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# Spatial and temporal analysis to identify clusters of MDR-TB in Jambi, Indonesia

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## Abstract
**Background:** Multidrug-Resistant Tuberculosis (MDR-TB) remains a major public health challenge in Indonesia. **Objective:** To identify spatial clusters of MDR-TB in Jambi City during 2020–2025. **Methods:** A total of 101 MDR-TB cases were geocoded based on patient residential addresses to obtain precise geographical coordinates. A retrospective space-time scan analysis was then performed using population and MDR-TB incidence data. The SaTScan™ software with the discrete Poisson model was applied to detect areas at higher risk. The analysis covered the period from January 1, 2023 to August 31, 2025. **Results:** 101 MDR-TB cases were recorded during the study period. The analysis identified two cluster. The first cluster located around (1.1571425 S, 103.598028 E) with a radius of 5.44 km, comprising 28 observed cases compared to 10.00 expected, with a relative risk (RR) of 3.49 (p = 0.0037). The second cluster not reached the statistical significance was cantered at (1.638602 S, 103.577643 E) with a radius of 2.22 km, including 3 observed cases compared to 0.46 expected with an RR of 6.74 (p = 0.99). **Conclusion:** Spatial concentrations of MDR-TB were observed in areas of Jambi City. Strengthened surveillance, integration of spatial analysis into TB control programs are recommended to support targeted interventions.

**Keywords:** MDR-TB; cluster; spatial; temporal; Jambi municipality

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## INTRODUCTION

Multidrug-Resistant Tuberculosis (MDR-TB) is a disease caused by *Mycobacterium tuberculosis* strains that have developed resistance to at least isoniazid and rifampicin, with or without resistance to other anti-tuberculosis drugs. This condition primarily arises from inadequate treatment management, including improper drug use, poor adherence, and incomplete treatment courses.[1,2] Multidrug-resistant tuberculosis (MDR-TB) remains a major global challenge in tuberculosis control. The World Health Organization (WHO) estimated that there were approximately 410,000 new MDR-TB cases worldwide in 2023, with the South-East Asia region accounting for nearly half of the global burden. Indonesia ranks second among countries with the highest TB cases globally and contributes approximately 7.4% of the total MDR-TB cases worldwide.[3,4]

Spatial analysis plays a critical role in understanding the distribution and determinants of MDR-TB, enabling the identification of high-risk areas where control interventions can be prioritized.[5,6] The distributions of TB are related to poor socioeconomic conditions, population density, climate, and gaps in health service coverage.[7] In Jambi City, MDR-TB incidence has shown a fluctuating but persistent pattern during the last five years. However, spatial epidemiological analysis focusing on MDR-TB has not been previously conducted in this area. Understanding the spatial clustering of MDR-TB is essential to strengthen surveillance systems and optimize resource allocation for TB control programs.

## METHODS

### *Study design and setting*

Indonesia, an archipelagic country consisting of 38 provinces and 514 districts, includes Jambi City—the capital of Jambi Province—located on Sumatra Island. The city lies between approximately 1°59′–2°04′ South Latitude and 103°36′–104°04′ East Longitude. Its area consist of 205.38 km² with about 612,000 inhabitants. Jambi City is the provincial capital and the most densely populated city of Jambi Province. Jambi City has divided into 11 districts and 66 sub-districts[8] The study area is illustrated in Figure 1.


**Figure 1.** Study Area

### *Population, samples and sampling*

This research employed a retrospective spatial and temporal analysis design. Data on confirmed MDR-TB cases between January 1, 2020, and August 31, 2025 were obtained from the Jambi City Health Office. A total of 101 MDR-TB cases were included. Population data were derived from the Central Bureau of Statistics (BPS) Jambi City. Each MDR-TB case was geocoded using the patient's residential address to obtain latitude and longitude coordinates via Google Earth Pro.

### *Statistical analysis*

Spatial cluster detection was conducted using SaTScan™ version 10.1 applying a retrospective space-time scan statistic based on the discrete Poisson model.[9] The analysis scanned for clusters with high MDR-TB incidence compared to expected counts. The scanning window was set with a maximum spatial cluster size of 50% of the population at risk and temporal window of 50% of the study period. The creation of maps to visualize the analysis results was facilitated using the open-source application Quantum GIS version 3.33.2.

### *Ethical concitlerations*

Ethical clearance for this research was approved by Health Research Ethic Commission Faculty of Medicine and Health Sciences Jambi University with number 2552/UN21.8/PT.01.04/2025.

