

Tuberculosis in Brazil: construction of a territorially based surveillance system

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Keywords

Tuberculosis, prevention control. Epidemiologic surveillance. Spatial distribution.

Abstract

Objective

To analyze the occurrence of tuberculosis and to identify variables that define situations of collective risk that determine the spatial distribution of the disease, as backing for implementing a territory-based surveillance system for tuberculosis control.

Methods

This was an ecological study performed in Olinda, a municipality in the metropolitan region of Recife, State of Pernambuco, between 1996 and 2000. The median number of notified tuberculosis cases in each census tract served as the cutoff point for characterizing areas of high and low transmission. A logistic regression model using this response variable allowed odds ratios for some socioeconomic variables from the 2000 demographic census and other covariates related to the transmission of the disease to be estimated.

Results

Tuberculosis in Olinda presented high incidence rates during the study period (average of 111 cases per 100,000 inhabitants). Significant associations with the occurrence of tuberculosis were found for the variables of average number of inhabitants per household (OR=2.2; 95% CI: 1.3; 3.6); existence of families with more than one case during the study period (OR=5.1; 95% CI: 2.3; 11.3); and presence of cases of retreatment (OR=6.8; 95% CI: 2.7; 17.1). The census tract where the latter two events occurred accounted for 45% of the total number of cases during the study period, while representing only 28% of the population of Olinda.

Conclusions

The two explanatory covariates that were strongly associated with higher incidence rates of the disease are events that need to be carefully monitored at a local level by the tuberculosis surveillance system. Simply by mapping out retreatment cases and households with more than one case, attention could be focused on small areas with high priority for intensive intervention, thus facing up to the tuberculosis problem.

INTRODUCTION

A new millennium has begun and, in Brazil, tuberculosis is a health problem that is as serious today as it was at the start of last century. Its incidence rates have remained high over the last two decades and it has been estimated that, over this period, more than 42 million cases of infection have occurred, and

that the disease has led to around 112,000 deaths.*

In addition, the present systems for epidemiological surveillance are characterized by slowness in generating information. As well as not linking the occurrence of health events to the space where they occur, the present systems are analysed far from the local levels of the system. Consequently, they do not enable health-

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*Ministério da Saúde. Sistema de Informações sobre Mortalidade. Available at : <URL: <http://www.datasus.gov.br>> [accessed in 2003] e Ministério da Saúde. Série histórica de doenças de notificação compulsória por UF, 1980-2001. Available at : <URL: <http://www.funasa.gov.br/epi/epi00.htm>> [accessed in 2002].
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care services to respond rapidly to health problems that are presented. Thus, it is important and necessary to structure a tuberculosis surveillance system that considers territory-based interventions, as a means of better identifying the determinants of this disease.

From this reality, some points regarding the tuberculosis problem need to be considered from the perspective of interventions made within the Brazilian healthcare system. The possible contributions that the incorporation of new technologies could bring to the surveillance system for the disease also need to be considered.

Faced with a situation of persistence and/or recrudescence of tuberculosis in various municipalities in Brazil, the Ministry of Health established the National Tuberculosis Control Plan (NTCP). This had the aims of involving 100% of Brazilian municipalities in the fight against the disease, discovering 92% of the existing cases by 2001, curing 85% of the diagnosed cases and reducing the incidence by at least 50% and the mortality due to tuberculosis by two-thirds, by 2007.^{9,14}

As well as setting these targets, the NTCP also defined its development phases, the existing and needed resources, and instruments for action and organization.⁹ However, little attention was given to verifying the appropriateness of the targets that were set to the determinants of the problem. The aim would be to structure a tuberculosis surveillance system that would be strategically designed to respond to the various demands of the present epidemiological situation of this endemic disease in Brazil. The system would be consonant with the principle of decentralization. The question that was posed was whether the targets outlined and the strategies utilized would be sufficient for "modifying the epidemiological situation of the disease".

