was used to make the factors more easily interpretable. From this analysis we derived two indicators: an SE and a PR, which were used as covariates in the regression. For the regression analysis, the scores for both indicators were calculated.

The analysis of the relationship between the two indicators and the incidence of TB was performed by Poisson regression for the response variable new cases of TB and as offset the natural logarithm of the population of each neighborhood in 2010, and robust variance estimation. Incidence rate ratios (IRR) were used as measures of effect. The quality of fit of the model was determined by analysis of its residuals.

The interpretation of the SE and PR indicators and of the results of the statistical model was carried out using a literature review regarding the main socio-spatial organization processes of Niterói, which made it possible to insert historicity in the understanding of the TB development process.

RESULTS

Between 2008 and 2012, there were 1,660 new cases of TB in the city of Niterói, corresponding to an average incidence rate of 68.09 cases per 100,000 inhabitants. Of these, 9.45% abandoned treatment (157 cases), 10.42% (173) had TB/HIV co-infection and 8.37% (145) were from retreatment. The distribution of incidence rates was heterogeneous in the city (Figure 1).

Of the 48 neighborhoods analyzed, 50% showed an average incidence rate higher than the city average. Both the highest and lowest incidences were observed in the neighborhoods of the Norte and Praias da Baía regions. Engenhoca (78.10 per 100,000 inhabitants), São Francisco (79.41 per 100,000 inhabitants), Centro (82.86 per 100,000 inhabitants), Barreto (84.71 per 100,000 inhabitants) and Caramujo (91.88 per 100,000 inhabitants) were classified as being at greatest risk for the disease.

The lowest rates were observed in Ingá, Vila Progresso, Viçoso Jardim, Santana and Icaraí, respectively 62.18, 61.41, 60.04, 52.27 and 41.61 per 100,000 inhabitants.

The spatial distribution of the SE indicator showed worse living conditions especially in the neighborhoods of the Norte and Pendotiba regions, with the exception of Morro do Estado and Viradouro (in Praias da Baía region) and Jacaré (in Oceânica region), which displayed high scores for this indicator, in contrast to the other neighborhoods in their regions (Figure 1).

Fonseca, Santa Rosa, Centro, Engenhoca, Barreto and Caramujo, located in the Norte and Praias da Baía regions, exhibited the worst situation regarding the PR indicator, which considers treatment abandonment, retreatment and TB/HIV co-infection. Table 1 presents a general summary, with mean, standard deviation, minimum, median and maximum values for all variables studied.

Table 2 describes the factor loadings for the composition of SE and PR indicators. Each factor loading can vary from -1 to +1: the closer to the extremes ± 1, stronger is the relationship of the variable with the indicator, and the closer to zero, the weaker. Thus, the SE indicator was composed of positive loadings by the following variables in descending order: proportion of households with up to 1 minimum salary (MS); proportion of poor; proportion of households with 7 or more residents; and proportion of households without sewage connected to the general network or rainwater. The SE indicator showed negative loading for the proportion of households with more than 10 MS, while the other factor loadings were irrelevant for this indicator. The PR indicator was composed of three variables that showed positive loadings, namely total cases of treatment abandonment, total cases of relapse, and total cases of co-infection; the other factor loadings were irrelevant for this indicator.

Table 3 summarizes the results of the Poisson model whose fit proved adequate (residual analysis not shown). It is noted that SE indicator one unit higher was associated with a 27% increased TB incidence, on average; while an PR indicator one unit higher was associated with a 7% higher TB incidence, on average.

