**Klinik: Jurnal Ilmiah Kedokteran dan Kesehatan**
**Volume 3, Nomor 2, Mei 2024**
E-ISSN .: 2809-2090; P-ISSN .: 2809-235X, Hal. 13-22
DOI: https://doi.org/10.55606/klinik.v3i22.2900
Tersedia: https://journalcenter.org/index.php/klinik

# Spatial Analysis of Pulmonary Tuberculosis Distribution in Bitung City: The Role of Altitude and Population Density

**Frelly Valentino Kuhon[1], Ronald Imanuel Ottay[2], Cicilia Pali[3], Jeini Ester Nelwan[4], Oksfriani Jufri Sumampouw[5*]**
[1,2,3]Faculty of Medicine, Sam Ratulangi University, Manado
[4,5]Faculty of Public Health, Sam Ratulangi University Manado
*Email correspondence: oksfriani.sumampouw@unsrat.ac.id

**ABSTRACT:**Pulmonary Tuberculosis (Pulmonary TB) remains a serious global and national health problem, with Indonesia ranking second in the global TB case burden. Bitung City is the area with the second highest cases of Pulmonary TB in North Sulawesi Province, with a prevalence rate that tends to increase. Environmental factors such as population density and the physical condition of the house are suspected to play a role in the spread of the disease. Spatial analysis is needed to understand disease distribution patterns to support effective, region-based interventions. This study aims to describe the spatial distribution of Tuberculosis disease in Bitung City based on the altitude of the place and population density. This study uses a spatial analysis approach by mapping data on area height, population density, and the average number of pulmonary TB cases per year (2020-2023 period) in each sub-district in Bitung City. The data is analyzed descriptively by grouping each variable into specific categories and visualized in the form of a thematic map. The results of the study show that all sub-districts in Bitung City are included in the lowland category (0-200 meters above sea level), so that no significant variation was found in terms of the height of the place. A total of five sub-districts have a high population density, namely Aertembaga, Girian, Madidir, Maesa, and Matuari. This sub-district with a high population density also recorded the highest number of pulmonary TB cases, with Maesa as the sub-district with the highest cases (97.5 cases per year), followed by Girian, Aertembaga, Matuari, and Madidir. It was concluded that the distribution of pulmonary TB cases in Bitung City did not show variation based on the altitude of the place, but had a correlation with population density. Districts with high population density tend to be the areas with the highest burden of Pulmonary TB cases. These findings emphasize the importance of public health interventions focused on densely populated areas to control the transmission of pulmonary TB.

**Keywords**: Pulmonary Tuberculosis; Bitung City; Spatial Analysis

## 1. BACKGROUND

Pulmonary tuberculosis (pulmonary tuberculosis) is an infectious disease caused by *Mycobacterium tuberculosis* (*M. tuberculosis*) which attacks various tissues and organs of the body. There are 2 (two) processes of transmission of *M. tuberculosis,* namely through sputum splashes of people affected by pulmonary TB (*droplets*) and through sputum splashes that float in the air so that they are inhaled by other people around them *(airborn).* ( Suryatinah Y, et al ., 2018) *M. tuberculosis* is one of the top 10 leading causes of death from a single infectious agent (above HIV/AIDS) worldwide. ( Mathofani , P. E, & Febriyanti , R., 2020)

A report from *the World Health Organization* (WHO) in 2021 estimated that 10.6 million people were infected with pulmonary TB disease, an increase of 4.5% from 10.1 million people in 2020. Indonesia is the second contributing country to Pulmonary TB cases globally with a case incidence rate of 9.2%, below India which has a case incidence rate of 28%. Geographically, there are 5 regions with the most cases of Pulmonary TB in 2021, including

*Naskah Masuk: 09 April 2024; Revisi: 27 April 2024; Diterima: 19 Mei 2024; Terbit: 30 Mei2024*

