



Research Article

Population Density, Occupation Of Traders, And Private Practice Doctors in Relation to The Tuberculosis Case Notification Rate (CNR) in Kuningan Regency 2024: A Spatial Analysis

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ABSTRACT

Indonesia aimed to eliminate Tuberculosis (TB) by 2050, with efforts scheduled to begin in 2030. However, TB cases remained high in Kuningan Regency, necessitating urgent measures to address this issue. This research employed a Geographic Information System (GIS) approach to map TB cases, helping to understand the distribution patterns of patients. This information guided the development of effective policies to address TB cases from an epidemiological perspective. **Methods.** In this non-reactive research design, the study focused on 32 sub-districts in Kuningan Regency, which included a total of 937 tuberculosis (TB) patients. The variables analyzed included the number of TB cases, case notification rate (CNR), total population, population density, the presence of private practice doctors, and the number of traders. Descriptive data analysis was conducted to create maps, along with spatial data analysis using Moran's Index through GeoDa software. **Results.** Spatial analysis using Geoda found spatial autocorrelation between the number of TB cases and population density, the availability of private practice doctors, and the number of trade workers. The Z scores of these four variables were quite large and >Z0.95, so the distribution pattern of TB sufferers was declared to be a group (cluster). **Conclusion.** Based on the mapping of TB sufferers and spatial analysis, it was determined that the distribution pattern of TB sufferers in Kuningan Regency formed a cluster pattern, and there was an autocorrelation relationship between population density, the availability of private practice doctors, and the number of traders with TB sufferers. It was hoped that the results of this research would serve as material for improving TB interventions.

Keywords: Tuberculosis, Population Density, and Private Practicing Doctors.

INTRODUCTION

Tuberculosis (TB) remains a global health priority, as it is the second leading cause of death worldwide from a single infectious agent, after coronavirus disease (COVID-19), and accounts for nearly twice as many deaths as HIV/AIDS (WHO, 2023). It is estimated that TB has caused one



billion deaths globally over the past 200 years. In 2022, approximately 10.6 million people developed TB and 1.3 million died from the disease. At the global level, India contributed 26.6% of TB cases, while Southeast Asia and Africa accounted for the largest burden, positioning Indonesia among the countries with the highest TB prevalence. Indonesia contributed 10% of global cases, followed by China at 7.1%. Consequently, in 2022, Indonesia ranked as the country with the second-highest estimated TB incidence and mortality worldwide.

By June 2024, TB case notifications in Indonesia reached 393,261, comprising 386,891 (98%) drug-sensitive TB cases and 6,370 (2%) drug-resistant TB cases. Nationally, TB case notification coverage was 36%, falling short of the 45% target set for June. According to the West Java Provincial Health Office, TB cases in West Java increased significantly over the past decade, from 62,996 cases in 2014 to 210,703 cases in 2023—an increase of 120% above projections, with many cases suspected to remain undetected. Of these, 24% were pediatric TB cases (50,533), representing a 477% increase in 2023. In the same year, 14,268 patients (8.66%) discontinued treatment, while TB-related deaths reached 3,968 (2.41%). Case notification coverage in West Java was 43%, close to the national achievement but still below target (MoH, 2024).

The rising number of undiagnosed and untreated TB patients continues to fuel transmission. Data from 2023 indicate a significant increase in TB cases in Indonesia, particularly in West Java, which reported a high Case Notification Rate (CNR) with many areas showing high-risk spatial patterns. Kuningan District, as part of West Java, bears a considerable TB burden. Based on data from the Ministry of Health and the TB-DIAH survey, CNR figures in West Java and Kuningan remain concerning. In 2023, Kuningan was among the districts failing to meet TB case detection targets, with 572 cases identified, 285 of which were bacteriologically confirmed. The declining success rate in case detection has contributed to the continued rise in TB incidence.

