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Tuberculosis dynamics from spatial analysis: integrative review

Dinâmica da tuberculose a partir de análise espacial: revisão integrativa

Dinámica de la tuberculosis a partir del análisis espacial: revisión integradora

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ABSTRACT

Objective: to analyze from literature, the contributions of spatial analysis to comprehend the tuberculosis dynamics. **Method:** integrative review of literature preformed within 2008 to 2017, developed from published manuscripts in any language on LILACS, PubMed and SCOPUS databases. **Results:** 140 studies were retrieved, of which 50 were included. The main findings refer to predominance of the use of tuberculosis incidence rates as outcome variable and its association with social and geographic conditions. The American continent presented the highest number of studies, although the African countries presented the highest incidence rates. **Conclusion:** the complexity of tuberculosis incidence in the geographic space is associated with epidemiologic factors. The spatial analysis presents advancements for the management of tuberculosis worldwide allowing identifying inequalities and health conditions of a population.

Descriptors: Tuberculosis; Spatial Analysis; Epidemiology; Review.

RESUMO

Objetivo: analisar a partir da literatura, as contribuições da análise espacial para compreender a dinâmica da tuberculose. **Método**: revisão integrativa da literatura realizada no período de 2008 a 2017, desenvolvida a partir de manuscritos publicados em qualquer idioma nas bases de dados LILACS, PubMed e SCOPUS. **Resultados**: foram resgatados 140 estudos, dos quais 50 incluídos. Os principais achados referem-se à predominância do uso das taxas de incidência de tuberculose como variável de desfecho e sua associação com as condições sociais e geográficas. O continente americano apresentou o maior número de estudos, apesar dos países africanos apresentarem as maiores taxas de incidência. **Conclusão**: a complexidade da incidência da tuberculose no espaço geográfico está associada aos fatores epidemiológicos. A análise espacial representa avanços para o gerenciamento da tuberculose mundialmente permitindo identificar desigualdades e condições de saúde de uma população.

Descritores: Tuberculose; Análise Espacial; Epidemiologia; Revisão.

RESUMÉN

Objetivo: Analizar a partir de la literatura las contribuciones del análisis espacial para comprender la dinámica de la tuberculosis. **Método**: revisión bibliográfica integradora realizada entre 2008 y 2017, desarrollada a partir de manuscritos publicados en cualquier idioma en las bases de datos LILACS, PubMed y SCOPUS. **Resultados**: se rescataron 140 estudios, de los cuales se incluyeron 50. Los principales hallazgos se refieren al predominio del uso de tasas de incidencia de tuberculosis como variable de resultado y su asociación con condiciones sociales y geográficas. El continente americano presentó el mayor número de estudios, aunque los países africanos tuvieron las tasas de incidencia más altas. **Conclusión**: La complejidad de la incidencia de tuberculosis en el espacio geográfico está asociada a factores epidemiológicos. El análisis espacial representa los avances en el manejo de la tuberculosis en todo el mundo, lo que permite identificar las desigualdades y las condiciones de salud de una población.

Descriptores: Tuberculosis; Análisis Espacial; Epidemiología; Revisión.

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INTRODUCTION

Tuberculosis (TB) is a disease caused by a slow growth bacillus, *Mycobacterium tuberculosis,* strict aerobic, acid-alcohol resistant (BAAR), of aerogenous transmissibility, that mainly affects lungs. It is closely related to poverty, poor living and housing conditions and human agglomeration.[1]

Although government implementation of various control and vigilance strategies, TB persists as a big public health problem.[2] It is estimated that one third of world population is infected by Koch bacillus. The African and Asian regions are the ones that present most risk of illness. Six countries were responsible for 60% of new worldwide TB cases in 2015: India, Indonesia, China, Nigeria, Pakistan and South Africa. The global progress to fight the disease depends on advancements in patient prevention and care in all the countries with high TB load, among them Brazil.[3]

The TB issue reflects the social development stage of the country, in which poverty determinants, poor sanitary conditions, significative increase of acquired immune deficiency syndrome (AIDS) cases, populational growth, large migratory movements and lack of management organization and health services limit the measures for eradication of the disease, keeping it endemic mainly in the most vulnerable populations, justifying the persistence of TB as serious public health problem.[4-5]