45% spread across the Southeast Asian continent, 23% Africa, 18% in the Western Pacific, 2.9% in the Americas, and 2.2% in Europe. The Southeast Asian continent is the highest number in the world, and the 3 countries with the highest burden in Southeast Asia, namely India, China, and Indonesia. (WHO, 2022)

The 2021 Indonesian Health Profile data states that the number of findings of all cases of Pulmonary TB is 397,377 cases with an incidence rate of 146 per 100,000 population. West Java is the province with the highest number of cases of pulmonary tuberculosis, with 91,368 cases (23%), followed by Central Java with 43,121 cases (10.9%) and East Java with 42,193 cases (10.6%). The Case Notification Rate (CNR) for Pulmonary TB per 100,000 population in North Sulawesi increased from 217 cases in 2016 to 273 cases in 2018. Pulmonary TB is one of the fourth highest diseases in North Sulawesi Province. Manado City recorded the highest cases of Pulmonary TB followed by Bitung City and Tomohon City ranked third (Ministry of Health, 2021). Pulmonary TB cases with the achievement of finding positive cases of Pulmonary TB in the last three years in 2020-2023 at the Bitung City Health Office, namely in 2021 (437 cases), 2022 (567 cases) and 2023 (534 cases). The highest number occurred in 2022 (Bitung City Health Office, 2023).

The elimination of Pulmonary TB will be held in 2035 and Indonesia will be free of Pulmonary TB by 2050 as the target of the national Pulmonary TB control program. Pulmonary TB control is carried out through health promotion activities, control of risk factors, discovery and treatment of pulmonary TB cases, immunization of immunity, and administration of preventive drugs to someone who has been in contact with pulmonary TB patients. (Princess) Snoop Dogg , F, P., 2022)

Referring to one of the implementation of the national strategy for the elimination of Pulmonary TB in Presidential Regulation No. 67 of 2021, namely strengthening commitment and leadership between the central government, provincial regions, and districts/city regions, which is carried out through the implementation of regional-based Pulmonary TB control. Which can be done using the spatial analysis method, so that information related to Pulmonary TB data is obtained. ( Zachrany , 2023)

Research conducted by Damayanti et al in 2018 concluded that there is a relationship between the risk of environmental and behavioral factors on the development of the spread of pulmonary tuberculosis. (Damayanti et al, 2018). In general, cases of Pulmonary TB are clustered in certain areas. The characteristics of areas that have the potential for transmission of Pulmonary TB are areas with high population density, interaction between residents with each other, and lack of knowledge and stigma from the community about Pulmonary TB. So

that it triggers the public's indecision to check themselves or seek treatment at the nearest health center. (Tanjung R, et al. 2021).

Based on the results of previous research, the majority of TB cases are found at low to moderate altitudes (Pratama 2016; Martya 2017). The results of Hartanto et al's research show that the distribution of pulmonary TB cases is mostly found in areas with an altitude of ≤150 meters above sea level. Altitude contributes to the incidence of TB where lowland areas are 3.28 times more at risk of having a high number of TB cases (Hartanto et al 2019; Tanrikulu et al 2008).

The increase in population density resulting in changes in humidity and air temperature also affects the increase in the number of cases of BTA+ Pulmonary TB (Achad 2010). The results of the study show that the distribution of pulmonary TB cases in Semarang City tends to follow the distribution of population density. High population density can increase the risk of transmission of diseases, especially those related to the respiratory tract such as pulmonary TB, because the chance of contact with people with pulmonary TB will be greater (Sasmita et al 2016). Coupled with the low coverage of healthy houses. Home conditions can directly affect the transmission of Pulmonary TB. The physical conditions of the house that usually affect the spread of Pulmonary TB are lack of ventilation, overcrowded housing, and lack of sunlight entering the house (Mahmuda & Rahmaniati, 2014).

Spatial-temporal analysis techniques in the case of pulmonary TB are needed for the control of the disease because each region must have different characteristics and regional order so that the spatial description of cases makes it easier to see the case points and specific environmental conditions in each region in a certain period of time (Teurlai et al 2015; Sumampouw 2020; Ottay et al 2024).

