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## The Spread of Tuberculosis Cases in the Highlands and Coastal Areas of Padang

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# The Spread of Tuberculosis Cases in the Highlands and Coastal Areas of Padang

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# The Spread of Tuberculosis Cases in the Highlands and Coastal Areas of Padang

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## Abstract

The current tuberculosis (TB) worldwide situation is very concerning in terms of the number of cases and the death toll, as well as the environmental factors that contribute to its transmission. This has driven policy decisions that aim to enhance contemporary TB control efforts. This study aimed to map the pattern of TB spread based on geographic location, particularly in the highland and coastal areas of Padang City, West Sumatra Province, Indonesia. This study employed a quantitative descriptive analysis using secondary data from 6 primary health care (PHC) from April 2022 to March 2023, comprising 896 cases. Data analysis was conducted using the ArcGIS program, as well as applying Nearest Neighbor Analysis across the PHC areas. The results indicated that TB cases were more prevalent in coastal areas. The distribution pattern was comparable between the mountainous and coastal areas, as indicated by similar clusters. Geographic differences did not affect the TB transmission pattern in Padang City. The reason for the occurrence of transmission was likely due to close contact, spreading from one person to another. Therefore, more effective education efforts, case detection, and restriction of TB patient movement are necessary to address the issue of interest.

**Keywords:** coastal, highlands, spread, tuberculosis

## Introduction

In the era of Sustainable Development Goals (SDGs), tuberculosis (TB) control programs are transitioning from the STOP TB program of the Millennium Development Goals (MDGs) period to the END-TB Program. The objective of the END TB Program is to end the Pulmonary TB epidemic throughout the world.<sup>1</sup> Nowadays, the number of those affected by the diseases is increasing, along with the number of mortality, both on a global and regional scale, such as in Indonesia.<sup>2,3</sup> Currently, Indonesia occupies the second place with the highest number of TB cases in the world after India.<sup>2</sup> In Indonesia, the kinematic rate of TB has recently reached 150,000 cases (one person every 4 minutes), an increase of 60% from 2020, with 93,000 kinematic cases of TB and a kinematic rate of 55 per 100,000 population.<sup>3</sup> In 2021, West Sumatra Province had 8,216 cases and was ranked 12th out of 38 provinces.<sup>4</sup> According to the Padang Health Office's Division of Communicable Disease Prevention and Control, 14 primary health cares (PHCs) had a consistently high proportion of TB patients in 2021 and 2022.<sup>4</sup>

The current high number of TB transmissions is greatly influenced by environmental factors, including physical, biological, and sociocultural elements. These factors include inadequate housing, residential density, and cramped spaces that increase the risk of TB transmission, especially among children.<sup>5,6</sup> Poor home conditions, such as unsuitable temperature, high humidity, inadequate lighting, poor air circulation,<sup>7</sup> and air pollution<sup>8</sup> are among the significant determinants. Additionally, the physical environment of a house has become an indicator of pulmonary TB transmission.<sup>9</sup>

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The biotic elements of the environment related to TB transmission are age-related, as babies, children, and the elderly are highly susceptible to TB.<sup>10,11</sup> More than 18% of TB cases are found to occur in children (aged 0-16 years), while more than 69% of sufferers are determined to be men.<sup>12</sup> On top of that, the TB condition can be aggravated by the habit of smoking,<sup>13</sup> low education,<sup>14</sup> HIV/AIDS infection, malnutrition, diabetes, and alcohol addiction.<sup>15</sup> From social and cultural elements, several aspects that influence TB transmission include beliefs, values, habits, interaction in a large group,<sup>16</sup> unemployment, poverty,<sup>14</sup> difficulties in accessing health service,<sup>17</sup> and low economic condition.<sup>18</sup> Social culture and environmental physique increase exposure to pathogens and exacerbate people's vulnerability to TB infection.<sup>19</sup>

The process of transmitting TB is influenced by the interaction of the third element environment (abiotic, biotic, and cultural (social culture)).<sup>20</sup> In this context, the pattern and duration of social contact are more influential than the frequency of contact.<sup>9</sup> For instance, 1 in 30 household contacts will develop active TB, with most of these cases occurring outside the house.<sup>21</sup> Therefore, the issue is postulated to depend on the density of residence and population.<sup>22</sup>