TB transmission is particularly prevalent in densely populated areas, where the likelihood of contact between TB patients and susceptible individuals is high. Spatial TB distribution tends to be elevated in urbanized regions with high worker mobility and frequent social interactions. Case detection through a Public-Private Mix approach can improve case finding, as the involvement of private practitioners significantly influences TB control (Sunjaya et al., 2022). Comprehensive TB control requires consideration of host characteristics, bacteriological agents, and both physical and social environments as risk factors. Spatial TB control can be enhanced through geospatial approaches, such as mapping TB patients using Geographic Information System (GIS) software (Tuntun, Aminah, & Yusrizal, 2023). GIS-based mapping provides epidemiological insights into disease distribution and identifies optimal locations for effective health interventions (Muller et al., 2020).

Although TB is influenced by multiple determinants, including socioeconomic conditions, nutrition, housing quality, environmental sanitation, comorbidities, and access to health services, this study specifically focuses on population density, trade-related occupations, and the presence of private medical practitioners because these factors are closely related to transmission dynamics and case detection within the spatial context of Kuningan District. Population density reflects the intensity of human interaction and crowding, which increases the probability of airborne transmission of *Mycobacterium tuberculosis*. Areas with dense settlements are more likely to experience sustained community transmission due to prolonged and repeated close contact among residents (Puspita et al., 2021).

The proportion of workers in the trade sector was selected because traders and market-related workers commonly interact with large numbers of people in enclosed or crowded environments, such as traditional markets, shops, transportation hubs, and commercial centers. These occupational settings often involve high daily mobility, prolonged social contact, and inadequate ventilation, all of which are recognized contributors to TB transmission. Trade activities may therefore act as potential transmission nodes within the community. In Kuningan District, the trade sector represents an important component of local economic activity, making it relevant to explore whether areas with higher concentrations of trade-related occupations are spatially associated with increased TB incidence (Koro & Sornlorm, 2026).

The number and distribution of private practice doctors were also included because private healthcare providers play a critical role in TB case detection, diagnosis, referral, and treatment through the Public-Private Mix (PPM) strategy. In Indonesia, many patients initially seek care from private practitioners rather than public health facilities. Consequently, the availability and spatial distribution of private doctors may influence access to diagnosis, timeliness of treatment initiation, reporting of TB cases, and continuity of care. Unequal distribution of private practitioners may contribute to disparities in TB notification and control across regions (Mahendradhata et al., 2010). Therefore, examining this variable spatially is important for understanding how healthcare accessibility affects TB case patterns in Kuningan District.

To confirm spatial relationships across locations, spatial autocorrelation analysis using Moran's Index is applied. Global spatial autocorrelation estimates the overall dependency of TB notifications within geographic space and identifies clustering patterns of TB cases in specific regions. This study will employ spatial analysis to examine TB distribution in Kuningan District, focusing on variables such as the number of physicians, population density, and the proportion of workers in the trade sector. Previous studies have shown that factors such as access to healthcare services, population density, and trade activities increase TB transmission risk due to higher social interactions and exposure in crowded areas. These variables are critical for understanding TB spatial patterns, supporting area-based interventions, and developing more effective control strategies in high-risk regions.

Identifying spatial risk factors and transmission patterns provides valuable information for policymakers in designing TB control programs. The urgency of this research lies in providing detailed, spatially informed data on TB distribution, particularly in identifying areas most in need of intervention. Such data will assist local health authorities in developing targeted programs to reduce TB incidence in Kuningan District and contribute to national TB elimination efforts. The objective of this study is to analyze TB transmission patterns and conduct spatial analysis of factors (population density, trade-related occupations, and private medical practitioners) associated with TB cases in Kuningan District in 2024.

MATERIAL AND METHODS

Type and Design of Study

This study is a quantitative research aimed at analyzing secondary data. The primary focus is to explore the relationship between population density, the number of private medical practitioners, and the number of traders with the incidence of the Case Notification Rate (CNR) of tuberculosis (TB) in Kuningan District in 2024. The research design employed is non-reactive research, meaning that the researchers do not intervene or manipulate the study subjects. The data used are secondary, collected by other institutions, and deemed relevant for the purposes of this study.

Study Subjects

The study subjects consist of TB patients recorded across 32 sub-districts in Kuningan District in 2024. Data will be compiled from multiple sources to analyze TB distribution patterns in relation to the selected variables.

