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Correlation Study between Population Density and Tuberculosis Incidence at Selogiri Community Health Center Area in 2023

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ABSTRACT

Introduction: Tuberculosis (TB) is an infectious disease that a public health issue both globally and nationally, with high incidence rates including Indonesia. Factors such as drug resistance, population mobility, and decreased vaccination coverage can worsen the situation. One of the influencing factors is population density, transmission through airborne droplets due to the closer proximity of individuals and poor air circulation. In the Selogiri Community Health Center area, the number of TB cases shows a concerning trend, making it important to investigate the relationship between population density and the incidence of TB.
Methods: This cross-sectional ecological correlation study was conducted in the Selogiri Community Health Center area covering a total population of 46,964 people. Secondary data were obtained from TB case reports and demographic data. The analysis used the Pearson correlation test after confirming the assumptions of linearity and normality.
Results: The study shows a positive and significant association between population density and the number of TB cases in the Selogiri Community Health Center area in 2023, with a correlation value of r = 0.825 and p = 0.002. Villages with higher population density, such as Kaliancar and Jendi, recorded a higher number of TB cases compared to villages with lower density. The findings indicate that higher population density is strongly associated with an increased number of TB cases, highlighting the need for special attention in disease prevention and control strategies in densely populated areas.
Conclusion: There is a significant relationship between population density and TB cases in the Selogiri Community Health Center area in 2023; the higher the density, the higher the TB cases.

Keywords: multidrug-resistant; population density; prevention and control; risk factor; tuberculosis incidence

INTRODUCTION

Tuberculosis (TB) is a contagious infectious disease that continues to pose a major public health challenge both globally and nationally. If left untreated or inadequately managed, TB can lead to severe complications and even death, including pleuritis, pleural effusion, laryngitis, and empyema [1]. What is even more concerning is the trend of increasing cases of drug-resistant TB, which exhibits resistance to

one or more anti-tuberculosis drugs (ATDs). The 2023 report on drug-resistant TB documented approximately 450,000 cases in 2022, with a treatment success rate of only 62% [2].

Drug-resistant TB represents a significant threat to global TB control efforts for several reasons. According to the Global TB Report 2023, TB incidence increased by 3.6% from 2020 to 2022, with an estimated 10.6 million new cases reported in 2022 [2]. Epidemiologically, the Southeast Asia region accounts for the highest estimated TB burden worldwide. Indonesia ranks second globally in TB burden, with an estimated 969,000 cases in 2022 an increase from 899,000 in the previous year [2].

In 2023, the number of TB cases in Indonesia reached 983,000, with a case detection rate of 355 per 100,000 population [3,4]. In Wonogiri District, the 2023 TB Program Report from the District Health Office recorded 1,235 TB cases with a detection rate of 197 per 100,000 population [5]. The Selogiri Community Health Center also continues to face challenges in managing TB. Based on Selogiri Community Health Center data for 2023, TB remains one of the most prevalent chronic diseases. According to the 2023 annual TB program report, 80 confirmed TB cases were diagnosed, with 30% occurring among individuals in the productive age group.

High population density facilitates the airborne transmission of *Mycobacterium tuberculosis*, particularly in environments with close interpersonal contact and poor ventilation. According to WHO (2023), an untreated TB patient can infect 10 to 15 people annually. This risk increases by up to 40% in areas with high population density and inadequate air circulation [6].

A concerning development occurred in 2024, marked by a significant increase in TB cases in the Selogiri Community Health Center area, contrary to previous declining trends. Several factors may have contributed to this rise, including: the resumption of social and economic activities following the COVID-19 pandemic, increased interpersonal contact, changes in migration patterns introducing new TB strains to the area, decreased BCG vaccination coverage among infants, and the potential emergence of drug-resistant TB strains. Moreover, improved public awareness and enhanced case reporting systems may have contributed to the recorded increase in incidence. These observations indicate the urgent need for comprehensive research to identify key determinants behind this alarming trend [7–9].

Based on the above background, the research question posed is: Is there an association between population density and tuberculosis incidence in the Selogiri Community Health Center area in 2023? Accordingly, the objective of this study is to analyze the relationship between population density and TB incidence in the Selogiri Public Health Center area.

METHOD

This study employed a quantitative approach with an analytical observational design using a cross-sectional ecological correlation analysis to investigate the relationship between population density and tuberculosis (TB) incidence in the Selogiri Community Health Center area. Data collection was conducted passively using secondary data sourced from two primary databases available at the Selogiri Community Health Center; the 2023 TB case records, which include information on confirmed TB-positive patients residing in the Selogiri Community Health Center coverage area; and the 2023 population data of Wonogiri Regency, which contains records on total population and land area specific to Selogiri. The study population comprised all residents living within the administrative coverage area of Selogiri Community Health Center. The total sample size consisted of 46,964 individuals, determined based on the documented population of the Selogiri area as recorded in the 2023 Wonogiri District demographic data archived at the Selogiri Community Health Center.