Geographical location is also closely related to air temperature, humidity, wind speed, season, and rainfall.<sup>23</sup> Cold temperatures can weaken the human body's resilience and, as a result, affect the physical home environments and public social culture. In colder temperatures, people are more likely to gather indoors, increasing prolonged close contact.<sup>24</sup> The spread of TB is also associated with limited access to healthcare services, especially in coastal regions.<sup>25</sup> It is important to consider factors of the season and different heights when implementing a prevention approach to control pulmonary TB.<sup>26</sup>

The current global challenge in controlling TB lies in the persistently high transmission rates.<sup>27,28</sup> Mapping the spread of TB is a key effort to limit its transmission within communities and effectively manage multimorbidity by identifying TB zones.<sup>29</sup> This study aimed to map the pattern of pulmonary TB spread based on geographical locations, specifically in highland and coastal regions. The novelty of this study is the development of a new database map of TB transmission risk areas, which is considered critical information that can serve as a foundation for future studies.

## Method

This study employed a quantitative descriptive approach with a total of 896 cases, consisting of all secondary data on TB patients from 6 PHCs, with the highest number of cases from April 2022 to March 2023. The PHCs were categorized by geographical regions: mountainous areas (Lubuk Kilangan, Belimbing, and Air Dingin PHCs) and coastal areas (Lubuk Buaya, Pegambiran, and Padang Pasir PHCs). The data were sourced from the TB information system of each PHCs. The data analysis was conducted using the Arcview version 3.1 program, which is a tool for creating, analyzing, and visualizing spatial and geographical data. Nearest Neighbor Analysis (NNA) was used with the following formula:

$$Rn = 2D\sqrt{(n/a)}$$

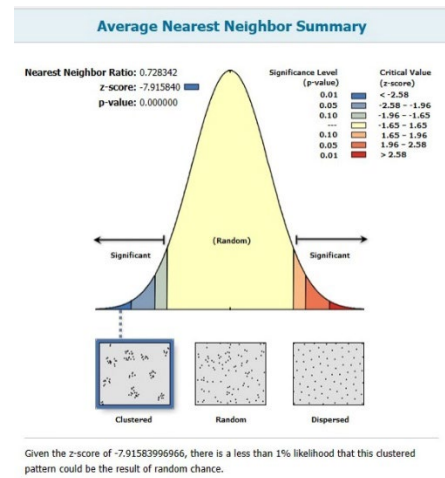
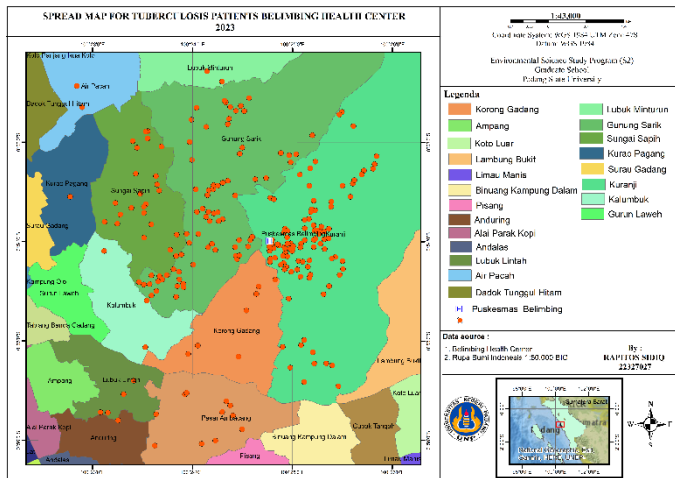
$Rn$  is the nearest neighbor index,  $D$  is the average distance between each point and its nearest neighbor,  $n$  is the number of points under study, and  $a$  is the size of the area. The nearest-neighbor analysis generated an  $Rn$  (nearest-neighbor index) value, which measured whether case transmission patterns were clustered, random, or regular. A clustered pattern was indicated by an  $Rn$  value of 0, where all points were close to a single point. Meanwhile, a random pattern showed an  $Rn$  value of 1.0, with no discernible pattern. A regular pattern was shown by an  $Rn$  value of 2.15, which indicated a perfectly uniform distribution where each point was equidistant from its neighbors. The main data included in the analysis process was related to geographic location, such as latitude and longitude coordinate point data and size scale.

