Original Article

Spatial and temporal patterns of tuberculosis in the city of Ribeirão Preto, Brazil from 1998 to 2002*

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ABSTRACT

Objective: To determine the spatial distribution of tuberculosis in the city of Ribeirão Preto, located in the state of São Paulo, Brazil, between 1998 and 2002, with a focus on the potential spatially-dependent nature of its occurrence. **Methods**: The secondary Epi-Tb database of the Ribeirão Preto Municipal Secretary of Health. Georeferencing of tuberculosis cases was performed using MapInfo 6.5 software, and the Spring program was used for statistical analysis of spatial data. **Results**: Through analysis of the existing spatial pattern and those of the previous years analyzed, we found a consistent pattern of spatial distribution of tuberculosis in Ribeirão Preto. Although there are areas that were homogeneous in terms of risk, the highest concentrations of cases were found in one zone, consisting of middle- to lower middle-class neighborhoods, located in the northeast part of the city. **Conclusion**: These results add to the store of knowledge regarding the spatial distribution of tuberculosis in Ribeirão Preto in various periods, emphasizing the importance of space as a methodological alternative to aid the planning, monitoring and evaluation of health care programs, allowing interventions to be more appropriately directed in order to decrease inequalities in the allocation of health care resources.

Keywords: Tuberculosis/epidemiology; Health status indicators; Residence characteristics; Urban health/ statistics & numerical data; Topography, medical

INTRODUCTION

The spatial distribution of certain diseases has long been a major concern in advanced societies. The first records of the correlation between a disease and the local/environment where it occurs are attributed to Hippocrates (480 BC). In his book "Airs, Waters and Places", Hippocrates emphasized the importance of the way of life of individuals and analyzed the effect that winds, waters and soil, as well as the location of the cities in relation to the Sun, have on the occurrence of the disease state.[1-2]

As of the 16th century, with the great voyages of discovery, the link between medical knowledge and geography received more attention due to the need to learn about the diseases in the conquered lands in order to protect settlers and develop commercial activities.[2]

Despite the great potential presented by spatial representation techniques and the fact that technologies to treat graphic information and maps using computers are ever more widely available,[3] such techniques are still underused in the health field due to the difficulties inherent to the handling of this type of information,

Geographic information systems are computing systems used to understand facts and phenomena that occur in geographic space. Their capacity to gather a considerable amount of conventional spatial expression data, structuring and integrating them appropriately, makes them essential tools to handle geographic information (Rede Interagencial de Informações para a Saúde - RIPSA, 2000).

The environment of the geographic information system can promote the integration of diverse information and thereby provide a broader view of the situation in space. However, researcher evaluation is essential since there is no automatic mechanism that can interpret the results produced.[4]

There have been many epidemiological studies using a spatial analysis approach. One such study was carried out from 1991 to 1996 in the city of Olinda, located in the state of Pernambuco, Brazil. The objective of that study was to analyze the incidence of cases of leprosy according to their spatial distribution and their correlation with the living conditions of the population, thereby creating a basis for the development of new intervention strategies.[5] The findings of those authors indicate that the heterogeneous spatial distribution of leprosy in the

city of Olinda is not random, and the spatial clustering pattern identified was found to be correlated with the living conditions of the population. This pattern was expressed using an instrument known as the Social Class Indicator, which is calculated based on scores related to socioeconomic variables from the demographic census.

Another study described the use of geographic information processing techniques to characterize social inequality using compound indicators to represent the risks for respiratory diseases in children from an area served by a school health clinic in the city of São Paulo, São Paulo, Brazil.[6] The measurement of compound indicators is a tool used to combine different socioeconomic and environmental variables into a synthetic indicator in order to analyze the characteristics of population groups living in certain geographic areas.[7] Through the methodological instrument used, this study contributes to recognizing risk factors in the area served by a health care facility, addressing the problems related to respiratory diseases in childhood in the hope of promoting equity and improving childhood health.

The analysis of the spatiotemporal distribution of diseases and their determining factors in the populations is a fundamental aspect of epidemiology and comprises three fundamental questions: "who became ill?"; "when was the disease identified?"; and "where was the disease identified?"

