



Tell me where you went, I may tell who you infected

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TO THE EDITOR,

The transmission of *Mycobacterium tuberculosis* depends on index-case characteristics, the type of exposure, and environmental factors.⁽¹⁾ Once a new case is identified, contact investigation is a key component of tuberculosis control. Screening contacts may become insufficient if we do not value person-to-person contact information in activity spaces (local areas where people go/travel to for their daily activities).⁽²⁾ Spatial analysis using Geographic Information Systems (GIS) has promoted targeted tuberculosis surveillance; however, detailed data on individual mobility are generally not collected, a fact that explains the lack of studies on the micro-scale.^(3,4)

Despite the overall decline in tuberculosis notification rates in Europe, the incidence of the disease in Portugal remains high (16.7/100,000 inhabitants), with northern coastal areas being the most concerning regions.^(5,6) Tuberculosis outpatient centers are responsible for the management of active tuberculosis and screening of risk groups in the country. The reorganization of assistance response and screening optimization is a priority for the tuberculosis end strategy.⁽⁶⁾

This pilot study aimed to 1) characterize the spatial distribution of the activity spaces of tuberculosis patients from a tuberculosis outpatient center in an urban area in northern Portugal and 2) determine if the activity spaces identified during contact investigation were more clustered than expected and identify where those clusters were located.

We included all patients diagnosed with pulmonary tuberculosis between March 2019 and March 2021 who were 18 years old or older, contactable, and capable of providing information. The contagious period included three months prior to symptom development for those with a positive sputum smear or chest radiograph with lung cavitation; or the four weeks before sample collection in cases of diagnosis through positive culture (smear-negative, without cavitation). High-risk activity spaces were those where, during the contagious period, contacts had ≥ 8 cumulative hours of exposure to smear-positive patients or ≥ 40 cumulative hours if smear-negative.⁽²⁾

Patients answered a phone call inquiry by their medical doctors, after consenting to participate in the study. We asked them to describe their typical week during the

contagious period and list the high-risk activity spaces they went/traveled to for their daily activities.

The activity spaces' addresses were geocoded using the QGIS software (Quantum GIS Development Team, 2013), the MMQGIS Python plugin, and Google Maps API. In order to depict the activity spaces' spatial distribution, we used the kernel density estimation (KDE) function, and the Nearest Neighbor Hierarchical Clustering (NNHC) method was applied using the CrimeStat 3.3 software to identify the clusters' areas.⁽⁷⁾

Among the 76 patients followed up for pulmonary tuberculosis, 19 were excluded (12 uncontactable, 6 deceased, and 1 minor of age). Most excluded patients were male (73.7%), with a mean age of 51 years (SD=26.7), and two-thirds were inactive/unemployed.

Thus, 57 patients were included in this study, most of whom were male (68.4%), with a mean age of 45.1 years (SD=16.4). Thirty-seven patients were active workers, and thirty were diagnosed before the COVID-19 pandemic and the implementation of containment measures.

The activity spaces (n=141) included mostly residencies (n=57) and public spaces, such as cafes and bakeries (n=41), companies/workplaces (n=15), schools (n=12), supermarkets (n=3), churches (n=2), and gyms (n=2). The median number of visited public spaces reported was 1 (IQR 1). More precisely, 57.9% reported 0 to 1 public spaces, while 42.1% reported ≥ 2 . The number of visited public spaces was independent of gender (p=0.313), age (p=0.162), and the period (pre- or post-pandemic measures) (p=0.462).

The identified public spaces were located at a median distance of 1,483 meters (IQR 4,876) from the residential area. Figure 1A depicts the spatial distribution of the activity spaces' point locations and the resulting density map. Darker areas represent locations with a higher concentration of activity spaces, mostly located in the northwestern portion of the Espinho municipality and the parishes of Canidelo and Vilar de Andorinho, in the Vila Nova de Gaia (VNG) municipality.

Figure 1B, in turn, represents the three spatial clusters with higher concentrations of visited spaces, corresponding to parishes with higher population density, lower-income, poor living conditions, and higher youth unemployment rates.^(8,9)