## Results

This study identified several characteristics of TB patients from various aspects, including sex, age, occupation, and the number of cases per service area. This study found that most TB patients were male, approximately 612 individuals (68.3%), and aged 17-65 years. A significant portion of TB patients were unemployed, and most of them resided in coastal areas. Of the 896 cases, 514 (57.4%) were distributed across three PHC areas: Lubuk Buaya, Pegambiran, and Padang Pasir. Based on the NNA analysis, it was found that in all service areas, whether in highland or coastal regions, the distribution pattern of TB cases was clustered (Figures 1-6).

The distribution pattern of TB cases in the six PHC working regions (Belimbing, Air Dingin, Lubuk Kilangan, Lubuk Buaya, Pegambiran, and Padang Pasir) was explained based on each region's demographic parameters. The working regions of Belimbing PHC were densely populated and covered a relatively large area, including hilly terrain, agricultural

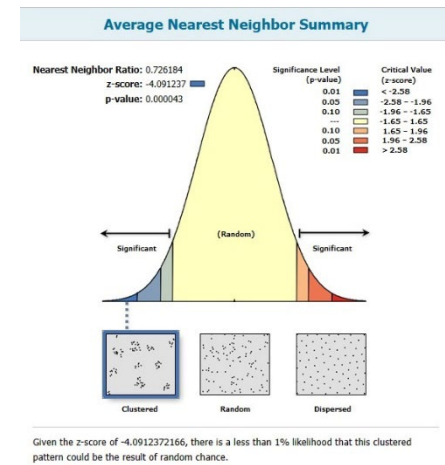
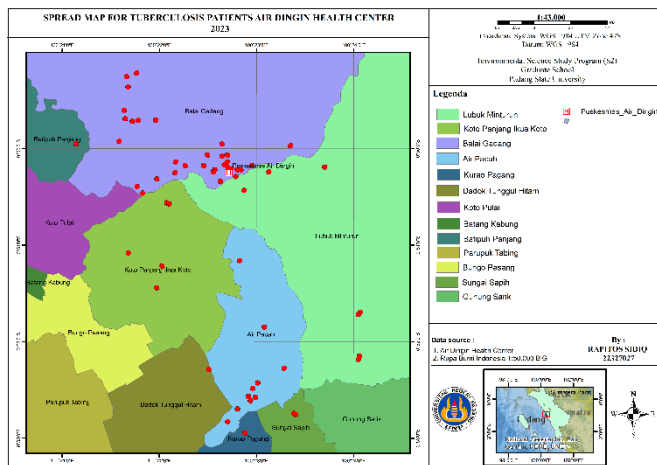
land, and plantations. These neighborhoods contained dense housing developments and various public services, with a mix of residential zones (Figure 1). According to the map, multiple cases occurred in heavily populated residential areas and public marketplaces within these regions. Hence, it could be suggested that transmission may spread from nearby areas such as Air Dingin, Ambacang, and Kuranji.



Notes: health center, *puskesmas* = primary health care

Figure 1. Belimbing Primary Health Care Working Regions

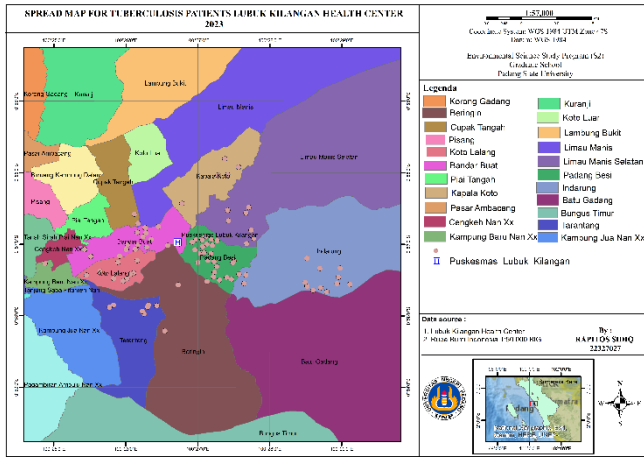
Air Dingin PHC's working regions were located on the outskirts of Padang City, near mountains, forests, and agricultural land, with occupations distributed unevenly (Figure 2). Case mapping in this area revealed clusters of pulmonary TB cases, with a total of 59 recorded cases. Meanwhile, the working regions of Lubuk Kilangan PHC were located in mountainous and industrial areas with a highly heterogeneous population (Figure 3). This area bordered the working regions of the Pauh, Pegambiran, and Lubuk Begalung PHCs, with a total of 92 TB cases. Mapping results showed clusters of pulmonary TB cases within these regions.