Research Variables

Independent Variables:

- Population Density: Number of inhabitants per square kilometer in each sub-district.
- Number of Private Medical Practitioners: Total number of private doctors operating in each sub-district.
- Number of Traders: Number of traders working in each sub-district.

Dependent Variable:

Case Notification Rate (CNR) of TB: Number of reported TB cases per 100,000 population in each sub-district.

Sources and Data Collection Techniques

- Secondary data will be obtained from the following sources:
- Population Density Data: Provided by the Central Bureau of Statistics (BPS) of Kuningan District.
- Number of Private Medical Practitioners: Obtained from the Kuningan District Health Office.
- Number of Traders: Collected from the Department of Trade and Industry.
- TB CNR Data: Derived from health reports issued by the District Health Office and other relevant institutions monitoring TB cases.

Data Analysis

Data will be analyzed using spatial analysis techniques, specifically the Moran's Index test. This test measures spatial autocorrelation between the studied variables and TB CNR incidence. Moran's Index is applied to identify spatial distribution patterns of TB CNR in Kuningan District. The index values range from -1 to +1:

- A positive value indicates clustering of TB cases (positive spatial correlation).
- A negative value suggests that TB cases are randomly distributed (negative spatial correlation).

RESULTS AND DISCUSSION

Result

Spatial Distribution

The spatial distribution of key sociodemographic and health-related variables associated with tuberculosis in Kuningan District is illustrated in Figure 1.

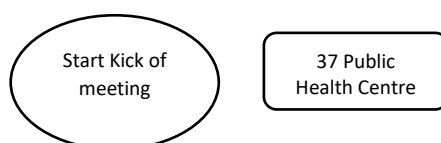




Figure 1. Distribution of Traders, Private Medical Practitioners, Population Density, Total Population, TB Case Notification Rate (CNR), and TB Cases in Kuningan District

Map A – Distribution of Traders: The map shows that 4 sub-districts have $\geq 7,510$ residents working as traders, 14 sub-districts have between 2,889–7,510 traders, and 15 sub-districts have fewer than 2,889 traders.

Map B – Distribution of Private Medical Practitioners: One sub-district has ≥ 16 private medical practitioners, 10 sub-districts have between 2–16 practitioners, and 22 sub-districts have fewer than 2 practitioners.

Map C – Distribution of Population Density: Six sub-districts have a population density $\geq 1,450.3$ persons/km², 12 sub-districts have densities between 861.9–1,450.3 persons/km², and 15 sub-districts have densities <861.9 persons/km².

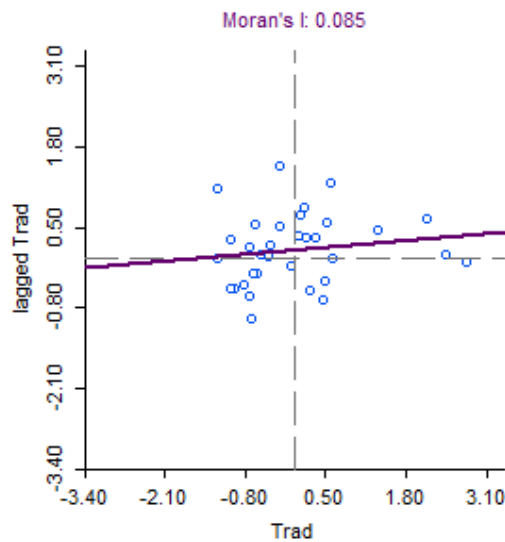
Map D – Distribution of Total Population: Two sub-districts have populations $\geq 108,946$ residents, 13 sub-districts have populations between 34,773–108,948 residents, and 18 sub-districts have populations <34,773 residents.

Panel E – Distribution of TB Case Notification Rate (CNR): Four sub-districts have a CNR ≥ 222 , 13 sub-districts have CNR values between 72–222, and 16 sub-districts have CNR values <72.