Data regarding the spatiotemporal diffusion of the disease are now available and constitute the links in the explanatory chain that can elucidate the problems in the area. These data will lend more authority to recommendations regarding specific intersectoral actions, thereby informing the decision making process.

The objective of the present study was to use secondary data to describe the spatial distribution of tuberculosis (TB) in the urban area of the city of Ribeirão Preto from 1998 to 2002.

METHODS

The geographic area studied corresponds to the city of Ribeirão Preto, which is located in the northeast region of the state of São Paulo (longitude 47°48'24''W and latitude 21°10'42''S), approximately 313 km from the state capital.

Ribeirão Preto is home to one of the principal

financial centers of the country and presents a strong service and commerce sector, which generates 65% of the jobs in the city. According to the 2000 census, Ribeirão Preto has 504,923 inhabitants, making it one of the largest cities in the state of São Paulo and in Brazil.

The present study is characterized as cross-sectional. "Cross-sectional studies are investigations that produce snapshots of the health status of a population or community based on the individual evaluation of the health status of each member of the group, thereby producing global health indicators for the group investigated. Such studies are very useful for diagnosing the local health status of a community."[8]

Data related to the January 1998-December 2002 period were collected from the Epidemiological Surveillance Unit of the Ribeirão Preto Municipal Department of Health. The Epi-Tb database was used. The population of the present study comprised the patients enrolled in the Ribeirão Preto Tuberculosis Control Program at the time of the study.

In order to obtain the thematic maps, the data were geocoded using the MapInfo 6.5 software program. Initially, the automatic form of geocoding was used, the interactive form being used when necessary. In this phase, grids were built to show point events. In a second phase, the maps were transferred to the Spring software program, developed by the Brazilian National Institute for Space Research, and statistical analysis of spatial data was carried out through the study of the density of the TB cases using the appropriate technique (kernel smoothing) for point events.

The smoothing method using the Gaussian kernel function is a nonparametric technique that promotes smoothing, or statistical softening, of data, which makes it possible to filter the variability of a data set and retain the essential local characteristics of the data. The smoothed estimate of the local intensity of the events in the area studied is thereby made, and a risk surface for their occurrence is obtained.[9]

The addresses relating to the reported cases were organized so as to establish a connection with the digital cartographic database. This procedure was complicated and very time-consuming because, in addition to the fact that some of the addresses reported were incomplete, the characteristics of the layout of the streets did

not permit this task to be completed in an automated way. Telephone directories, street guides and analog maps were used in order to make this organization possible.

In order to carry out the present study, the project was previously submitted to the Ethics in Research Committee of the University of São Paulo Nursing School for appraisal and approval. Since the study exclusively used information from the Epi-Tb database, which safeguards personal privacy by not identifying patients, written informed consent forms were not required.

RESULTS

The number of TB cases reported between 1998 and 2002, according to the Epi-Tb database, were georeferenced by home address and are shown in Table 1.

It is of note that, for every year studied, the georeferencing percentage of cases was higher than 85%.

The quality of the information of the address variable, as well as the efficiency of the geographic information system in precisely identifying the location of each event, is essential to analyzing the distribution patterns of these occurrences. Georeferencing was not possible in 10.70% of the cases, either because no address had been provided or because the address provided did not exist.

This demonstrates the need for improving the quality of the data collected. Such data can benefit the community by facilitating the implementation of appropriate measures aimed at harm reduction among individuals affected by the disease, as well as among those having come into contact with

TABLE 1

Distribution of tuberculosis cases in the city of Ribeirão Preto, located in the state of São Paulo, by number of geocoded cases from 1998 to 2002

| Year | Cases Reported | | |
	Total	Georeferenced	(%)
1998	287	262	91,29
1999	259	232	89,57
2000	200	182	91,00
2001	218	186	85,32
2002	133	115	86,46
Total	1097	977	89,30