Notes: health center, *puskesmas* = primary health care

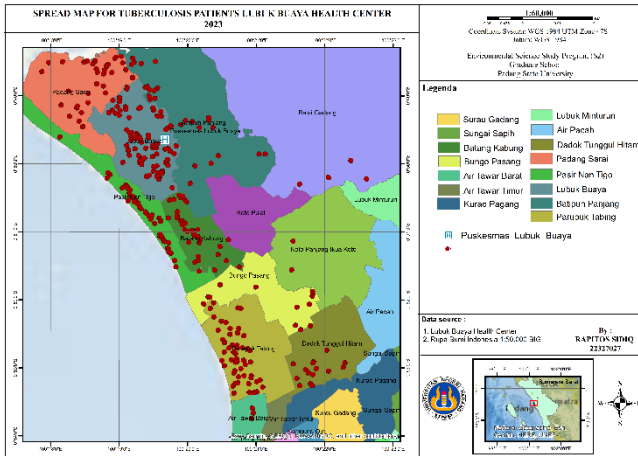
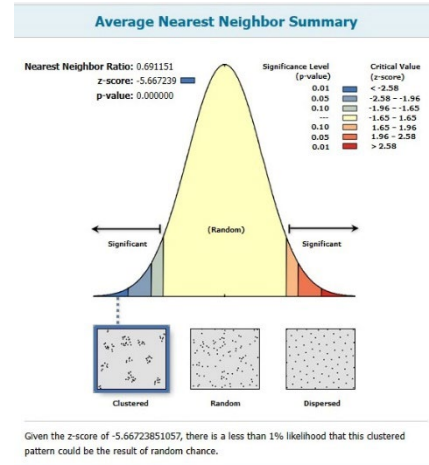
Figure 2. Air Dingin Primary Health Care Working Regions

The working regions of Lubuk Buaya PHC were densely populated coastal areas with inadequate environmental sanitation (Figure 4). These regions bordered the working areas of Anak Air Tawar PHC and have the highest number of cases in Padang (302 cases). Mapping results indicated TB cases in groups or clusters, with numerous cases reported in densely populated areas and along the coast. Furthermore, disease transmission was likely influenced by proximity to the nearby Anak Air working area.



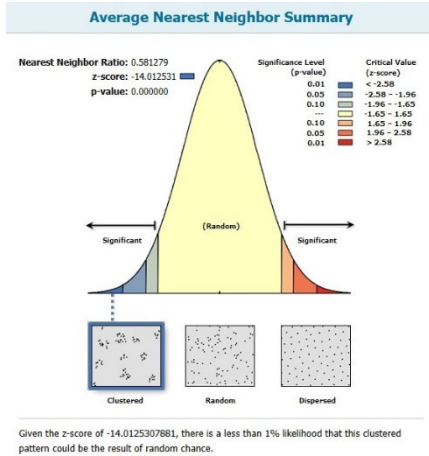
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Figure 3. Lubuk Kilangan Primary Health Care Working Regions