Some risk factors for Pulmonary TB are related to the region. One of the region-based information delivery can use spatial analysis, which is a field that combines research in the health field with *Geographic Information System* (GIS) through the study of environmental epidemiology (Gatrell & Loytonen 2003). The pattern and location data of GIS results help the epidemiology field to provide the most appropriate location clues in the provision of effective health interventions (Hartanto et al 2010).

This research was carried out in Bitung City because Bitung City is the second highest city/regency of Pulmonary TB cases in North Sulawesi and the prevalence rate of Pulmonary TB also tends to increase. The results of observation found that the highest environment-based disease in the city of Bitung is Pulmonary TB for various age groups, from children (0-14 years), adults (15-65 years) and the elderly (69-85 years). Another thing is because Bitung City

is included in an area with high population density and interaction between residents with each other that is at risk of increasing the spread of pulmonary TB. The purpose of this study is to describe the spatial distribution.

## 2. RESEARCH METHODS

This study uses a descriptive approach with spatial analysis methods to describe the distribution of Pulmonary Tuberculosis (TB) disease in Bitung City. Data on pulmonary TB cases for the 2020-2023 period was obtained from the Bitung City Health Office. Other secondary data, namely data on the height of the place and population density per sub-district, were also collected from relevant sources. Data analysis was carried out spatially by mapping the distribution of three main variables. First, the height of the place is classified into two categories: lowland (0-200 meters above sea level) and highland (>200 meters above sea level). Second, population density is categorized into three levels: low (1-250 people/km$^2$), medium (250-500 people/km$^2$), and high (>500 people/km$^2$). Third, the number of pulmonary TB cases is calculated based on the average number of cases per year and is grouped into three categories: low (3-25 cases), medium (25-40 cases), and high (>40 cases). All data is then processed and visualized into a thematic map using Geographic Information System (GIS) software. The maps were analyzed descriptively and comparatively to identify distribution patterns and spatial relationships between the altitude, population density, and concentration of pulmonary TB cases in each sub-district.

## 3. RESULTS OF RESEARCH AND DISCUSSION

Spatial analysis of the distribution of tuberculosis disease in Bitung city based on the altitude of the place and population density. The description of the average height of the sub-district in Bitung City is divided into 2 categories, namely low if the average is 0-200 meters above sea level and high if > 200 meters above sea level. A spatial map of Bitung City based on the height of the place can be seen in the following Image.