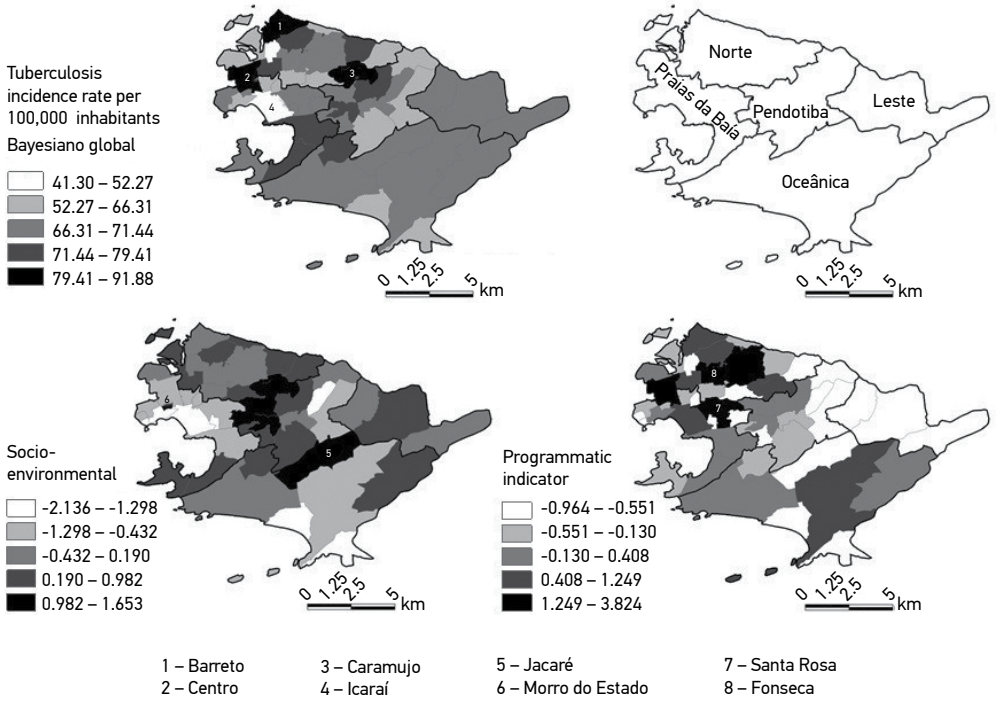

Figure 1. Distribution of tuberculosis incidence rate and socio-environmental and programmatic indicators by neighborhood. Niterói, RJ, 2008 to 2012.

Table 1. Descriptive statistics of the variables that make up the socio-environmental and programmatic indicators. Niterói, Rio de Janeiro.

Variables	Min.	Median	Max.	Mean	SD
Socio-environmental					
Proportion of households with up to 1 MS	0.240	0.245	0.251	0.230	0.112
Proportion of poor	0.478	0.479	0.480	0.446	0.190
Proportion of households with more than 10 MS	0.072	0.075	0.079	0.124	0.121
Proportion of households without sewage connected to general network or rainwater	0.000	0.0008	0.0008	0.001	0.001
Proportion of households with more than 7 residents	0.021	0.0214	0.022	0.022	0.011
Programmatic variables					
Total cases of treatment abandonment, 2008 to 2012	1	1.50	2	3.27	5.144
Total cases with co-infection, 2008 to 2012	2	2.00	22	3.60	5.311
Total cases with retreatment, 2008 to 2012	0	1.50	15	3.02	3.317

SD: standard deviation; MS: minimum salary.

Table 2. Rotated factor loadings that make up socio-environmental and programmatic indicators. Niterói, Rio de Janeiro.

Variables	Indicator	
	SE	PR
Proportion of households with up to 1 MS	0.961	-0.110
Proportion of poor	0.860	-0.137
Proportion of households with more than 10 MS	-0.925	-0.103
Proportion of households without sewage connected to general network or rainwater	0.649	0.102
Proportion of households with more than 7 residents	0.796	-0.230
Total cases of treatment abandonment, 2008 to 2012	-0.031	0.921
Total cases with co-infection, 2008 to 2012	-0.107	0.913
Total cases with retreatment, 2008 to 2012	0.005	0.914

SE: socio-environmental; PR: programmatic; MS: minimum salary.

DISCUSSION

The spatial distribution pattern of TB in the municipality of Niterói was heterogeneous. The greatest risks were observed in the Norte e Praias da Baía neighborhoods, especially in Caramujo, Barreto and Centro (Figure 1). These regions have areas with worse living conditions, in which the SE and PR indicators showed a significant association. This scenario may seem contradictory, considering that Niterói has the best HDI in RJ and ranks seventh in all of Brazil, besides having the fourth largest gross domestic product (GDP) in the state[16]. However, this paradoxical relation reflects the pattern described by Sabroza and Waltner-Towels,[17] who affirm that areas of TB development are those cities fully integrated in the economy and responsible for wealth production.