The presupposition for constructing a territory-based surveillance system is the widely demonstrated knowledge that the distribution of endemic diseases is also determined by social processes that are intrinsically related to the characteristics of the space in which they take place.^{2,7,16}

This new configuration points towards the implementation of a public health surveillance system that is structured around healthcare services and is located and organized according to the logic of sanitary districts. It needs to be constructed within a perspective of changing sanitary practices and have the capability

to identify areas or situations that are at risk, within the "defined population base".

Considering the need to understand the breakdown of the distribution of diseases within the urban space, it becomes fundamental to utilize smaller basic units for data collection and analysis. One alternative that is being employed is the utilization of the basic unit of the demographic census, which makes available socioeconomic information on populations, and also other information of a sanitary and environmental nature, from all the census tracts of all Brazilian cities.**

With regard to the etiology of health problems, Rose¹² stated that two aspects need to be considered: the causes of cases among individuals and the determinants of disease rates among populations. It was emphasized that, even though strategies for preventing individual risk are needed for protecting susceptible individuals, the priority question should always be the search for and control of the determinants of disease incidence among populations.

Although these two approaches must not be considered to be opposed to each other, analysis of the variability of risk at the ecological level is fundamental for a comprehension of the social determinants of the health-disease process. In this, in particular, the socioeconomic conditions of the population groups perform a preponderant role in explaining the health conditions of these groups.⁶

The present work had the objective of showing, from a spatial approach, the possibility for implementing a territory-based surveillance system in relation to tuberculosis, as a contribution to the NTCP.

The occurrence of tuberculosis has been analysed by taking the municipality of Olinda as an example. Variables defining collective situations of risk that determine the spatial distribution of tuberculosis have been identified, as backing for the planning of interventions directed towards priority population groups.

METHODS

An ecological study was carried out in Olinda, a municipality within the metropolitan region of Recife, State of Pernambuco, between 1996 and 2000. According to the demographic census of 1991,* the municipality had 341,394 inhabitants in its urban region. According to the demographic census of 2000,* it had 367,902 inhabitants. The municipality

*Instituto Brasileiro de Geografia e Estatística [IBGE]. Censos demográficos. Available at: <URL:http://www.ibge.gov.br/censos> [Accessed in 2001]

has an area of 40.83 km², thus implying a demographic density of more than 9,000 inhabitants per square kilometer, which ranks it as one of the most densely populated in the country.

For the information relating to tuberculosis cases, data from the notifiable diseases information system of the Ministry of Health (SINAN/MS), the National Health Foundation (FNS) and the National Epidemiology Center (CENEPI) for the period 1996 to 2000 were utilized. The data were collected from the State Health Department of Pernambuco. Duplicated cases were eliminated.

With regard to deaths, data from the mortality information system (MIS) of the Ministry of Health were utilized, by means of accessing the databases of the Informatics Department of the Brazilian National Health System (Datasus). To obtain socioeconomic and demographic data on populations and homes, broken down to the level of each census tract of the municipality of Olinda, the database of the demographic census of 2000 was utilized.

A digital map containing the street layout and network of the 299 census tracts of Olinda relating to the 2000 census was also utilized, furnished by the Brazilian Institute for Geography and Statistics (IBGE).

The georeferencing of the tuberculosis cases among residents of the municipality of Olinda was done from information on residential addresses appearing in the SINAN database and from descriptors of the tract limits.

In the data analysis, the census tracts were considered to be the basic unit. The next stage consisted of the incorporation of the tuberculosis cases into the Geographical Information System (SIG), using the ARC/INFO/ARCVIEW software (ESRI)* to relate the data to the respective census tracts where such individuals lived. Following this, the socioeconomic and demographic information from the 2000 census was tied in with SIG, linking the case information to the respective census tract layer within the digital map of Olinda.

Descriptive analysis was firstly done on the occurrence of all forms of tuberculosis within the municipality of Olinda, using the annual incidence and mortality rates per 100,000 inhabitants as the indicators.