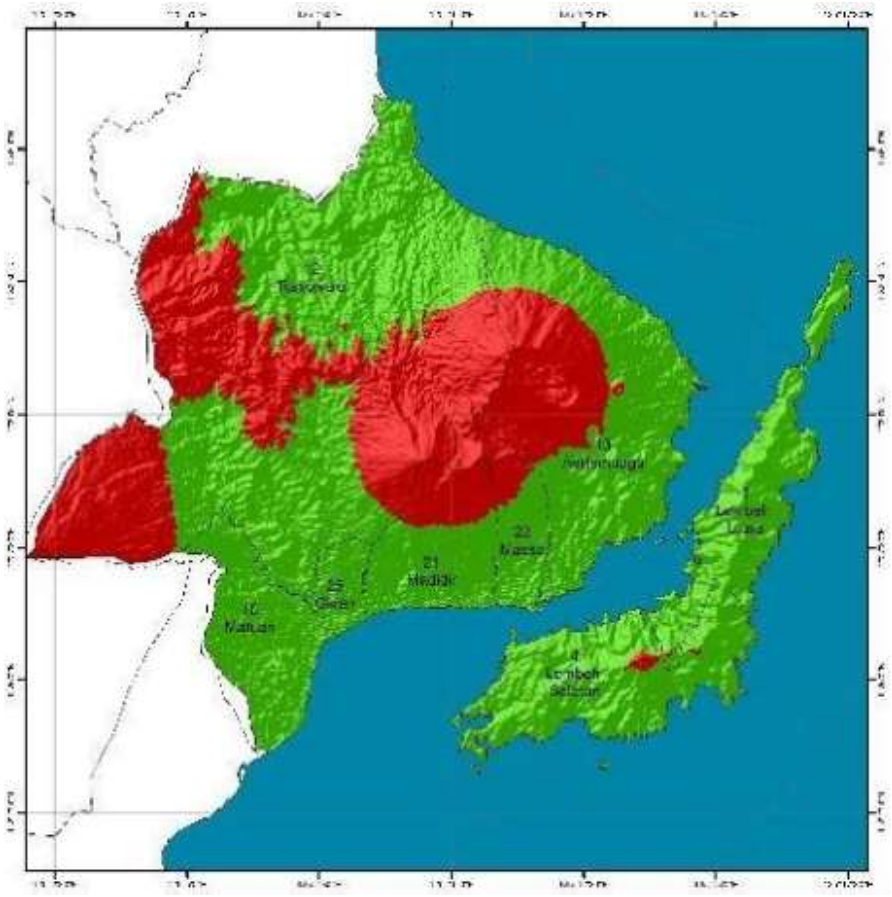


**Figure 1.** Spatial Distribution of the height of the place of Bitung City

The results of this study show that Ranowulu and South Lembeh sub-districts are sub-districts with sub-district areas whose areas are in the highland category (> 200 meters above sea level) where Ranowulu sub-district is the sub-district with the most area in the highlands. Furthermore, the sub-districts of Matuari, Girian, Madidir, Maesa, Aertembaga and North Lembeh whose areas are included in the lowland category (< 200 meters above sea level). In general, all sub-districts in Bitung City are in the low category so no variation was found for the height of the place. Furthermore, a spatial map of Bitung City based on population density is presented. Population density is categorized into 3 categories, namely high (> 500 people/km$^2$), medium (250-500 people/km$^2$) and low (1-250 people/km$^2$). The following is presented a spatial map of population density per sub-district in Bitung City.