Developing countries, such as Brazil, are those that present the highest incidence rates of the disease because they share some common characteristics in high-risk global regions, as the high urbanization index, high social inequality and ethnic and cultural diversity as well as the neglected control by public policies and society, making it difficult to comprehend the disease dynamics and responsiveness.[6]

In the last decades, the development of new statistical techniques deployed to epidemiology as well as the use of computers and creation of new programs have helped in a better comprehension of the health-disease process, making the application of analyses from data obtained in epidemiologic investigations accessible to an increasing number of researchers by extracting elements that contribute to minimize the health problems of society. Also, elements for the orientation of intersectoral actions that contribute to decision making have been provided.[7]

In this sense, the use of technologies that can subsidize the decision making, organizing and planning actions to eradicate TB is substantial. The geographic information systems associated with geoprocessing techniques constitute a big tool for TB monitoring, control and evaluation, as they lead to distribution dynamics understanding between illness and death risks because it allows an evaluation of TB distribution and its populational determinants in space and time.[2,8]

Therefore, it was chosen as objective to analyze from the literature the contributions of spatial analysis for comprehending TB dynamics.

METHOD

Study outline

Integrative review of literature aiming to answer the following question: what are the main contributions of spatial analysis for

comprehending the tuberculosis (TB) dynamics over the years?

Exclusion and inclusion criteria

All the original manuscripts with complete availability on LILACS, PubMed and SCOPUS databases, indexed within January 1, 2008 to December 31, 2017, written in any language, that cover the use of spatial analysis for the study of TB in human beings were included.

Media news and manuscripts: about animals, review, incomplete, paid, thesis, dissertations were excluded.

Definition of databases, descriptors and search strategies

As search source, finished and published national and international manuscripts with free public access that described the techniques of spatial analysis associated to TB control and prevention, within 2008 to 2017 in world population were utilized. The search strategies were employed according to the norms of each selected electronic database.

Aiming to perform a broad search and reduce the possibility of bias, the utilized terms were defined by means of search in controlled vocabularies: Medical Subject Headings (MeSH) and Descritores em Ciências da Saúde (DeCS). These vocabularies gather a range of descriptors and synonyms organized in importance order, ensuring the search execution in scientific and technical literature related to health.

The search included as descriptors: Tuberculose; Tuberculose AND Análise Espacial, Tuberculose AND Sistema de Informação Geográfica; Tuberculose AND Geoprocessamento em Saúde. As well as their synonyms: TB; Pneumologia Sanitária; Geomática; Estimativa de Densidade Kernel.

Collect and data analysis instrument

To reach the objective, a bibliographic instrument was made, and it allowed each article to be analyzed separately, according to the preestablished purposes. This instrument provided advantages such as: the systematization in collecting information, later article retrieval, selection of articles of excellence, identification of methodological problems and comparison with other works.