Figure 1 - 1998 Map showing the spatial density of residences of patients with tuberculosis, Ribeirão Preto, São Paulo
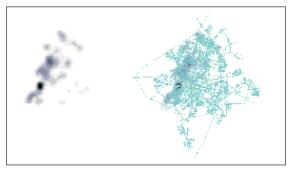

Figure 3 - 2000 Map showing the spatial density of residencesof patients with tuberculosis, Ribeirão Preto, São Paulo

Figure 2 -1999 Map showing the spatial density of residences of patients with tuberculosis, Ribeirão Preto, São Paulo

Figure 4 - 2001 Map showing the spatial density of residences of patients with tuberculosis, Ribeirão Preto, São Paulo

Figure 5 -2002 Map showing the spatial density of residences of patients with tuberculosis, Ribeirão Preto, São Paulo

such individuals, thereby preventing dissemination of the disease within the community.

In order to determine whether TB cases were spatially aggregated, local intensity was estimated using kernel smoothing. The results for the period studied are shown in Figures 1, 2, 3, 4 and 5.

By consulting the maps, we noted that the distribution of the at-risk population in the city of Ribeirão Preto was heterogeneous. In the analysis of the spatial density of residences in which TB cases were reported, it was found that the concentration of cases in 1998 was highest in a portion of the western region of the city, decreasing toward other neighborhoods. The areas of the city in which TB incidence coefficients were higher in 1998 were concentrated in peripheral neighborhoods, where some locales known to present higher risk for transmission are located. Such locales include slums and public jails, where unhygienic conditions, misery and overcrowding prevail.
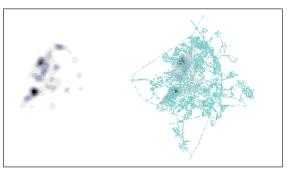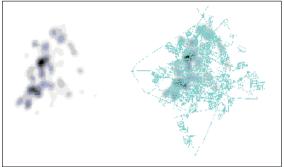
As can be seen in Figure 2, the cases reported in 1999 were highly concentrated in the northern region of the city. Similar to previous years, high-risk (black area in the figure) and low-risk (white area in the figure) areas were identified in certain regions.

The focus identified in 1999 was maintained in 2000 and 2001. In addition, the concentration of cases was similar to that observed in 1998. The situation in 2002 was similar to that found in 1999.

DISCUSSION

For all of the years studied, TB cases in the urban area of Ribeirão Preto were distributed unequally, concentrated in the northwest region of the city. It is believed that TB is directly linked to social inequality. Enarson et al. stated that "[TB] is a strange disease: it is infectious but chronic; it is caused by a bacillus but also by poverty; it reflects what is happening in the present and what happened decades ago; it is exogenous and yet endogenous. It is more prudent to say that [TB] is so complex that it comprises several conditioning factors and not only one".[10]

In the present study, it was assumed that the spatial distribution of TB cases is not uniform, suggesting a correlation with the areas of the region that are traditionally more destitute. The kernel smoothing made it possible to detect where the events were concentrated, revealing geographic inequalities related to events occurring in the city, as well as to identify spatial clustering of cases. Therefore, the stratification of the city by risk made it possible to view it as a collection of heterogeneous subgroups rather than as a whole. This is vitally important in establishing priorities for health programs, allowing for more rational allocation of resources.

The geographic information system, due to its integrating capacity, made it possible to correlate information from the Epi-Tb database spatially. This system is a powerful instrument that allowed us to create maps on which the homes of individuals with TB can be seen, thereby increasing the accuracy of the spatial analysis.

The present study aimed to contribute in some way to the local health care system by identifying the areas of the city in which the incidence of TB cases is highest. We suggest that some interventions in these areas be considered priorities. Contacts should be identified, individuals presenting respiratory symptoms should be actively sought, and healthy individuals should be protected against TB (through vaccination). In addition, drug-resistant cases should be investigated, and all patients presenting positive sputum smear microscopy results should receive supervised treatment (as recommended by the World Health Organization). Furthermore, TB education campaigns should be conducted in cooperation with schools in the region. Moreover, current health care delivery systems should be reviewed, as should current programs for TB prevention and control.

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