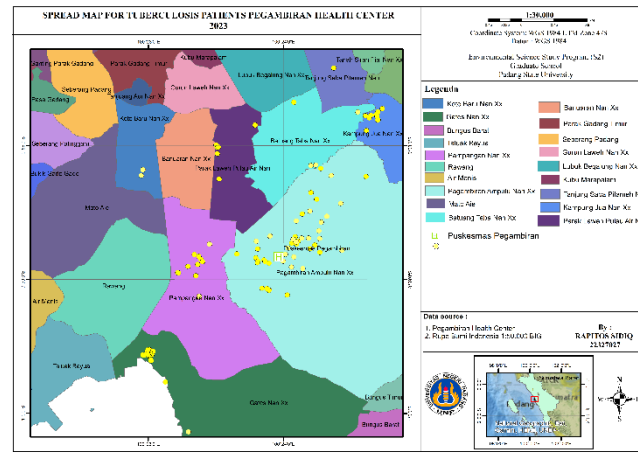


Notes: health center, *puskesmas* = primary health care

Figure 4. Lubuk Buaya Primary Health Care Working Regions

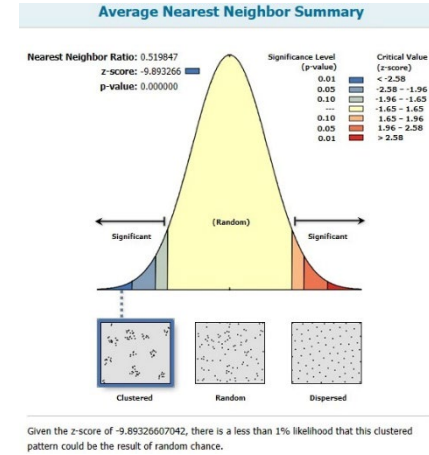


Pegambiran PHC's work area was densely populated and extensive, consisting of hilly areas, agricultural land, and rubber processing companies, with various public services, including markets, port, and railway transportation. Several densely populated housing areas were also adjacent to the Lubuk Begalung, Rawang, and Pauh PHCs. There were several residential neighborhoods in this area (Figure 5). With 115 cases, this area ranked fourth in the country, with one case originating from outside the region. Mapping results revealed clustered or group TB cases. According to the map, several clusters of cases occurred in various densely populated communities around the PHC, as well as along the roadsides and near the port. In particular, those clusters of cases were located near the Lubuk Begalung and Rawang PHCs working regions.

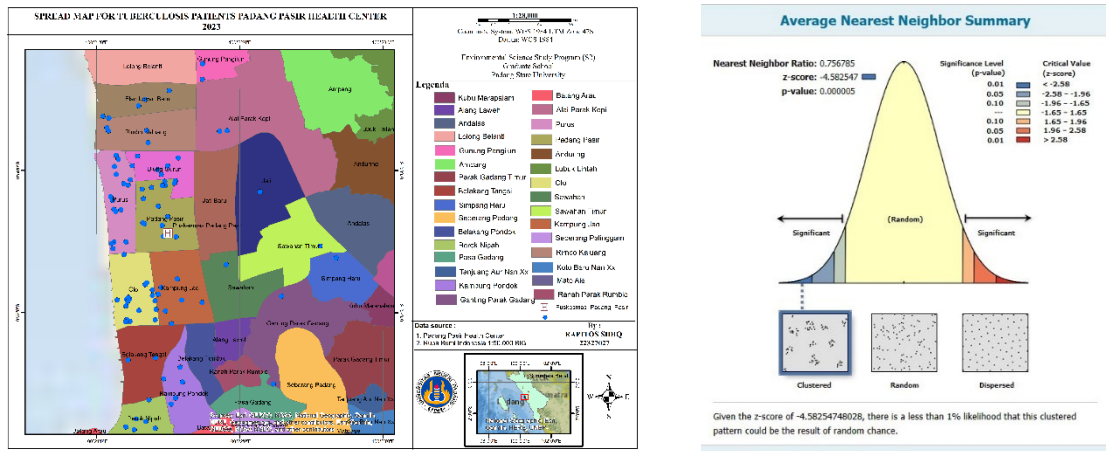


Notes: health center, *puskesmas* = primary health care

Figure 5. Pegambiran Primary Health Care Working Regions



Padang Pasir PHC working region was located in the center of Padang City, surrounded by other busy areas such as supermarkets, public facilities like office buildings, hospitals, and coastal areas, with a highly heterogeneous population (Figure 6). According to the data, the number of recorded pulmonary TB cases was 97. Upon closer examination, the distribution of TB cases was found to be concentrated along the coastline. In this location, there was a residential facility (apartment complex) that housed many residents. This densely populated condition made it easy for transmission to occur in a cluster pattern.



Notes: health center, *puskesmas* = primary health care

Figure 6. Padang Pasir Primary Health Care Working Regions

## Discussion

This study indicated that most TB cases were found in coastal areas rather than highland areas. The results contrast the prevailing theory, suggesting that TB is more prevalent in areas with a cool climate or highland regions with heavy rainfall.<sup>20</sup> The assumption was based on the low oxygen levels in cold air, which can weaken the body's immune system, as well as environmental conditions, all of which may influence TB transmission from a socioeconomic perspective. Limited access to healthcare services in rural or mountainous areas also contributes to TB spread.<sup>22</sup> As discussed earlier, population density is a more influential factor in TB transmission than geographic features like elevation above sea level.<sup>30</sup>