## RESULTS

Table 1 presents the sociodemographic characteristics of the respondents. The majority of respondents were aged 46–55 years (23.8%), followed by those aged 26–35 years (21.8%) and 36–45 years (21.8%). Meanwhile, the smallest proportion was found in the ≤15 years age group (2.0%). In terms of gender, most respondents were male (69.3%), while female respondents accounted for 30.7%. Regarding occupation, the highest proportion was categorized as farmer/livestock breeder/fisherman (29.7%), followed by housewives (18.8%) and those not specified (12.9%). A smaller proportion of respondents were entrepreneurs (9.9%), unemployed (8.9%), laborers (7.9%), and students (5.9%), while only 3.0% were civil servants (PNS) and another 3.0% were recorded as not available.[10] In addition, this study has identified lymph nodes as the most commonly affected organs in cases of extrapulmonary TB (55.3%). (see Table 1)

**Table 1.** General Characteristics of Respondents

| Variable | Total | Percentage (%) |
|---|---|---|
| **Age Group (years)** | | |
| ≤15 | 2 | 2.0 |
| 16-25 | 10 | 9.0 |
| 26-35 | 22 | 21.8 |
| 36-45 | 22 | 21.8 |
| 46-55 | 24 | 23.8 |
| ≥56 | 21 | 20.8 |
| **Gender** | | |
| Male | 70 | 69.3 |
| Female | 31 | 30.7 |
| **Occupation** | | |
| Unemployed | 9 | 8.9 |

| | | |
|---|---|---|
| Students | 6 | 5.9 |
| Housewife | 19 | 18.8 |
| Entrepreneur | 10 | 9.9 |
| Civil Servant (PNS) | 3 | 3.0 |
| Laborer | 8 | 7.9 |
| Farmer/livestock breeders/fisherman | 3 | 29.7 |
| Not specified | 30 | 12.9 |
| Not available | 13 | 3.0 |
| **Total** | **101** | **100.0** |

**Table 2.** MDR-TB clusters based on space-time analysis using the poisson model.

| Year | Cluster type | Coordinates (latitude, longitude) | Radius (km) | Cases (n) | Expected Case (n) | People at risk (n) | RR | LLR | P value |
|---|---|---|---|---|---|---|---|---|---|
| 2020-2025 | *Most Likey cluster* | 1.1571425 S 103.598028 E | 5.44 | 28 | 10.00 | 4310 | 3.49 | 12.74 | 0.0037 |
| 2020-2025 | *Secondary Cluster* | 1.638602 S 103.577643 E | 2.22 | 3 | 0.46 | 2917 | 6.74 | 3.13 | 0.999 |