Following this, a description was made of the mean values of epidemiological and operational indicators for the period. These were constructed from the vari-

ables of sex, age, forms of tuberculosis, history of previous treatment, performing of sputum bacilloscopy, association with HIV and treatment outcome. As an indicator of morbidity, the mean incidence rate per 100,000 inhabitants for the period was calculated by means of SIG, for each census tract. This mean was adopted as a simple treatment for ensuring greater stability for the data relating to events coming from small areas (census tracts), which are subject to large random variations. For this calculation, the numerator taken was the total number of tuberculosis cases during each period, divided by five. The denominator was the population of each tract in the middle of the period.

A thematic map was produced from these mean rates, using SIG. This furnished a classification of the census tracts according to quartiles of the distribution of mean incidence rates.

For identifying the variables that defined collective situations of risk, a multivariate logistic regression model was utilized. The variable selection method utilized was backward stepwise selection, with verification of the significance of the likelihood ratio.^{5,13}

The mean incidence (y) was taken as the dependent variable. The explanatory variables were the percentage of heads of families without schooling or with less than one year of schooling (x_1), the percentage of heads of families with income of less than one minimum salary or no income (x_2), the average number of residents per home (x_3), the demographic density (x_4), the existence of families with more than one tuberculosis case during the study period (x_5), and the existence of cases of retreatment (x_6). All the variables were calculated per census tract and the explanatory variables chosen presented statistically significant associations with the dependent variable, by means of the chi-squared test, with continuity correction by 2x2 tables.

Both the dependent variable (y) and the independent variables (x_1 , x_2 , x_3 and x_4) were recoded, assuming a value of 1 when the value originally observed for the census tract was greater than the median for the municipality, and zero for the opposite case. For the variables x_5 and x_6 , the recoding consisted of attributing a value of 1 to tracts that were positive for the event of interest and zero for the opposite case.

RESULTS

Out of the 1,984 tuberculosis cases registered during the study period, 1,678 (84.6%) were georeferenced

*ESRI: Environmental Systems Research Institute.

by census tract. Thus, it is stressed that, for all the years of the study, the percentage of referencing obtained was greater than 82%.

Olinda had an estimated population of 358,381 inhabitants on July 1, 1998. The resultant annual mean incidence rate was 111 cases of tuberculosis per 100,000 inhabitants. Moreover, the occurrence of 213 deaths over the same period signifies an annual mean coefficient of specific mortality of approximately 12 deaths per 100,000 inhabitants, thus suggesting a lethality rate of more than 10%.

The median of the frequency distribution of mean incidence per census tract was 77.4 cases per 100,000 inhabitants, which was lower than the mean of the distribution, even considering only the georeferenced cases. This signifies the occurrence of high incidence rates in a small number of tracts.

For Brazil, over the same period, a mean incidence of tuberculosis of around 50 cases per 100,000 inhabitants and a mortality coefficient of just under four per 100,000. This implies that the incidence in Olinda was approximately twice the national average and the mortality was more than three times the average for the country.¹⁷

Table 1 presents the set of operational and epidemiological indicators utilized in the descriptive analysis of the tuberculosis situation in Olinda.

Prominent among the results were the facts that there were 594 cases without any information on their outcomes, which represented 30% of all the cases. Also, low percentages of cases had bacilloscopy performed, were examined for HIV and had culturing tests performed.