This study also found that the results of NNA for all study areas showed a clustered pattern of TB distribution. This means that TB cases tended to appear in specific groups or areas rather than being randomly distributed. This result indicated the presence of specific factors that propel the spread of the disease in those areas. One of the arguments explaining this clustered pattern of TB distribution in this location included the occurrence of local transmission. This was because the clustered pattern of TB cases often indicated local transmission. In other words, the disease spreads from one person to another within close-knit communities or groups. This is especially the case for households or community groups with frequent interactions.<sup>9,31</sup>

Another factor that may contribute to the clustered spread of TB is social and economic factors, such as poverty levels, population density, or limited access to healthcare services.<sup>14</sup> This is further exacerbated by the stigma surrounding TB in the community,<sup>32</sup> though this argument has not yet been proven. Stigma has a significant impact on the transmission of pulmonary TB. It causes individuals with TB to delay seeking treatment, which in turn leads to further spread of the disease within the community.<sup>33,34</sup> Other factors that can contribute to the spread of TB in certain areas are environmental conditions such as poor ventilation, overcrowded living spaces, and damp environments.<sup>35</sup>

Environmental conditions are a current trend in large cities as rapid urban growth continues worldwide,<sup>36</sup> including Padang City, a central coastal city. Many of its population lives along the beach, in crowded areas like Padang Pasir, Lubuk Buaya, and Pegambiran. This high population density is likely a more significant factor in TB transmission<sup>37</sup> than temperature and humidity, as there is minimal difference in these conditions between the higher plains and coastal areas within Padang City. The factor of population density plays a larger role in TB transmission in Padang City since interactions among people with TB increase the chances of transmission.<sup>38</sup> This condition resulted in a similar spread pattern between the high plains and coastal areas, where cases form clusters, indicating that this pattern arose due to environmental or social factors influencing TB transmission in the area.

TB spreads primarily through close contact with infected individuals, such as family members, coworkers, or others in shared environments. In most cases, those affected were mostly men (68.3%) in the productive age range (15-55 years).

Transmission within the home is particularly concerning, especially for children.<sup>10</sup> This study found that over 10.4% of TB cases were spreading in children aged 0-5 years. This result provided stronger evidence that TB transmission in Padang City was more due to social contact between pulmonary TB sufferers and the general public. Therefore, in this regard, there was no difference between the high plains and coastal areas. This issue was worsened by poor sanitation in households, especially among people living along the coast, such as in the Gates Nan XX Urban Village and Pegambiran PHC working regions. To address the spread of TB through social contact, several alternative interventions could be considered, such as contact tracing or active case-finding among individuals infected with TB to identify additional cases within clusters.<sup>39</sup>

Other than that, improving sanitation conditions and environmental cleanliness in areas with TB clusters to reduce the risk of transmission through the air or contact with contaminated surfaces can also be done. Additionally, the government needs to focus on educating the public about TB, including its symptoms, methods of contagion, and the importance of prevention and proper treatment.<sup>40</sup> Therefore, identifying cluster patterns of spread is expected to enable more targeted interventions, such as effective contact tracing, routine screening in high-incidence areas, and health education campaigns specifically tailored to at-risk communities.

## Conclusion

TB cases are higher in coastal areas compared to the highlands, with cluster distribution patterns in both geographic locations. TB transmission is not related to temperature and humidity factors but is more influenced by population density, where frequent interaction is the most significant risk factor. Additionally, data analysis has successfully mapped the distribution of cases according to these patterns. It can now be used as a reference for controlling TB transmission, including educational efforts and case tracking.

## Abbreviations

TB: tuberculosis; PHC: primary health care; NNA: Nearest Neighbor Analysis.

## Ethics Approval and Consent to Participate

The analysis performed passed research ethics from the research ethics committee at Andalas Padang University, with an ethical approval number of 501/UN.16.2/KEP-FK/2023.

## Competing Interest

The authors declare that there are no significant competing financial, professional, or personal interests that might have affected the performance or presentation of the work described in this manuscript.

## Availability of Data and Materials

Data and materials are available from the corresponding authors.

## Authors' Contribution

RS was responsible for the entire process, including the manuscript's analysis, writing, and revision. ID, H, and NS were responsible for conceptualization, and LH and AA supervised the findings of the work. All authors discussed the results and contributed to the final manuscript.

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