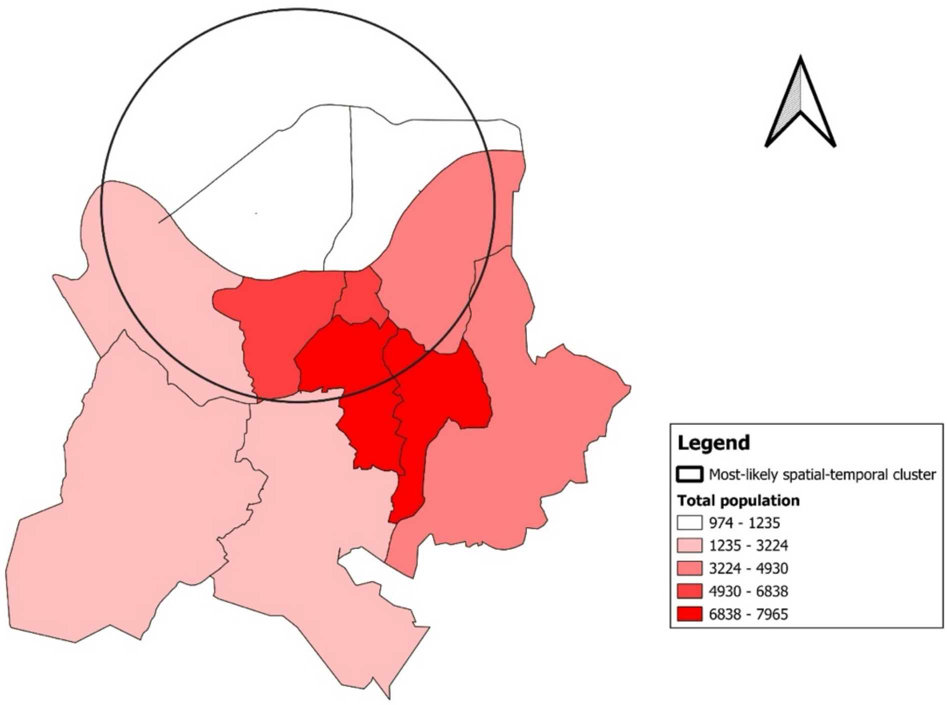


**Figure 2.** Clusters of MDR-TB Cases in Jambi City (2020-2025)

Table 2 presents the results of the space–time scan statistical analysis of dengue cases in Jambi City during the period 2020–2025. The analysis identified two clusters, with one cluster found to be not statistically significant. The cluster was detected at coordinates 1.1571425 S, 103.598028 E with a radius of 5.44 km, encompassing 28 observed cases compared to 10 expected cases among a population of 4,310 people at risk. This cluster showed a relative risk (RR) of 3.49 and a log likelihood ratio (LLR) of 12.74, with a statistically significant p-value of 0.0037, indicating a high probability of true clustering rather than random distribution.

Meanwhile, a secondary cluster was identified at coordinates 1.638602S, 103.577643E with a radius of 2.22 km. This cluster contained 3 observed cases compared to 0.46 expected cases among 2,917 people at risk, showing an RR of 6.74 and an LLR of 3.13. However, this cluster was not statistically significant (p = 0.999), suggesting that the observed aggregation may have occurred by chance.

## DISCUSSION

This study analyzed the spatial and temporal distribution of Multidrug-Resistant Tuberculosis (MDR-TB) cases in Jambi City from 2020 to 2025 using a space–time scan statistical approach. The results revealed two spatial clusters of MDR-TB, with one cluster being statistically significant. These findings indicate that MDR-TB transmission in Jambi City is not evenly distributed, and certain areas bear a higher disease burden than others.

The results of this study are consistent with previous research that also identified spatial clustering of MDR-TB cases. Alene et al. reported MDR-TB clusters in the Ethiopia–Sudan and Ethiopia–Eritrea border regions, which are inhabited by seasonal migrants. The study also found significant associations between MDR-TB incidence, urbanization, and the proportion of male population.[11] Similarly, a later study by Alene et al. (2021) in Hunan Province, China, detected MDR-TB hotspots in the northern and eastern parts of the province and revealed a strong association between MDR-TB occurrence and urban communities.[12]

In the present study, the districts included within the identified clusters were small administrative areas with high population density. These areas also represent the city's central business districts characterized by intense human mobility. Densely populated areas create conditions conducive to TB and MDR-TB transmission due to frequent interpersonal contact and environmental exposure. Moreover, the majority of respondents in this study were males of productive age, consistent with established demographic risk factors for TB infection. The occurrence of MDR-TB clusters in Jambi City illustrates the close interrelationship between host, agent, and environmental factors.

The detection of a statistically significant cluster highlights the need to strengthen surveillance activities and local TB control efforts [13,14]. The existence of clustering also indicates the importance of implementing targeted interventions in high-risk areas. Areas within or adjacent to significant clusters likely experience delayed diagnosis, incomplete treatment, or adverse socioeconomic conditions that facilitate ongoing transmission. Strengthening TB control programs through enhanced case finding, contact tracing, and community engagement could help reduce continuous transmission [15–20].

The spatial aggregation of MDR-TB cases also reflects associations with urbanization, population density, and limited healthcare accessibility.[21] As the provincial capital and the most densely populated urban area in Jambi Province, Jambi City may exhibit similar risk dynamics, which likely explain the observed clustering pattern. Integrating geospatial analysis into the TB surveillance system would enable real-time monitoring of new clusters and more efficient resource allocation.This study has several limitations. First, the relatively small number of MDR-TB cases may have reduced the statistical power to detect clusters. Second, the analysis relied on residential addresses, which may not accurately represent the actual sites of transmission. Lastly, socioeconomic and behavioral variables were not included in the analysis, which could have provided further insight into the determinants of MDR-TB clustering in Jambi City.

## CONCLUSIONS

This study identified spatial and temporal clustering of Multidrug-Resistant Tuberculosis (MDR-TB) cases in Jambi City from 2020 to 2025, with one statistically significant cluster indicating localized transmission. The findings suggest that MDR-TB distribution is not random. Integrating spatial analysis into routine TB surveillance is essential to detect emerging hotspots and guide targeted interventions for effective disease control.

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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