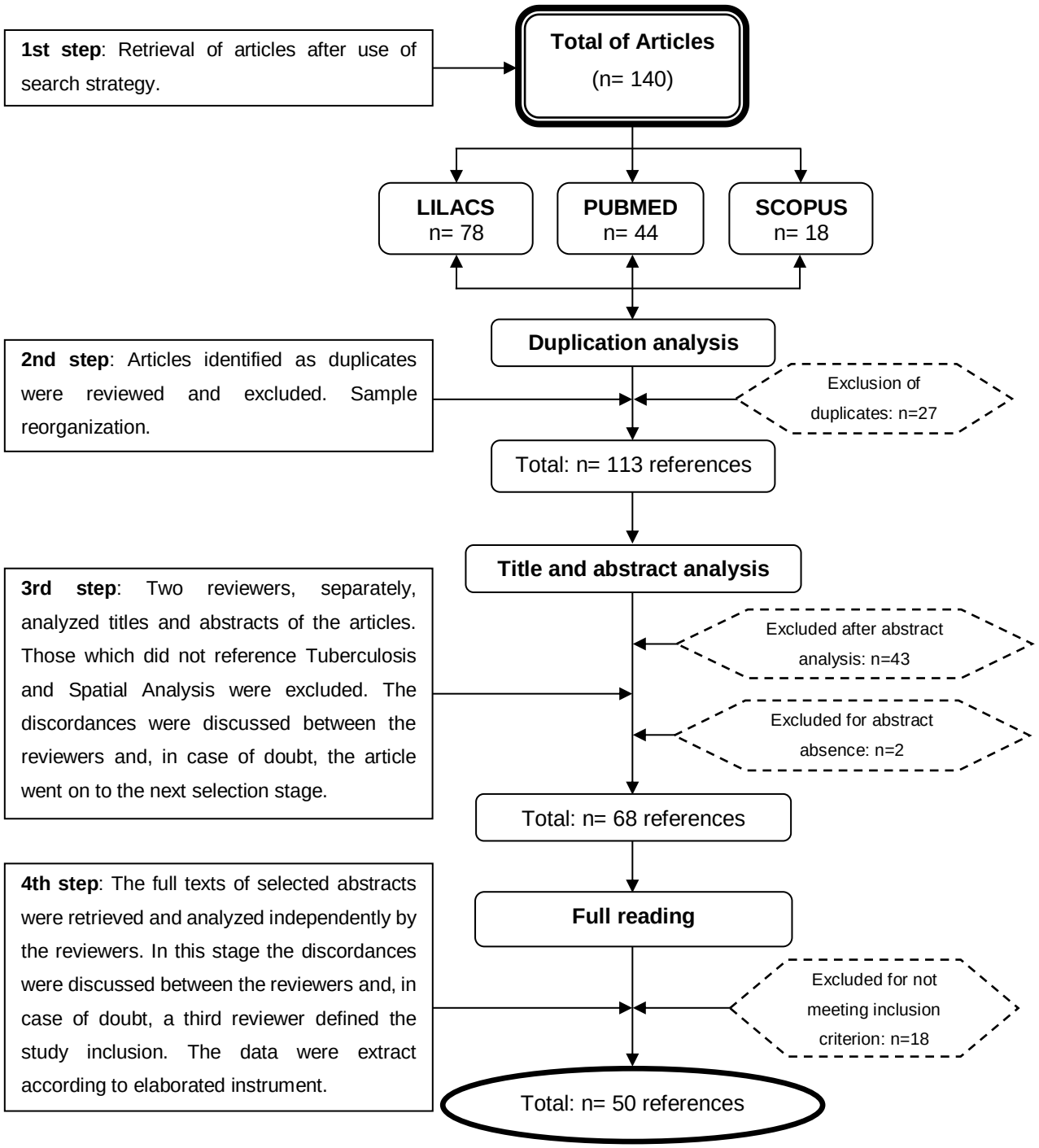
The instrument contemplates the items: identification, publication type, methodological characteristics of study, data treatment and statistical analysis, techniques of spatial analysis, results, description of sample aggregation level, main findings and implications in addition to identify limitations or bias.

After the selection of manuscripts, the data were tabulated in Microsoft Excel® program.

RESULTS

A primary selection of 140 published manuscripts was performed. After the initial evaluations, 27 articles were excluded just by reading the title and for being duplicates. After this exclusion, 113 references remained, of which 43 were excluded by reading the abstract, and 2 were excluded due to its absence. Among the 68 remained ones, 18 were excluded after reading the whole text, remaining 50 articles for systematic review (Figure 1).

Figure 1: Flux of selection of studies retrieved in integrative review about tuberculosis and Spatial Analysis over the world, 2008 to 2017.



General characteristics of the studies were showed on Table 1 and in categories of social determinants, strategic measures to fight tuberculosis (TB) and spatial factors for TB control, which point out aspects of objectives, theme discussion, independent variables, outcome variable and conclusion of studies.

The findings identify that 38 articles (76%) correspond to recent publications starting from 2013. As for the place where the study was performed, twenty eight were developed in America: four in North America and twenty four in South America; fourteen were in Asia: eleven in East Asia and three in West Asia; and eight

studies in Africa: three in Central Africa and three in South Africa. It was evidenced that the aggregation level of sample composed 20 articles (40%) performed in Cities; 6 articles (12%) in Countries; Census Tracts, Neighborhoods and Provinces 5 articles each (10%); 4 articles (8%) in Districts; 3 articles (6%) in States; Counties and Regions 1 article each (2%) (Table 1).