In Figure 1, the thematic map represents the mean incidence observed over the study period. In this, the

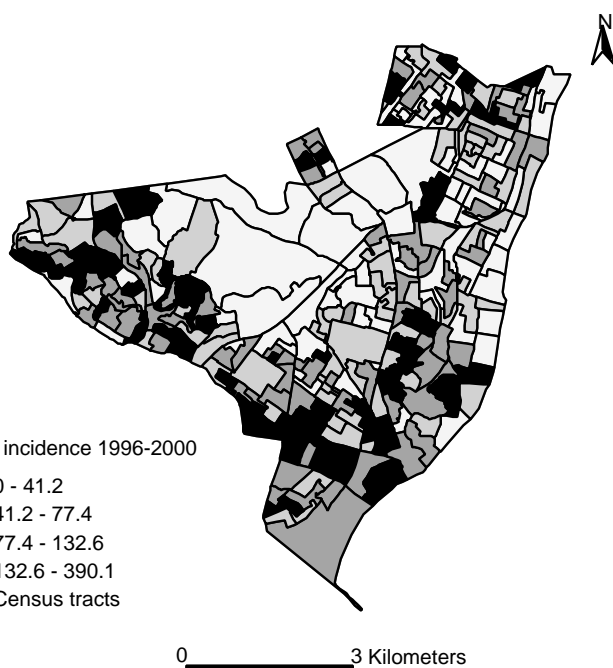


Figure 1 - Mean tuberculosis incidence rates per 100,000 inhabitants. Olinda, State of Pernambuco, during the period 1996-2000.

census tracts are classified according the quartiles of the distribution of the incidence rates per 100,000 inhabitants. It can be seen that the center-southern and northwestern regions of the city were the ones that presented the most serious occurrences of tuberculosis, while the northern and eastern (seafront) areas has less serious occurrences.

Table 2 presents the results from the final risk model obtained through the use of the logistic regression model. These results indicate that the defining factors for situations of risk of the occurrence of tuberculosis were the variables of mean number of residents per home (x_3), existence of families with more than one case during the study period (x_5) and existence of cases of retreatment (x_6).

With the objective of identifying priority areas for interventions, the map of the municipality (Figure 2)

Table 1 - Epidemiological and operational indicators of tuberculosis, Olinda, State of Pernambuco, 1996-2000.

Description	Frequency	Total number of cases with information	%
Female cases	735	1,983	37.1
Cases among children aged under 15	89	1,979	4.5
Cases of the pulmonary form	1,709	1,976	86.5
Bacilloscopy performed	1,308	1,984	65.9
History of previous treatment	334	1,697	19.7
Culturing performed	201	1,984	10.1
Unfavorable outcome*	501	1,390	36.0
HIV-positive cases	45	290	15.5

*Unfavorable outcomes were considered to be those in which death occurred, treatment was abandoned, or continued treatment included failure of the therapeutic scheme

Table 2 - Results from the final risk model: logistic regression (*Backward /Likelihood Ratio*).

Variable	OR	95% CI	Degrees of freedom	p
Average number of residents per home (x_3)	2.17	1.32-3.57	1	0.002
Existence of families with more than one case during the period (x_2)	5.09	2.30-11.29	1	<0.001
Existence of cases of retreatment (x_6)	6.78	2.68-17.15	1	<0.001