The independent variable in this study was population density, while the dependent variable was the incidence of tuberculosis, measured based on the number of confirmed TB cases reported in Selogiri Community Health Center throughout in 2023. Univariate analysis was conducted to describe

the distribution of age, population density, and TB incidence in the study area. Bivariate analysis was performed using Pearson's correlation test to assess the relationship between population density and TB incidence.

RESULT

Table 1. Tuberculosis Cases by Age Group in the Selogiri Community Health Center Area, 2023

No.	Age Category	TB Cases	Non-TB Cases	TB Case Proportion (%)
1.	Infants (<5 years)	20	2107	0,94
2.	Children (5-9 years old)	19	2984	0,63
3.	TeAdolescentsen (10-18 years old)	6	6152	0,09
4.	Adults (19-59 years old)	24	27150	0,08
5.	Elderly (>59 years old)	11	8491	0,12
	Total	80	46884	0,17

*Proportion = (TB Cases / Total Population) × 100

As presented in Table 1, the distribution of tuberculosis (TB) cases in the Selogiri Community Health Center reveals that infants (<5 years) represent the most vulnerable age group. Although the absolute number of TB cases is highest among adults aged 19-59 years, the highest proportion of TB cases relative to the population within each age group is found among infants, at 0.94%. This is followed by the children group (5-9 years) with a proportion of 0.63%, and the elderly group (>59 years) with 0.12%. The proportion of TB cases among adolescents (10-18 years) and adults (19-59 years) is relatively lower, at 0.09% and 0.08%, respectively. These findings suggest that younger age groups, particularly those under five years, require special attention in TB prevention strategies.

Table 2. Tuberculosis Cases by Village in the Selogiri Community Health Center, 2023

No.	Village	TB Cases	Non-TB Cases
1.	Kaliancar	12	6317
2.	Pare	7	4812
3.	Keloran	3	2407
4.	Kepatihan	4	2641
5.	Pule	3	3672
6.	Jendi	14	5559
7.	Singodutan	10	4952
8.	Gemantar	7	3277
9.	Jaten	8	4585
10.	Nambangan	6	5125
11.	Sendangijo	6	3537
	Total	80	46884

Source: Selogiri Community Health Center TB Report, 2023

As shown in Table 2, the distribution of tuberculosis (TB) cases across villages in the Selogiri Community Health Center service area reveals a total of 80 recorded TB cases and 46,884 non-TB residents in 2023. The village with the highest number of TB cases was Jendi, reporting 14 cases, followed by Kaliancar with 12 cases, and Singodutan with 10 cases.

Conversely, the lowest TB incidence was found in Keloran and Pule Villages, each recording only 3 cases. Regarding the non-TB population distribution, Kaliancar Village had the highest number of non-TB residents (6,317), while Keloran Village had the lowest (2,407). These results suggest variation in TB burden between villages, which may be influenced by differences in population density,

housing conditions, mobility, or health service utilization. Further spatial and contextual analysis is needed to explore these disparities and inform targeted public health interventions.

Table 3. Population Density by Village in the Selogiri Community Health Center Area, 2023

No.	Village	Area Region (ha)	Population (Individuals)	Population Density (people/ha)	Category
1.	Kaliancar	325	6329	19.47	Low
2.	Pare	756	4819	14.83	Low
3.	Keloran	686	2410	3.19	Low
4.	Kepatihan	506.1	2645	3.86	Low
5.	Pule	336.8	3675	7.26	Low
6.	Jendi	494.9	5573	16.55	Low
7.	Singodutan	321.5	4962	10.03	Low
8.	Gemantar	295.1	3284	10.21	Low
9.	Jaten	505.2	4593	15.56	Low
10.	Nambangan	326.8	5131	10.16	Low
11.	Sendangijo	556.2	3543	10.84	Low
	Total	5109.6	46964	84.44	

*Based on the Ministry of Public Works and Public Housing criteria

As shown in Table 3, the total area covered by the villages under the Selogiri Community Health Center is 5,109.6 hectares, with a total population of 46,964 individuals in 2023. This results in an average population density of 84.44 persons per hectare across the region.

Kaliancar Village has the highest population count 6,329, followed by Jendi 5,573 and Nambangan 5,131. Conversely, Keloran Village has the smallest population 2,410. In terms of population density, Kaliancar ranks the highest with 19.47 people per hectare, followed by Jendi 16.55 and Jaten 15.56. The lowest population densities are found in Keloran 3.19 and Kepatihan 3.86.

Although all villages fall under the *"low-density"* classification based on national standards issued by the Ministry of Public Works and Public Housing, a closer inspection reveals significant variation between villages. Ordering the data from the highest to the lowest density illustrates demographic disparities that may influence disease transmission dynamics, including tuberculosis. These spatial differences warrant further investigation in the context of TB control and prevention strategies.