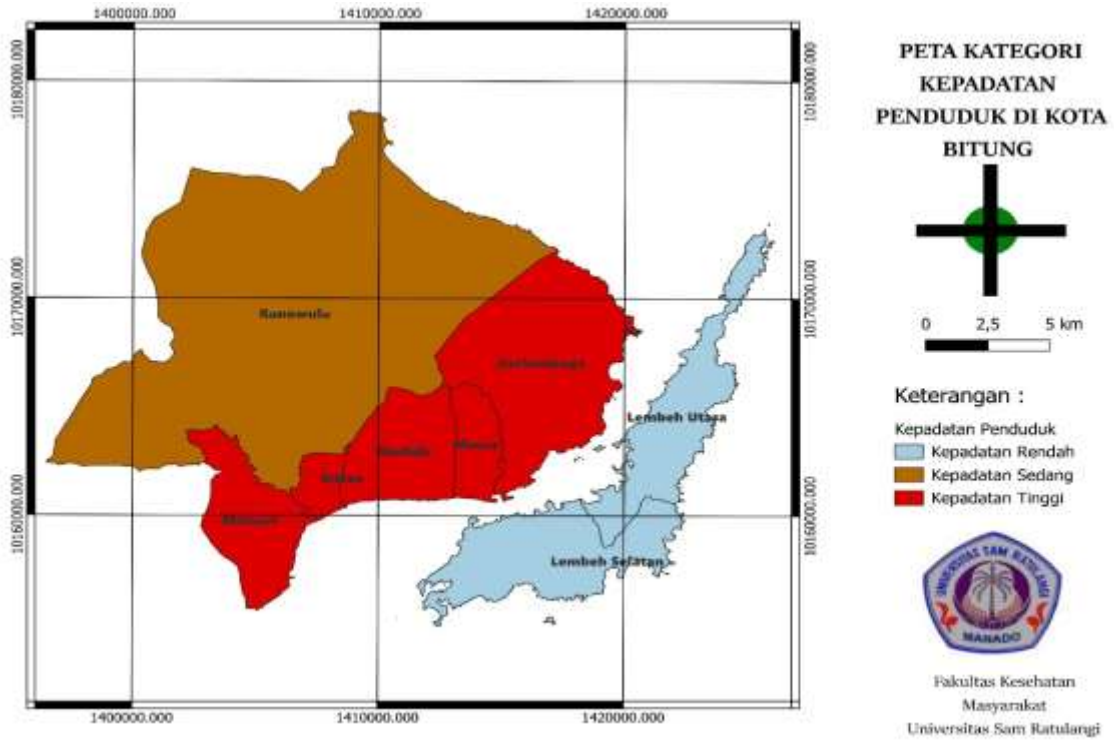


**Figure 2.** Population Density Map in Bitung City by Sub-district

The results of this study show that 5 sub-districts are found to be in the high-density category (> 500 people/km$^2$), namely Aertembaga, Girian, Madidir, Maesa and Mawari sub-districts. There are 2 sub-districts in moderate density (250-500 people/km$^2$), namely North Lembeh and South Lembeh sub-districts. Ranowulu District is in the low density category (1-249 people/km$^2$). Furthermore, a spatial map of Bitung City is presented based on the category of the number of cases per sub-district. The number of cases of Pulmonary TB is calculated based on the average number of pulmonary TB per year (the number of Pulmonary TB in 2020-2023 divided by 4 years). These results were divided into 3 groups, namely low (3–25 cases),

medium (25–40 cases) and high (>40 cases). This can be seen in the following Image.

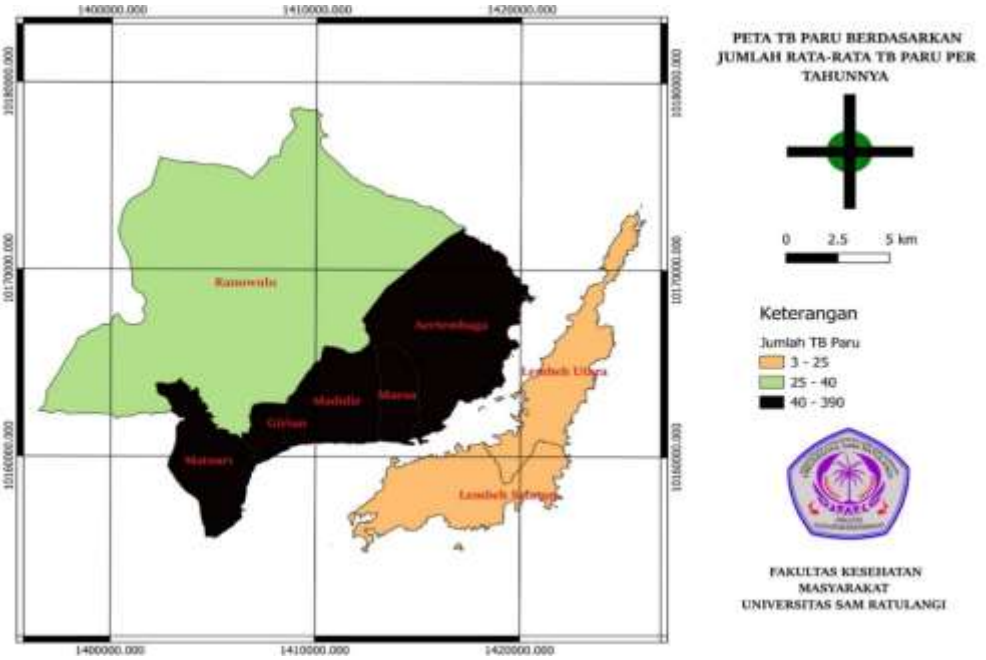


**Figure 3.** Map of the Average Number of Pulmonary TB per Year

The results of this study show that all sub-districts in Bitung City are in the low category so that no variation was found for the height of the place. Based on the results of previous research, the majority of TB cases are found at low to moderate altitudes (Pratama 2016; Martya 2017). The results of Hartanto et al's research show that the distribution of pulmonary TB cases is mostly found in areas with an altitude of ≤150 meters above sea level. Altitude contributes to the incidence of TB where lowland areas are 3.28 times more at risk of having a high number of TB cases (Hartanto et al 2019; Tanrikulu et al 2008).