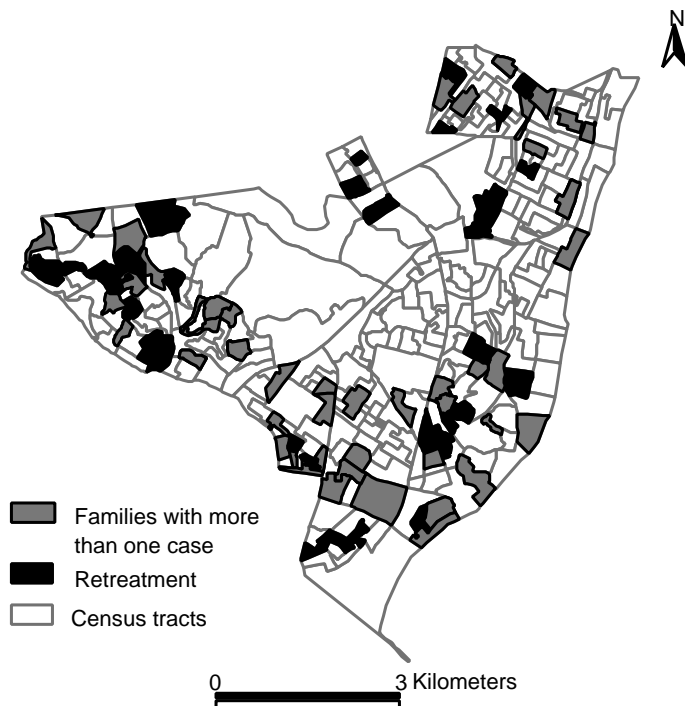


Figure 2 - Census sectors with one or more cases of retreatment of tuberculosis and/or homes with more than one case during the period. Olinda, State of Pernambuco.

indicates the tracts in which the occurrence of cases of retreatment and/or homes with more than one case between 1996 and 2000 was verified. These variables that were identified as indicating the greatest risk in the analysis, are intrinsically related to the activities of the NTCP.

The areas indicated correspond to 77 census tracts in which there was a total of 755 tuberculosis cases during the study period (45% of the total), with a population of 100,689 inhabitants (28% of the total). This implies an annual mean incidence rate of 150 cases per 100,000 inhabitants.

Figure 3 presents the census tracts that are situated above the 90th percentile of the distribution of the mean incidence (196 cases per 100,000 inhabitants). This approach has enabled the identification of critical areas and shown the concentration of the most serious situations regarding the occurrence of the disease in a small number of tracts.

The areas indicated correspond to 30 tracts, in which 420 cases are concentrated (25% of the georeferenced total), with only 9.5% of the population of the municipality. This implies a mean incidence over the period of more than 245 cases per 100,000 inhabitants.

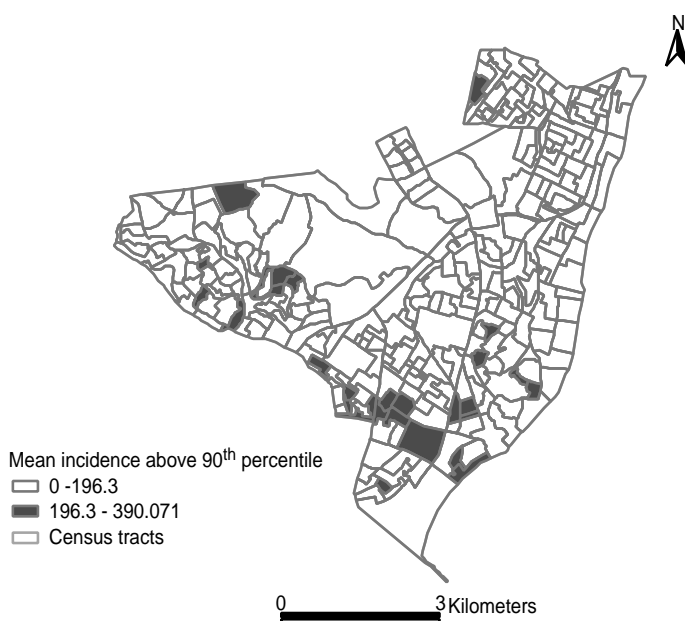


Figure 3 - Census sectors with mean tuberculosis incidence greater than the 90th percentile. Olinda, State of Pernambuco.

DISCUSSION

High mortality rates were found in the municipality. This went together with the fact that 36% of the cases with information available finished with an unfavourable outcome, including 15% that resulted in death. In addition to this, bacilloscopy was performed in only 66% of the cases; the system had low coverage regarding the tuberculosis-HIV/Aids association; and extremely low percentages of cases had sputum culturing tests performed. These elements are essential for assessing the processes and indicate serious problems for which intervention is possible.