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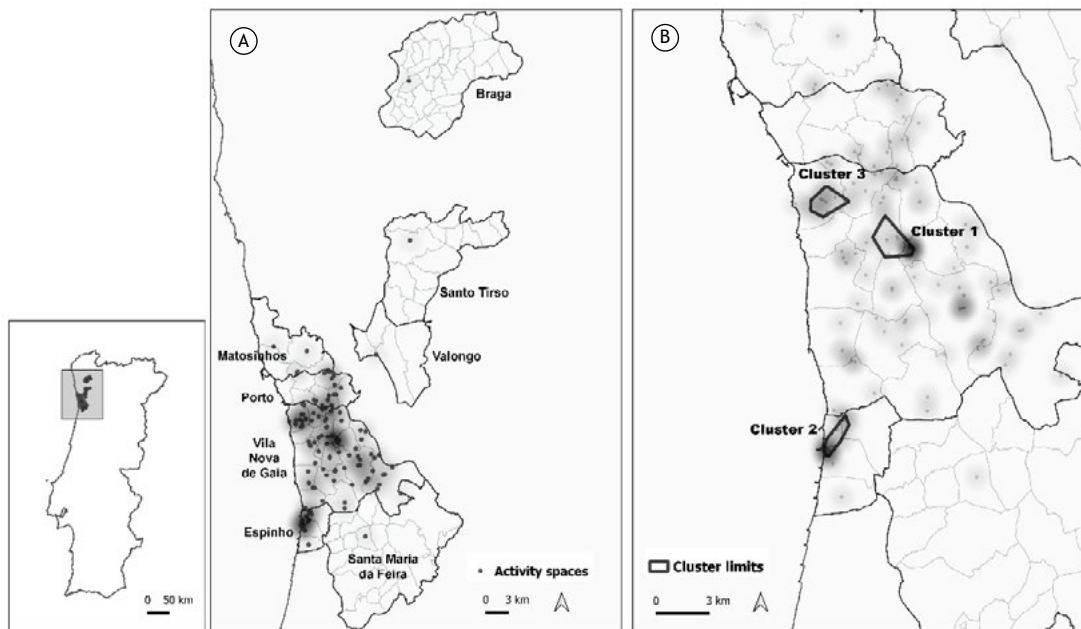


Figure 1. Spatial distribution of the activity spaces. A) Density surface and location of the tuberculosis patients’ activity spaces. B) Clusters of activity spaces obtained using the Nearest Neighbor Hierarchical Clustering method.

Cluster 1 was in the intersection of Vilar de Andorinho, Mafamude, and Vilar do Paraíso (VNG municipality), with an area of 3.0 square kilometers (km²), and encompassed 18 activity spaces, mainly composed of concentrated residential locations (large social housing complexes), cafes, bakeries, and supermarkets.

Meanwhile, cluster 2 was located mostly within the parish of Espinho (Espinho municipality), with a 2.1-km² area, and comprised 13 activity spaces, mainly residential locations (different social housing complexes), cafes, bakeries, restaurants, and schools.

Finally, cluster 3 was located mostly within Canidelo (VNG municipality), with a 1.3-km² area, and included 17 activity spaces, mainly residential locations, churches, companies, supermarkets, cafes, bakeries, gyms, and schools.

There is growing evidence that using spatial analysis in tuberculosis surveillance contributes to a better understanding of transmission dynamics.⁽¹⁾ We used a different approach by asking patients to describe their daily activities during the contagious period, in addition to the identification of close contacts. This method allowed the identification of several activity spaces that would remain unknown in a classic screening method, which usually focuses on close contacts rather than routine activities.

The georeferencing of activity spaces enabled us to identify three regions with a potentially higher risk of transmission. These clusters were mainly composed of social housing complexes and eating places, revealing the importance of sociability as a contributor to contagiousness. Additionally, correlating spatial analysis with sociodemographic data, such as immigrants’ aggregation, socioeconomic deprivation,

housing conditions, or poor healthcare accessibility, may help detect and improve tuberculosis diagnosis earlier and possibly break transmission links, especially in these vulnerable groups.⁽¹⁰⁾

This pilot study presented several limitations. Firstly, this is a retrospective study subject to recall bias, with a limited sample size. However, the included patients were more active/mobile than the excluded group, meaning we could identify a substantial number of public places. Secondly, the study period partially coincided with the COVID-19 pandemic and consequent mobility restrictions. Nevertheless, we did not observe significant differences in visited places pre- and post-pandemic measures.

In conclusion, using spatial analysis in tuberculosis screening can improve the understanding of tuberculosis local epidemiology at the micro-scale and allows for early interventions in tuberculosis control. Moreover, this methodology can be applied to other respiratory infections, namely influenza virus or SARS-CoV-2.

AUTHOR CONTRIBUTIONS

RD conceived the project idea and mentored the study. SSG and ES performed the inquiry, collected the data, and performed the statistical analysis. SSG and AIR performed the geocoding and spatial analysis and wrote the manuscript. RD and AIR revised the manuscript. All authors have read and approved the final version.

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