Regarding the study type, 40 articles (80%) were type Ecological, and the other articles type: retrospective, transversal, temporal, descriptive, temporal tendency and ecological, historic/cohort/ecological, epidemiological, control case/ecological, and descriptive spatial. (Table 1).

Table 1: Study place, study type and aggregation level of manuscripts selected in the systematic review, 2008 to 2017.

Study characteristics		(n=50)	%
Study Place	North America	4	8
	South America	24	48
	East Africa	3	6
	Central Africa	2	4
	South Africa	3	6
	East Asia	11	22
	West Asia	3	6
Study Type	Ecologic	40	80
	Retrospective	2	4
	Transversal	1	2
	Temporal	1	2
	Descriptive and Spatial	1	2
	Temporal tendency and Ecologic	1	2
	Historic / Cohort / Ecologic	1	2
	Epidemiologic	1	2
	Control case / Ecologic	1	2
	Descriptive	1	2
Aggregation Level	City	20	40
	Country	6	12
	Census tract	5	10
	Province	5	10
	Neighborhood	5	10
	District	4	8
	State	3	6
	County	1	2
	Region	1	2

In the analysis of outcome variables, the predominance of TB incidence and prevalence cases were observed, and coinfection and mortality cases were cited.

Among the analyzed independent variables, the following predominated: sociodemographic (age range, sex, race/color, marital status, occupation, educational level, address, sanitation); socioeconomic (income, Human Development Index); clinic; epidemiologic; etiopathogenic and climatic/geographic/environmental. Among the

variables related to treatment, it is worth noting: diagnosis date, clinical evolution, use of prophylaxis, treatment type and finish date, directly observed treatment and treatment adherence.

Among the analyzed studies, distinct models of spatial analysis were found, in which more than one type of analysis were present in the most part of analyzed studies. The predominant models were: kernel density estimation; spatial distribution; Poisson model; Kulldorff model; Bayesian model; K-function; statistical scan; Moran analysis; spatial regression; Monte Carlo simulation; kriging method; and permute scan.

Didactically, the main results were grouped in the following categories, considering theme, objectives and main results of each one of the analyzed manuscripts:

Social Determinants

Spatial analysis evidence direct relations between social determinants and TB.[9] Relations evidenced by the inverse association between the socioeconomic status and TB incidence, relation between vulnerability, socioeconomic and sociodemographic condition, mortality and coinfection by HIV-TB.[10-21] The vulnerability was also observed among indigenous people, in the data of child mortality due to HIV-TB coinfection, being 3 times higher in orphan children, along with in the difficult adherence to the TB treatment and poor living conditions of people subjected to such circumstances.[22-24]

Strategic measures to fight tuberculosis

The studies showed that the spatial analysis is an extremely important tool in statistically significant data collection and indicators to subsidize strategic actions for TB prevention and control.[25-26] Thus, it was possible to identify endemic and coendemic areas (HIV-TB; Intestinal Infection by Helminths-TB), regions with late diagnoses, cases of avoidable hospital stay, the incidence control of infantile TB, with focus in primary care.[27-32]

The analysis of spatial distribution enables, also, the identification of regions with death toll and TB cases, thus contributing to the action planning of territorial base, granting subsidies to figure out strategies to reduce inequities in health and limits for the increasing TB incidence.[33-34]

Qualified investment in TB control, reformulation and restructuration of policies and health services are essential to control the cases (TB and TB-HIV) and generate positive effects on reducing the incidence in population.[35-36] Strategic measures of prevention are urgent to the incidence control and decreasing in significantly affected regions, reinforce the need for technologies such as geocodification and genotyping as important tools in TB control and prevention in priority areas, the utilization of spatial analysis to identify local particularities, geographic, cultural and socioeconomic differences, valuing the specific needs of educative actions about the disease.[37-44]

Special factors for the tuberculosis control

It was possible to identify that the TB spatial distribution occurs in a heterogeneous and non-random way in the analyzed regions, also evidencing that the TB incidence was positively

associated to temperature, precipitation and wind speed, while socioeconomic and geographic factors were considered as covariables. These factors had impact in regional differences of TB prevalence.[45-49]