The results of this study show that 5 sub-districts are found to be in the high-density category (> 500 people/km$^2$), namely Aertembaga, Girian, Madidir, Maesa and Mawari sub-districts. There are 2 sub-districts in moderate density (250-500 people/km$^2$), namely North Lembeh and South Lembeh sub-districts. Ranowulu District is in the low density category (1-249 people/km$^2$). The results of this study show that there are 5 sub-districts in the high category, namely the highest sub-districts in Maesa (97.5 cases), Girian (81.7 cases), Aertembaga (79.5 cases), Matuari (67.7 cases) and Madidir (65.5 cases). There is 1 sub-district in the medium category, namely Ranowulu District (28.2 cases). There are 2 in the low category, namely South Lembeh District (24.7 cases) and North Lembeh (16.7 cases).

The results of this study show that in sub-districts with high population density, the highest cases of pulmonary TB were also found, namely Maesa (97.5 cases), Girian (81.7 cases),

Aertembaga (79.5 cases), Matuari (67.7 cases) and Madidir (65.5 cases). The increase in population density resulting in changes in humidity and air temperature also affects the increase in the number of cases of BTA+ Pulmonary TB (Achad 2010). The results of the study show that the distribution of pulmonary TB cases in Semarang City tends to follow the distribution of population density. High population density can increase the risk of transmission of diseases, especially those related to the respiratory tract such as pulmonary TB, because the chance of contact with people with pulmonary TB will be greater (Sasmita et al 2016). Coupled with the low coverage of healthy houses. Home conditions can directly affect the transmission of Pulmonary TB. The physical conditions of the house that usually affect the spread of Pulmonary TB are lack of ventilation, overcrowded housing, and lack of sunlight entering the house (Mahmuda & Rahmaniati, 2014).

## 4. CONCLUSION

The conclusion of this study is shows all sub-districts in Bitung City are in the low category so that no variation was found for the height of the place. The results of this study show that in sub-districts with high population density, the highest cases of pulmonary TB were also found, namely Maesa, Girian, Aertembaga, Matuari and Madidir sub-districts.

## ACKNOWLEDGMENT

The researcher expressed his sincere appreciation and gratitude to the Institute for Research and Community Service (LPPM) of Sam Ratulangi University for providing research funding. The financial assistance that has been distributed is a very meaningful support for the smooth and sustainable of this research activity. This financial support not only encourages the achievement of academic research goals, but also is clear evidence of LPPM's commitment to advancing the research climate at Sam Ratulangi University.

## BIBLIOGRAPHY

Achmad, F. A. (2010). Analisis Spasial Penyakit Tuberkulosis Paru BTA Positif di Kota Administrasi Jakarta Selatan Tahun 2007-2009. *Universitas Indonesia*.

Amalia, A. I., & Setiyadi, N. A. (2021). Analisis Spasial Tuberkulosis 2018–2020: Kabupaten Magelang, Indonesia. *Jurnal Manajemen Informasi Dan Administrasi Kesehatan (JMIAK)*, *4*, 1-9.

Asyila Zachrany, A., (2023). *Analisis Spasial Kasus Tuberkulosis pada 514 Kab/Kota di Indonesia.* Skripsi, Ilmu Kesehatan Masyarakat, Fakultas Kedokteran Universitas Jambi.

Konde, C.P. A. Asrifuddin., dan FLFG Langi. (2020). Hubungan Antara Umur, Status Gizi Dan Kepadatan Hunian dengan TB Paru Di Puskesmas Tuminting Kota Manado. *Jurnal KESMAS*, *Vol*. 9, *No 1*, *Januari 2020*

Damayati, D. S., Susilawat, A., & Maqfirah. (2018). Risiko Kejadian TB Paru di Wilayah Kerja Puskesmas Liukang Tupabbiring Kabupaten Pangkep. Higiene: *Jurnal Kesehatan Lingkungan*, 4(2), 121-130.