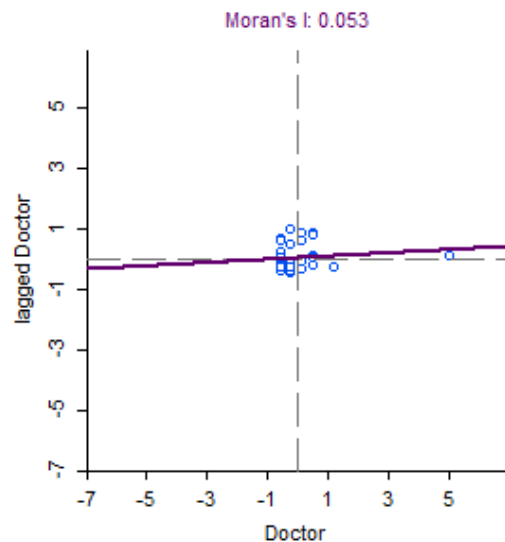
Map F – Distribution of TB Cases: Four sub-districts reported ≥ 116 TB cases, 13 sub-districts reported between 29–116 cases, and 19 sub-districts reported fewer than 29 cases.

Univariate Analysis

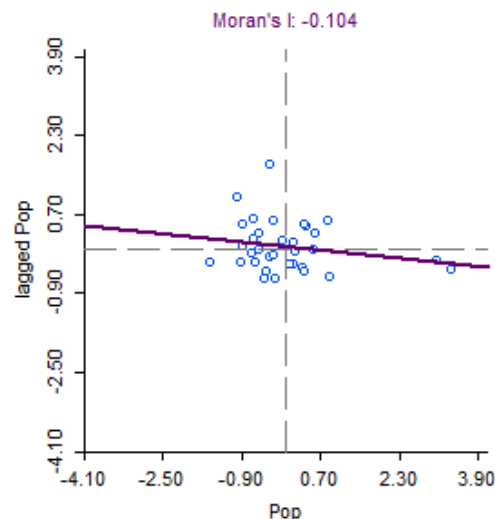
To further examine the spatial characteristics of each variable, univariate spatial analysis was conducted using Moran's Index. This analysis aimed to identify the presence, direction, and strength of spatial autocorrelation for each variable, thereby determining whether their spatial distribution across sub-districts in Kuningan District exhibited clustered, dispersed, or random patterns.