In this light, and considering the causes of tuberculosis indicated in the NTCP,⁹ including the social processes that determine its occurrence, two major axes for action were uncovered. The first axis contains the actions aimed at improving the program, which must encompass the integration of analytical activities into the management model, so as to institute an assessment system for policies and programs.⁴ In the case of Olinda, over the period studied, the indicators presented suggest that there was a lack of coordination between analysis activities and the management model, thereby configuring a serious situation with regard to the endemic disease. The second axis relates to the actions aimed at surveillance of collective situations of risk, such as in needy areas, with the scope of a territory-based epidemiological surveillance system that is no longer centered solely on the concept of individual risk.

Such a system should produce a breakdown of the information. It would allow visualization of the distribution of the disease, within the urban space stratified according to living conditions, which is indicated as one of the causes of tuberculosis.¹⁰ The occurrence of a case of antituberculosis drug resistance, a case of retreatment, or more than one case of the disease within the same home should be considered to be sentinel events. Verification of the existence of at least one of these events, especially in areas of precarious living conditions, ought to trigger a set of actions aimed at that area and not just towards the sick individual, thus characterizing a procedure of active surveillance.

To this end, it becomes necessary to strengthen the coordination of the NTCP with the Community Agents Program (CAP) and the Family Health Program (FHP). These programs, which were implemented in Brazil from 1991 and 1994 onwards, respectively, have formed instruments for reorganizing the health-care system. They could contribute towards tuberculosis control by adding at-risk population group surveillance logic to the cases and communicants surveillance model, with a territory basis that is defined and coherent with the causes identified for the tuberculosis problem.⁸

Specific activities of active search for infected individuals and those with respiratory symptoms, recovery of abandoned cases and supervision of the treatment of priority groups of patients must be structured through the CAP/FHP.

Directly supervised treatment is a procedure that could increase the adherence to treatment. It could result in higher cure percentages and reduce the ap-

pearance of antituberculosis drug resistance.^{3,11,18} This is a very useful strategy that has started to be implemented in Brazil. It is a means of intervention that could also be accomplished through the CAP/FHP.¹

The information systems available for the NTCP, and also for the other disease control programs in Brazil, are SINAN, the Mortality Information System (MIS) and the Hospitalization Information System (HIS). Among these, SINAN is the one that has been utilized most for epidemiological surveillance. However, in attempting to encompass the functions of a notification system and those of a case investigation system, this system results in a sluggish product with many information gaps, particularly regarding the locations where such individuals live. This makes the task of relating the case to the space within which it occurs very difficult.

In addition to this, just as with the other health information systems in Brazil, SINAN does not have a communication interface within itself, or with other information systems. It ends up characterized as a record office system without the agility to develop analyses and immediate actions.

The present study has shown, with the use of SIG, that the identification of areas in which events relevant to the tuberculosis transmission process are localized (cases of retreatment and families with more than one case during the period), or simply areas with greater incidence of the disease, forms a useful instrument for the structuring of a territory-based surveillance system, thereby identifying priority population groups. Moreover, the delimitation of the problem based on census tracts has enabled viewing of the heterogeneity of the distribution of the disease in the urban space. This makes it possible to plan interventions directed towards specific groups, as presented in Figures 1 and 2.

Even though some operational questions relating to constructing the digital maps and tying in the database have arisen, the adoption of census tracts as the basis for analysis has enabled the construction of a portrayal of the collective risk of falling ill, stratified within the urban space. This is despite the fact that census tracts do not form absolutely homogeneous cells. In addition to this, such an approach has been capable of indicating the differences in the occurrence of tuberculosis in Olinda,¹⁹ in a way that is coherent with the conceptual proposal for surveillance of the space.

The analysis model utilized in the present study has also demonstrated that two of the three variables that explain the occurrence of greater incidence rates

for the disease are the direct responsibility of the local levels of the control programs. Thus, it can be stated that simply mapping out the cases of retreatment and homes with the occurrence of repeated cases, in a manner analogous to what was done by Snow in

relation to cholera around 150 years ago,¹⁵ will allow refinement of the focus of attention towards priority micro-areas in need of intensive intervention, as a means of facing up to the problem of tuberculosis, with rational utilization of resources.

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