DISCUSSION

The use of techniques of statistical analysis by the authors of selected studies can be justified due to its relevance to estimate correlations between tuberculosis (TB) occurrence and spatial dependence. It is important to have a geospatial perspective in TB epidemiology to clearly comprehend the factors that influence spatial variations and dissemination of pathogenesis of worldwide TB.[50]

The understanding of TB depends on the spatial disposition of infectious agent, host and the possibility of the encounter of both, with spatial analysis and geographic information system (GIS) being important tools for its control, as they identify factors that contribute to its dissemination and make evident areas with high incidence rates.[8]

The outcome analysis as TB incidence points out the persistence of relation between socioeconomic and demographic factors in disease reproduction, once the low social and economic level may worsen the life conditions of the individual, making him vulnerable. This assertive corroborates with the findings of San et al.[51] study, that by investigating through a systematic review the existence of association between socioeconomic factors and the TB occurrence, describe that the incident and prevalent cases indicate a positive association with sex, age, illiteracy, low income, marital status, food deprivation, previous contact with TB patient and coinfection with HIV, with this variables being also found in the present study.

It is worth noting that lack of social opportunities excludes part of the population from conditions of dignity and citizenship, placing them at a disadvantage in relation to availability and access to technologies and health services, which may contribute for a late diagnosis of the disease and/or treatment abandonment.

Moreover, the public policies not always have produced actions aimed to fulfill the needs and social reality of priority territories, reaffirming in this context the importance of the spatial analysis and GIS.[52] Santos-Neto and their collaborators reiterate that areas devoid of decent housing and sanitation also tend to approve services with little resolvability and large limitations.[34]

A discrepancy of those results compared with the Ximenes et al and Barcellos was observed because the latter affirm that the socioeconomic and epidemiologic indicators do not act in an isolated way, inferring the existence of particular characteristics inherent to the aggregation level of sample that should be considered in analyses since the environment is result of historical, environmental and social situations, proving the influence of particular characteristics of geographical areas.[53-54]

In the context of public health, various studies have used the technologies in health for risk analysis and information of a given disease, but they are still little used to this purpose.[50,55] Most of the studies considered for this review choose city as spatial unity of analysis, but a careful analysis of each neighborhood is more

recommended, forming micro-areas, facilitating the qualification of areas based on collective and individual risk indicators.[56]

Similar findings are also found by Brazilian authors, which defend that for the definition of priorities the cities should be stratify in distinct areas, according to life conditions, generating a better detailing of the place of disease occurrence, by means of home addresses, coordinates surveyed in field with the help of GPS or even detailing of census tracts for making indicators, considering the territoriality in health that enables a real spatial view of the aggravation.[55,57]

It was found that 48% of studies were performed in South America. Discrepancy was detected when the TB magnitude concentrated in the Asian and African region was analyzed: the most critical areas merge with the geographic representation of extreme poverty and underdeveloped countries, realizing that African countries present the highest incidence rates, followed in descending order by Southeast Asia, Latin America, Europe and North America regions.[58] In this way, it is suggested to intensify studies aimed at the most critical geographical areas.

This study presented limitations because it is an integrative review, and the results reflect only an instant picture of reality and do not allow comparing interventions, because they are most of time populational studies, not experimental ones.[59] The aggregate information about the epidemiologic situation and TB spatial distribution in world stage show that they themselves can be used to direct measures to correct flaws that still exist in health systems and in the disease prevention and control.

CONCLUSION

We highlight that the spatial analysis in health represents a great advancement for the management of tuberculosis worldwide, by means of mapping the risk places, that allows identifying inequalities and detailing the health conditions of a population. The aggregating information about the epidemiologic situation and spatial distribution of tuberculosis in world stage show that they themselves can be used to direct measures to correct flaws that still exist in health systems and in the disease prevention and control.

The monitoring strategies are based on geospatial studies that reveal the reality of each region, presenting as a viable alternative for different public sectors. The articulation with local programs for a better direction of interventions is necessary, but only public policies are not enough, it should have political interest in investments and strategies that aim to reduce the inequities and social responsibility of disease, factor that would allow the optimization of material, financial and human resources.

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CONFLICTS OF INTEREST
There are no conflicts of interest to declare.

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