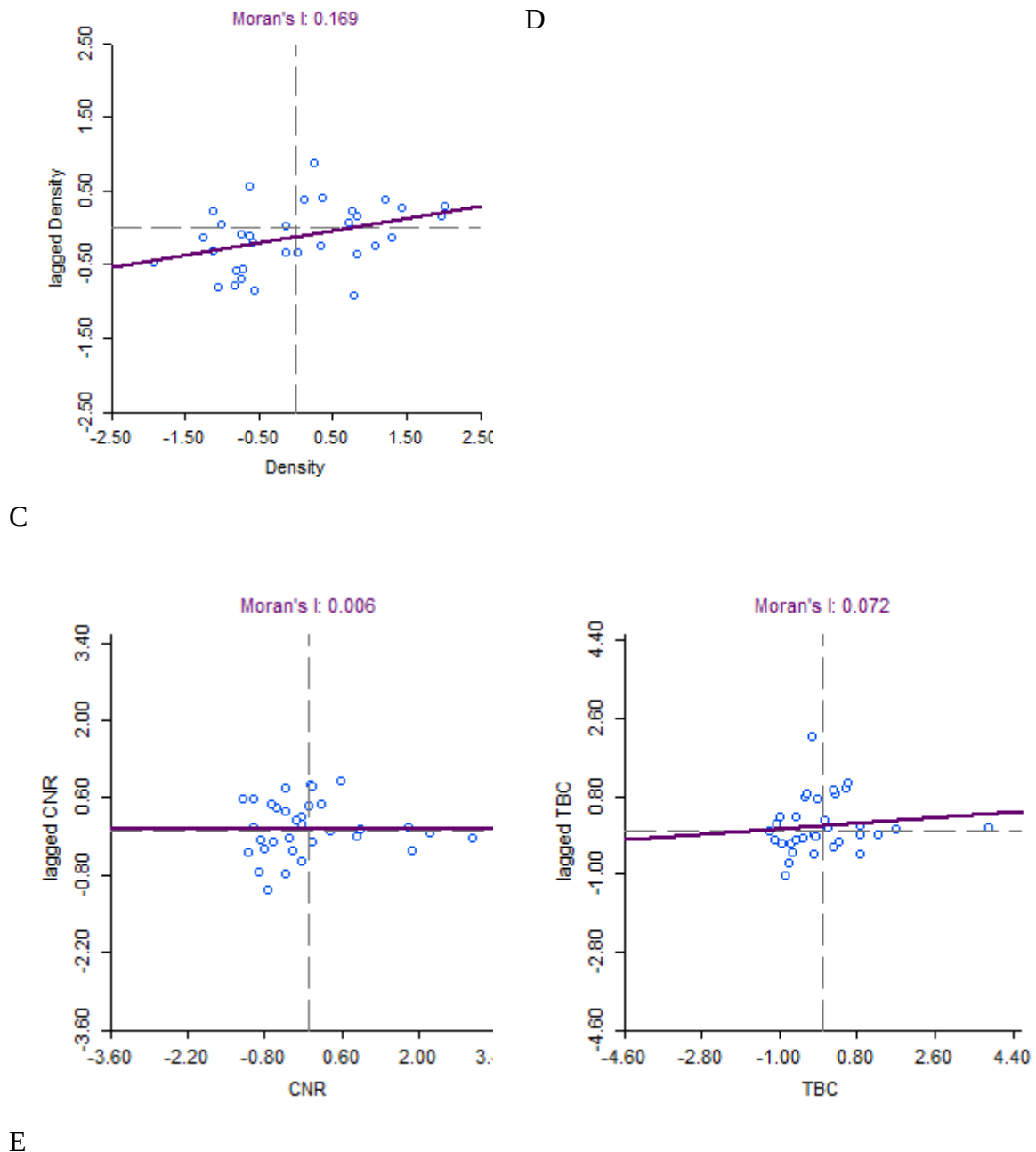


A



B

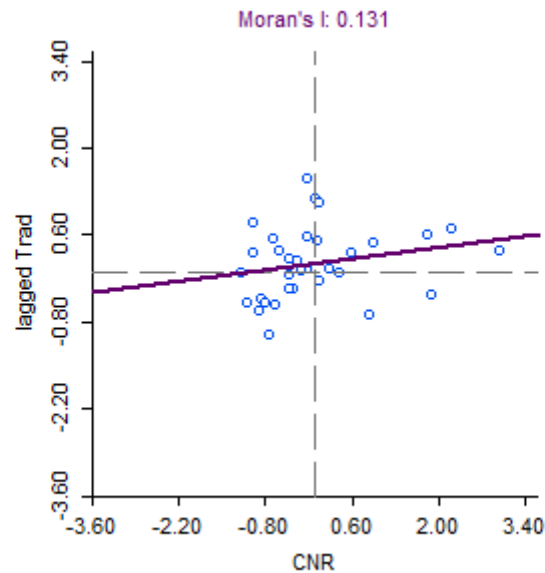




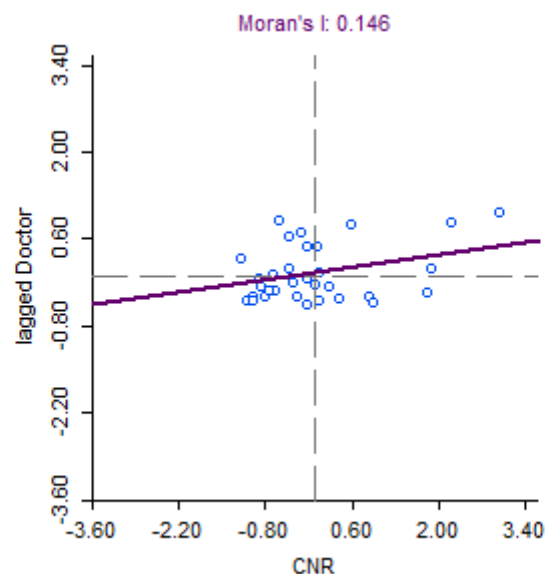
- Scatterplot A – Trader Occupations The calculated Moran's Index value is $I = 0.085$. This falls within the range $0 < I \leq 1$, indicating positive spatial autocorrelation. However, the correlation is weak as the value is close to zero, suggesting a clustered pattern.
- Scatterplot B – Private Medical Practitioners The Moran's Index value is $I = 0.053$, also within the range $0 < I \leq 1$. This demonstrates positive spatial autocorrelation, though the correlation is weak, with clustering tendencies.
- Scatterplot C – Population Density The Moran's Index value is $I = 0.169$, within $0 < I \leq 1$. This indicates positive spatial autocorrelation, with a weak correlation approaching zero.
- Scatterplot D – Total Population The Moran's Index value is $I = -0.104$, which falls within the range $-1 \leq I < 0$. This result indicates negative spatial autocorrelation, meaning TB cases are more randomly distributed rather than clustered.

- Scatterplot E – TB Case Notification Rate (CNR) The Moran's Index value is $I = 0.006$, within $0 < I \leq 1$. This shows positive spatial autocorrelation, but the correlation is extremely weak, nearly random.
- Scatterplot F – TB Cases The Moran's Index value is $I = 0.072$, within $0 < I \leq 1$. This suggests positive spatial autocorrelation, though the correlation remains weak, with clustering tendencies.

Bivariate analysis

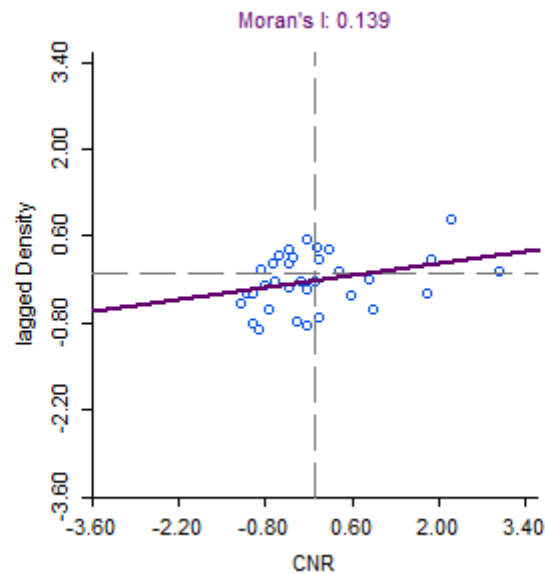


Based on the Moran Scatterplot for the variable Case Notification Rate (CNR) in relation to the number of traders, the calculated Moran's Index value is $I = 0.131$. This value falls within the range $0 < I \leq 1$, indicating the presence of positive spatial autocorrelation between CNR and the number of traders in Kuningan District.



