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## Original article

# Relationship between climatic factors and air quality with tuberculosis in the Federal District, Brazil, 2003–2012

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## ABSTRACT

**Introduction:** Despite the high rate of tuberculosis indicators in Brazil, the Federal District shows a low prevalence of the disease.

**Objective:** To analyze the relationship between climatic factors and air quality with tuberculosis in the Brazilian Federal District.

**Methodology:** This was an ecological and descriptive study comparing 3927 new cases of Tuberculosis registered at the Federal District Tuberculosis Control Program with data from the National Institute of Meteorology, Brazilian Institute of Geography and Statistics, Brazilian Agricultural Research Institute, Brasilia Environmental Institute, and the Federal District Planning Company.

**Results:** From 2003 to 2012, there has been a higher incidence of Tuberculosis (27.0%) in male patients in the winter (27.2%). Patients under 15 years of age (28.6%) and older than 64 years (27.1%) were more affected in the fall. For youth and adults (15–64 years), the highest number of cases was reported during winter (44.3%). The disease was prevalent with ultraviolet radiation over 17 MJ/m<sup>2</sup> (67.8%;  $p < 0.001$ ); relative humidity between 31.0% and 69.0% (95.8% of cases;  $p < 0.001$ ); 12 h of daily sunlight or more (40.6%;  $p = 0.001$ ); and temperatures between 20 °C and 23 °C (72.4%;  $p < 0.001$ ). In the city of Taguatinga and surrounding area, pollution levels dropped to 15.2% between 2003 and 2012. Smoke levels decreased to 31.9%. In the Sobradinho region, particulate matter dropped to 13.1% and smoke to 19.3%, coinciding with the reduction of Tuberculosis incidence rates during the same period.

**Conclusion:** The results should guide surveillance actions for Tuberculosis control and elimination and indicate the need to expand observation time to new climate indicators and air quality.

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## Introduction

Although Brazil is among the 22 countries with the highest TB burden (35.4/100,000 inhabitants), the Brazilian Midwest Region (MW) presents a low-tuberculosis burden scenario (24.1/100,000 inhabitants). The Federal District (FD) features 13 cases per 100,000 inhabitants and an annual decrease of 2.2%, indicating a trend toward pre-elimination of the disease.<sup>1</sup>

Social limitations,<sup>2</sup> vitamin D deficiency,<sup>3–6</sup> comorbidities,<sup>7</sup> and limited access to health services<sup>8</sup> are risk factors for developing TB. In addition, ecological studies conducted in countries where the incidence of TB was high relate the magnitude of TB to climatic summer factors – Spain<sup>9,10</sup>; Peru<sup>3</sup>; India<sup>10,11</sup>; Cape Town, South Africa<sup>12</sup>; United Kingdom, Wales and Scotland<sup>4,10,13</sup>; and South Africa, Kuwait, Ireland and Mongolia.<sup>10</sup> In Hong Kong, TB reports were high in sputum-smear or culture positive patients in the summer.<sup>10,14</sup> TB cases increased in spring in New York<sup>15</sup> and in the rainy season in Cameroon.<sup>16</sup> In Japan, the seasonality of TB varied according to clinical form and age, being higher in the spring among AFB+ ganglionic TB young patients (late spring to summer) and in AFB+ elderly in summer.<sup>17</sup> In Cape Town, South Africa, TB affected more children in the spring,<sup>12</sup> whereas in Spain was in the winter.<sup>18</sup> In addition, studies revealed that the less ultraviolet light exposure, the more frequent is TB, as verified in Australia<sup>5,19</sup> because of vitamin D deficiency.<sup>20</sup> In contrast, in Peru the development of TB was higher in the summer due to the rainy period with low sunlight incidence.<sup>3</sup>

Other climatic factors such as temperature,<sup>21</sup> precipitation, and humidity can influence the development of *Mycobacterium tuberculosis*.<sup>22</sup> Air quality is affected by atmospheric pollution, where carbon monoxide induces bacillary reactivation<sup>23</sup> and increases the incidence of tuberculosis.<sup>24</sup> In addition, large seasonal amplitudes of TB often occur in upland regions with temperate mountain climate and low annual average temperature.<sup>21</sup> Therefore, findings described in the literature confirm the relevance of conducting a study to better understand how climate and air quality can influence TB development in the Federal District. The objective of this study was to analyze the relationship between climatic factors and air quality with tuberculosis in the Federal District of Brazil (2003–2012). Through this analysis, we suggest improvements in the accuracy of the monitoring system and in the planning and allocation of resources to activities of the TB control program, taking into consideration the global climate change context.