Niterói is characterized as a naval industrial pole, being part of the East Fluminense Consortium (CONLESTE). The economy is fundamentally based on the tertiary or services sector, but at the end of the 19th century, Niterói was an important industrial center. However, due to the decay of the port and the railway branch, in the 1970s, and with the transfer of the capital to Brasilia, the industrial economy lost its position, and only in the 2000s did it return to restructuring its naval industry[11,18].

Currently, with this restructuring and proximity to major industrial developments, such as the Rio de Janeiro Petrochemical Complex (COMPERJ), there have been changes in the urban pattern, with revitalization of the central area and increased movement of labor attracted by industry. In the last years, Niterói has undergone extensive transformations in its urban network, reflecting real estate speculation and the establishment of large residential projects of high standard to meet the demand of population groups with greater purchasing power moving to the area[19].

As a result of the exploration of marketing Niterói as a city in RJ with a better quality of life and the presence of quality urban facilities in the state[19], for example, Fluminense Federal University (UFF), the city acts as an attractive pole for people coming from the interior of the state in search of these services and for those groups with higher schooling and integrated in the urban economy that develop better paying activities. In addition, it is part

Table 3. Poisson regression model of socio-environmental and programmatic indicators as predictors of the number of new cases of tuberculosis (as offset, the natural logarithm of the population in the middle of the period). Niterói, Rio de Janeiro.

	Incidence Rate Ratio	95% confidence interval		p-value
		Lower limit	Upper limit	
Socio-environmental situation indicator	1.27	1.20	1.33	< 0.001
Programmatic indicator	1.07	1.04	1.11	< 0.001

of the guidelines of the Municipal Master Plan (PDM) to encourage a creative economy and transform the city into a center of technological development, which in partnership with UFF, makes it possible to establish about 50 startups in the next five years, related particularly to the videogame and biotechnology sector[20].

However, despite the urban characteristics that make Niterói stand out as a city with a better quality of life, the distribution of TB associated with SE and PR indicators (Figure 1) points to the relationship between the maintenance of the endemic disease and the living conditions and shows the territorial social inequalities existing in the city.

The health-disease process of TB in population groups is related to the historical social development of space and, at the individual level, to the biological deterioration of the body due to living and working conditions. In this sense, the TB health-disease process is a social product that reflects the socio-spatial organization of an area[21].

According to Sabroza and Waltner-Towels[17], the social production of TB is concentrated in the population of the "vulnerable", because they are the ones that suffer most from the process of social reproduction, especially by the survival strategies resulting from the intense mobility across the country, uncertainties arising from the fragility of labor relations and exposure to risks.

In Niterói, the process of occupying the aforementioned neighborhoods as those that posed the greatest risk for the disease may explain, in part, the permanence of the endemic disease in the city. Both the Norte and Praias da Baía regions are consolidated occupancy spaces, being the first areas occupied in the city.

The Praias da Baía area has the oldest occupation. In the eighteenth century, as capital of the Province of Rio de Janeiro, it received many investments and installation of important urban facilities [22]. However, in the 1970s, the transfer of the state capital to the city of Rio de Janeiro impacted, mainly, the central part of the city, resulting in a process of economic stagnation, decay and urban degradation, which explains the presence of slums next to upscale neighborhoods [22,23].

The neighborhood of Barreto, located in Norte region, had urban characteristics as early as 1870, due to the development of various industries in textiles, fishing and the naval sector, which served as vectors of urban expansion and are still in operation[24].

However, the neighborhoods of Baldeador, Caramujo, Viçoso Jardim and Santa Bárbara, also located in the Norte area, were established differently compared to Barreto, where they were not affected by the industrialization process; they are more distant areas and until today show some rural characteristics along with poor infrastructure[24,25].