Berdasarkan Moran Scatterplot variabel CNR dengan jumlah dokter maka berdasarkan perhitungan, nilai Indeks Moran $I = 0,146$. Nilai Indeks Moran ini berada pada rentang $0 < I \leq$

1 sehingga menunjukkan adanya autokorelasi spasial positif antara CNR dengan jumlah dokter di Kab. Kuningan..



Based on the Moran Scatterplot for the variable Case Notification Rate (CNR) in relation to population density, the calculated Moran's Index is $I = 0.139$. This value lies within the range $0 < I \leq 1$, indicating the presence of positive spatial autocorrelation between CNR and population density in Kuningan District.

Discussion

Population Density

Population density is generally associated with inadequate environmental and housing conditions that fail to meet health-related requirements, thereby facilitating the spread of infectious diseases, including tuberculosis (TB) (Harling & Castro, 2014). High population density also provides greater opportunities for TB bacteria to spread through contact between infectious individuals and susceptible populations (Li et al., 2019). Clusters of TB cases are predominantly found in densely populated areas, often in crowded public spaces, which facilitate pulmonary TB transmission through direct contact with other patients. Pulmonary TB is transmitted via droplets released when infected individuals cough, sneeze, or speak. A single cough from a TB patient can produce up to 3,000 droplet nuclei, which may remain airborne for extended periods. While direct sunlight can rapidly kill TB bacteria, they can survive in dark and humid environments (Tandirogang et al., 2020).