Dhaniasri, D., Rejeki, D. S. S., & Raharjo, S. (2020). Analisis spasial kasus TB paru di Kabupaten Banyumas Tahun 2009-2018. *Balaba: Jurnal Litbang Pengendalian Penyakit Bersumber Binatang Banjarnegara*, 169-180.

Dinas Kesehatan Kota Bitung. (2024). *Profil Kesehatan Kota Bitung*. Bitung

Dwi Hartanto, T., Dian Saraswati, L., Sakundarno Adi, M., & Udiyono, A. (2019). *Analisis Spasial Persebaran Kasus Tb Paru Di Kota Semarang Tahun 2018* (Vol. 7, Issue 4). Jurnal Kesehatan Masyarakat (e-Journal)

Erdini, D., Dwimawati, E., & Chotimah, I. (2020). Evaluasi Program Tb Paru Di Puskesmas Ciampea Kabupaten Bogor Tahun 2019.

Fadilla, M., Utomo, B. (2017) *Analisis Faktor Risiko TB Paru di Wilayah Kerja Puskesmas Kaligondang Kabupaten Purbalingga Tahun 2017*. Keslingmas Vol. 37 No. 3 Hal. 240-404

Gatrell A, Loytonen M. (2003). *GIS and Health*. VI. London: Taylor & Francis

Grahyta Dhamayanti., Ari Rahma Yanti, Hanifah Nurdani, Rijikanias Suningsih. (2017). Analisis Spasial Penyakit TB Paru di Kalimantan Tengah Tahun 2017. Bikfokes Volume 1 Edisi 1 Tahun 2020.

Hartanto S, Halim S, Yuliana OY. (2010). Pemetaan Penderita Pneumonia di Surabaya Dengan Menggunakan Geostatistik. *Tek Ind*. 12(1):41–6

Hartanto, T, D., Saraswati, L. D., & Adi, M. S. (2019). Analisis Spasial Persebaran Kasus TB Paru di Kota Semarang Tahun 2018. *Jurnal Kesehatan Masyarakat* (*e-Journal*), 7(4), 719-727.

Hartanto, T. D., Saraswati, L. D., Adi, M. S., & Udiyono, A. (2019). Analisis Spasial Persebaran Kasus Tuberkulosis Paru Di Kota Semarang Tahun 2018. *Jurnal Kesehatan Masyarakat*, *7*(4), 719-727.

Kementrian Kesehatan RI. (2023). *Profil Kesehatan Indonesia 2021-2022*. Jakarta

Mahmuda, D., & Rahmaniati, M. (2014). Hubungan Status Rumah Sehat dengan Kejadian Tuberkulosis Paru di Provinsi Banten Tahun 2010 (Analisis Data Riset Kesehatan Dasar 2010). *Universitas Indonesia*.

Rahmaniati, M. (2017). Pola Penyebaran Kasus Tuberkulosis Dengan Pendekatan Spasial-Statistik (Studi kasus di Kota Depok, Jawa Barat).

Mathofani, P. E., Febriyanti, R. (2020). Faktor-Faktor Yang Berhubungan Dengan Kejadian Penyakit Tuberkulosis (TB) Paru di Wilayah Kerja Puskesmas Serang Kota Tahun 2019. The Factors Associated With The Incidence Of Pulmonary Tuberculosis In The Working Area Of Serang City Health Center 2019. *Jurnal Ilmiah Kesehatan Masyarakat* (Vol. 12,).

Mubarak, sari, N. P., Nasution, N. H., Simamora, J. P., & Argaheni, N. B. (2021). *Pengantar Kesehatan Lingkungan* (Issue Desember). *PROMOTOR Jurnal Mahasiswa Kesehatan Masyarakat* (Vol. 3, Issue 5).