## Methodology

The study was conducted in the Federal District (FD), the capital city of Brazil, located in the Midwest region. The FD has an area of 5,778,999 km<sup>2</sup> and is divided into 31 administrative regions<sup>25</sup> (AR), with the health sector distributed into 15 Health Districts. The public service is responsible for 79.9% of all health actions<sup>26</sup> and is the only entity to provide TB treatment.

The FD has a population of 2,957,954 inhabitants,<sup>25</sup> 96.6% of whom are living in urban areas.<sup>26</sup> High-altitude tropical

climate prevails in the region, with wet and rainy summers, dry and cold winters, and relative humidity of  $\leq 20.0\%$ . The average annual temperature is 21 °C, with an average high of 35.8 °C and an average low of 16 °C. From 2003 to 2012, solar ultraviolet radiation in the FD showed a variation of 17–20 MJ/m<sup>2</sup>.<sup>27</sup> The region has little cloudiness and an average 75.0% days of sunshine during the year. During the period analyzed in our study, in general air quality in the FD was considered good.<sup>28</sup>

We analyzed 3927 TB cases (pulmonary, extrapulmonary, and pulmonary+extrapulmonary) of patients in the FD registered under the information system of health events (SINAN/TB), part of the Federal District Health Department (DF). We excluded non-residents and cases without address identification (0.4% excluded). Health Centers in the FD are 70.0% public and free-of-charge,<sup>1</sup> and 67.3% of the Centers manage tuberculosis cases.<sup>1</sup>

We analyzed climate variables, air quality indicators, and demographic data from 2003 to 2012. Secondary data was obtained from the National Institute of Meteorology – INMET,<sup>29</sup> Brazilian Agricultural Research Corporation – EMBRAPA,<sup>27</sup> Brasilia Environmental Institute – IBRAN,<sup>28</sup> Brazilian Institute of Geography and Statistics – IBGE,<sup>25</sup> and the Federal District Planning Company – CODEPLAN.<sup>30</sup>

The variables included demographic data (gender, age, educational level, and race/skin color), climate (temperature), solar radiation levels, relative humidity, and TB incidence. Regarding air quality and pollution, four regions in the FD were analyzed: Taguatinga, Sobradinho, the North Wing, and the South Wing. Pollution monitoring sampling points were defined by IBRAN in order to prioritize areas with high traffic and population density.

A case was defined as direct smear and/or culture proven TB medium with histopathology confirmation or clinical and epidemiological findings suggestive of TB.<sup>1</sup> We used the Köppen classification model<sup>31</sup> for climate analysis and the national standards established by the CONAMA Resolution for air quality assessment (No. 3 of 28, 1990).<sup>28</sup>

Statistical analyses were performed using Pearson's chi-square test to check the dependence or independence of the variables<sup>32</sup> with a 5% significance level. The study was approved by the Ethics Committee of the University of Brasilia, Opinion No. 1,098,421.

## Results

The Federal District Health Department reported 4017 new cases of TB to SINAN-TB between 2003 and 2012. Out of the 4017 cases a total of 3927 were selected; 0.4% excluded: 52 had no address information and 38 for being residents of other states.

Among the demographic variables, there was a predominance of males (63.6% of cases). The most frequent age group was 15–64 years (53.7%), the most common level of education was primary school (40.2%), and the predominant race was mulatto (44.0%) (Table 1).

In the 10 years examined, the highest incidence of tuberculosis was in the winter (27.0%), followed by fall (25.0%), spring (24.7%), and summer (23.3%). Male patients showed higher

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