However, population density alone may not fully explain the occurrence of TB cases. Other factors such as poor ventilation, overcrowded housing conditions, low socioeconomic status, malnutrition, smoking behavior, diabetes mellitus, HIV infection, and limited access to healthcare services may also contribute to increased TB incidence. These variables can interact with population density and potentially influence the spatial distribution of TB cases. Therefore, interpretation of the relationship between population density and TB incidence should consider the possible contribution of these confounding and contextual factors. (CDC, 2024)

Number of Traders

Trade activities increase interaction and communication between traders and customers. However, such interactions carry the risk of TB transmission. During these exchanges, TB mycobacteria may be released into the air and inhaled by nearby individuals (CDC, 2024). In adult social interactions, most contacts occur between adults, which heightens the risk of TB transmission (Horton et al., 2020). The risk factors in trading activities include the duration and frequency of contact. Long-term social contact, rather than the number of contacts, may be the primary factor associated with TB transmission in this population (Amoori et al., 2022). Contact is a critical factor in TB transmission, as approximately 1% of all TB contacts are diagnosed with active TB during screening and require treatment. Furthermore, 20–30% of TB contacts are infected with *M. tuberculosis* and risk developing active TB if latent infection (LTBI) is not diagnosed and treated (CDC, 2014).

Nevertheless, the relationship between the number of traders and TB incidence may also be influenced by additional factors, including workplace ventilation, duration of daily exposure, use of protective behaviors, mobility patterns, and environmental sanitation in market areas. Markets located in densely populated urban centers may further increase transmission risk due to crowding and prolonged interpersonal interactions. Socioeconomic conditions among traders, including income instability, nutritional status, and healthcare-seeking behavior, may also contribute to vulnerability to TB infection and delayed diagnosis (Horton et al., 2020).

Distribution of Private Medical Practitioners

Private physicians often initiate the diagnostic process but, once TB is confirmed, they typically refer patients to TB facilities for treatment (WHO, 2020). Physicians play an important role in reporting suspected TB cases, ensuring patients are identified, treated according to standards, and recorded in the National Tuberculosis Program (NTP) information system. However, challenges in TB case detection by private practitioners include limited time, lack of awareness, outdated knowledge, infrequent visits from health officers, administrative burdens, and fear. In addition, poor coordination between the NTP and the private sector has been identified as one of the main reasons for low TB case notification rates among private practitioners (Rupani et al., 2021). Misaligned private practices may contribute to increased TB drug resistance in the community. For example, private practitioners reported only 34% of TB cases in Bhavnagar District, 25% in India overall, and just 19.1% of suspected TB cases in Surabaya, Indonesia. Data analysis further revealed that physician age, years of practice, and patient volume were associated with their role in TB screening (Yuliandari et al., 2023).

In addition, the distribution of private medical practitioners may not independently determine TB case notification patterns. Several other factors, such as accessibility to public healthcare facilities, availability of diagnostic tools, community awareness of TB symptoms, stigma related to TB disease, and health insurance coverage, may influence patients' decisions to seek treatment and obtain diagnosis. Variations in healthcare infrastructure and reporting systems between regions may also affect the observed relationship between private practitioner distribution and TB incidence (Wiem Lestari et al., 2020).

CONCLUSION AND SUGGESTION

Based on TB case mapping and spatial analysis, the distribution pattern of TB patients in Kuningan Regency formed clusters. There was a spatial autocorrelation relationship between TB incidence and population density, the availability of private practice doctors, and the number of traders. In contrast, the population variable showed negative spatial autocorrelation. This study is expected to serve as a basis for developing policies on District Public-Private Mix TB programs. It is recommended that the District Health Office implement interventions based on these findings to reduce TB transmission

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CONFLICT OF INTEREST

Not Conflict of Interest.

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