Muli Rezky., (2017). Analisis Spasial Kejadian Tuberculosis di Daerah Dataran Tinggi Kabupaten Gowa. Skripsi. Fakultas Kedokteran dan Ilmu Kesehatan. Universitas Islam Negeri Alauddin Makassar.

Nasution, D. J., Elfira,. & Faswita W, (2021) *Pencegahan Penularan TB paru.* Jawa tengah: Eureka Media Aksara

Ottay, R. I., Sapulete, I. M., Rosalinda, M., Sapulete, O. J. S., & Nelwan, J. E. (2024). Dengue Hemorrhagic Fever in North Minahasa Regency in 2021-2022: Study Epidemiological.

Pratama, R. M. (2016). Epidemiologi spasial kejadian tuberkulosis paru BTA positif di wil. kab. banyumas tahun 2013-2015.

Prihyono Putri, F. P. (2022). *Analisis Spasial Kasus Tuberkulosis Di Kota Jambi Tahun 2015-2021*. Skripsi, Fakultas Kedokteran dan Ilmu Kesehatan Masyarakat. Universitas Jambi.

Santoso, R., Susilawati, E., & Susanti, E,. (2021). *Analisa Pola Penggunaan Dan Kepatuhan Obat Tuberkulosis Di Salah Satu Rumah Sakit Swasta Di Kota Bandung*. Jurnal IKRA-ITH TEKNOLOGI Vol 5 No 2 Bulan Juli 2021.

Sasmita, S., Junaid, J., & Ainurafiq, A. (2016). *Pola Spasial Kejadian Tb Paru Bta Positif di Wilayah Kerja Puskesmas Puuwatu Tahun 2013-2015* (Doctoral dissertation, Haluoleo University).

Srisantyorini, T., Nabilla, P., Herdiansyah, D., Dihartawan, Fajrini, F., Suherman. (2022). *Analisis Spasial Kejadian Tuberkulosis di Wilayah DKI Jakarta Tahun 2017-2019*. Jurnal Kedokteran dan Kesehatan, Vol. 18, No. 2.

Sumampouw, O. J. (2020). Epidemiologi Demam Berdarah Dengue di Kabupaten Minahasa Sulawesi Utara. *Sam Ratulangi Journal of Public Health*, *1*(1), 001. https://doi.org/10.35801/srjoph.v1i1.27272. (Diakses 11 November 2021).

Suryatinah, Y., Sari RGS, W., Sulasmi, S. (2018). *Pengaruh Jenis Obat Terhadap Kerutinan Penderita Tb Paru Meminum Obat Anti Tuberkulosis*. Balai Litbangkes Tanah Bumbu. Prosiding Seminar Informasi Kesehatan Nasional (SIKesNas).

Tanjung, R., Mahyuni, E.L., Tanjung, N., Simarmata, O.S., Sinaga, J., & Nolia, H.R. (2021). Sebaran Spasial Penyakit TB Paru di Kecamatan Kabanjahe, Kabupaten Karo, Indonesia. *Jurnal Ilmu Kedokteran Sains, 9, 817-822.*

Tanrikulu, A. C., Acemoglu, H., Palanci, Y., & Dagli, C. E. (2008). Tuberculosis in Turkey: high altitude and other socio-economic risk factors. *Public Health*, *122*(6), 613-619.

Teurlai, M., Eug, C., Cavarero, V., & Degallier, N. (2015). Socio-economic and Climate Factors Associated with Dengue Fever Spatial Heterogeneity: A Worked Example in New Caledonia. *PLOS Neglected Tropical Diseases*, 12(e12): 1–31.

World Health Organization. (2022). *Global Tuberculosis Report 2022*. Geneva.

Yunita, S., Nurfadhilah, N., Srisantyorini, T., & Herdiansyah, D. (2022). Analisis Spasial Kejadian Tuberkulosis Berdasarkan Lingkungan Fisik. *Environmental Occupational Health and Safety Journal*, *3*(1), 1.