The Caramujo neighborhood had initially rural occupation. As of the 1970s, the slopes began to be occupied, initiating the slum process. The Morro do Céu region is located in this neighborhood, a community in which the municipal garbage dump has been since the early 1980s. In addition, in 1994, the slum Maria Thereza favela, located in the São Domingos neighborhood, was moved to Morro do Céu[26].

In contrast, the Barreto neighborhood had suburban occupation. The suburbs were industrial zones linked to the center by railroad lines and occupation by the working class.

Several industries and shipyards settled at the site, forming worker towns. In addition, Avenida do Contorno was built, a stretch of BR-101 that passes through the site. However, with the economic crisis in the 1970s, there was deindustrialization of the neighborhood, and the suburban concept gave way to the concept of the periphery, as a place of the excluded and of abandonment[24].

The neighborhoods of the Norte region, besides the high incidence rate and direct and positive association with the SE indicator, showed an association with the PR indicator, pointing out the relevance of control actions for TB, since it is an airborne disease and some patterns are associated with a higher risk of exposure and illness, as discussed by San Pedro[9], Erazo[26], Vicentin[27] and Vendramini[6].

In the Centro neighborhood, the observed spatial pattern did not differ compared to the others. Despite the high incidence rate, this finding suggests that the persistence of TB in this neighborhood, located in the Praias da Baía region, depends on factors other than poverty, despite being a consolidated neighborhood with a good result in relation to the SE indicator.

The neighborhood Centro is the region of the city where there are stores and services. In this neighborhood, there are ferries for transportation to the city of Rio de Janeiro. In the 1970s, the neighborhood suffered the impact of the change of government headquarters to Brasilia. As a result, there was a decrease in population mobility and a substitution of formal commerce by the informal sector, giving rise to many abandoned areas, and neighborhood's role was reduced to connecting residential areas and surrounding cities[28].

This intra-urban spatial dynamics of the Centro neighborhood may explain the persistence of TB, because although the SE indicator showed less risk, the PR indicator showed association. Centro had one of the highest proportions of TB/HIV co-infection in the city (12%). It is worrisome, since TB/HIV co-infection has a great impact on mortality due to AIDS, where TB causes more than 50% of deaths in patients with co-infection[29]. This finding calls attention to prostitution areas of the Centro neighborhood, whose largest representative is the "Caixa Econômica" building[28,29]. In a similar study, in the city of Juiz de Fora, a significant association between TB and AIDS was found in the central area of the city, also especially related to the concentration of prostitution activities. In contrast, in a study in Porto Alegre, TB/HIV co-infection did not reach only the periphery, a fact demonstrated by high rates in neighborhoods that have better living conditions. In that study, the authors identified two perspectives for the occurrence of TB, a traditional one related to misery and to those socially excluded, and co-infection with HIV and AIDS, which encompasses other population groups[30,31].

The results of the present study suggests that there are two explanatory models for the occurrence of TB in the city of Niterói, as was also observed in the studies of Juiz de Fora and Porto Alegre. The first is related to the poverty of already consolidated areas and the second to HIV co-infection. However, statistical analysis showed that the relationship with living conditions assumes a greater magnitude to the detriment of co-infection (Table 2), and it can be explained by the fact that TB/HIV co-infection is more important only in the central area of the city, where there is a concentration of activities related to prostitution.

These findings point to a relationship between the incidence rates of TB and the SE and PR indicators in Niterói, suggesting a higher risk of illness in the population groups in unfavorable living conditions, or the condition of urban poverty historically produced in the process of city organization, or by the social and institutional vulnerability of specific groups that show high occurrence of TB/HIV coinfection.

CONCLUSION

We can conclude that the dynamics of TB transmission in Niterói can be explained by the occurrence of the disease in areas of consolidated social periphery and by the social and institutional vulnerability of specific groups with high rate of TB/HIV co-infection. The results of this study corroborate the historical relationship between the occurrence of TB and living conditions, but the complexity of the factors involved in the maintenance and transmission of TB suggests the need for deeper local studies to show peculiar characteristics that favor the persistence of the disease in each location.

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