Relationship Between Population Density and TB Case Count

Prior to conducting correlation analysis between population density and the number of TB cases, prerequisite tests were performed, including a linearity test using a scatter plot and a normality test using the Shapiro–Wilk method. The scatter plot illustrating the relationship between population density and the number of confirmed TB cases showed a generally linear trend. However, the data points were widely dispersed and did not form a strong linear pattern, indicating a weak linear association between the two variables.

The Shapiro–Wilk normality test produced p-values of 0.695 for population density and 0.453 for TB case count, both exceeding the 0.05 threshold. These results suggest that both variables follow a normal distribution. Given that the assumptions of linearity and normality were met, Pearson's correlation test was deemed appropriate to analyze the relationship between population density and TB incidence.

As shown in Table 4, the Pearson correlation coefficient between population density and the number of confirmed TB cases is $r = 0.825$ with a significance level of $p = 0.002$. A correlation

coefficient in the range of 0.7–0.9 indicates a strong positive relationship, while a p-value less than 0.01 confirms that the correlation is statistically significant. Although the correlation between population density and TB case count was strong (r = 0.825; p = 0.002), this study's cross-sectional design does not allow for causal inference. The findings demonstrate a significant association between the two variables, but not a direct cause-and-effect relationship. Therefore, the results should be interpreted as evidence of correlation rather than causation, suggesting that higher density areas are more likely associated with increased TB cases, potentially due to environmental and behavioral factors.

Table 4. Pearson Correlation Test Results

		Population Density	TB+ Cases
Population Density	Pearson Correlation	1	.825**
	Sig. (2-tailed)		.002
	N	11	11
TB+ Cases	Pearson Correlation	.825**	1
	Sig. (2-tailed)	.002	
	N	11	11

**. Correlation is significant at the 0.01 level (2-tailed).

These results suggest that an increase in population density is strongly associated with a rise in TB case incidence. In other words, as the number of individuals per unit area increases, the number of TB cases also tends to increase.

Previous studies support this finding, showing that the risk of TB transmission is higher in densely populated areas due to several contributing factors:

1. High levels of social interaction, which increase opportunities for transmission [10].
2. Poor ventilation in residential settings**,** which facilitates the survival and spread of *Mycobacterium tuberculosis* in indoor air [11].
3. Aerosol transmission via respiratory droplets released during coughing, sneezing, or speaking, which may persist longer in confined and poorly ventilated spaces [1].

These findings reinforce the importance of considering spatial and environmental factors, such as housing density and air circulation, in TB control strategies.

DISCUSSION

Pearson correlation analysis shows that the higher the population density, the higher the number of recorded TB cases. Jendi Village recorded the highest number of TB cases (14) but only the second-highest population density (16.55 people/ha), while Kaliancar Village had the highest density (19.47 people/ha) yet fewer cases (12). These spatial variations suggest that unmeasured factors—such as housing ventilation, building conditions, or social interaction patterns may also influence TB. This is consistent with epidemiological theory, which states that population density is a factor that facilitates the spread of Mycobacterium tuberculosis due to more intense interactions between individuals and inadequate ventilation conditions. The results of this study are in line with the research conducted by Karyanto et al., (2019), which shows that the level of social interaction and population density increases the risk of TB transmission. They emphasize that in areas with high population density, the incidence of TB tends to be higher due to increased transmission through airborne droplets produced when talking, coughing, or sneezing, as well as poor ventilation [10].

Data from table 1 shows that the adult and elderly age groups have a relatively high proportion of TB cases, which also contributes to the increase in incidence in the region. Research by Sunarmi and Kurniawaty (2022) shows that individual characteristic factors such as age play a more significant role

in the incidence of TB compared to population density factors, although they acknowledge that density can accelerate disease transmission. This indicates that environmental factors and individual characteristics interact with each other in influencing the incidence of TB [12]. In this study, population density showed a very strong and statistically significant correlation with TB incidence ($r = 0.825$; $p = 0.002$), indicating that environmental factors play a crucial role in disease spread. The difference between the two studies may stem from the level of analysis: Sunarmi and Kurniawaty (2022) emphasized individual-level determinants, while the present study highlights community-level or spatial determinants. These perspectives complement each other, suggesting that both environmental and individual factors interact to influence TB transmission. Individuals with greater biological or behavioral susceptibility may be more easily infected in densely populated environments where exposure risk is higher.

Nevertheless, this study has limitations, including the data used being sourced from secondary records which may have limited accuracy and cannot identify other risk factors in depth. Therefore, subsequent studies are recommended to examine other factors such as education level, economic status, and healthy lifestyle behaviors that also influence the incidence of TB.

In general, the results of this study emphasize the importance of controlling environmental and social factors in the effort to control TB, including improving ventilation quality and reducing population density in areas prone to TB cases. Preventive strategies such as immunization, community education, and improving access to healthcare services are important steps to reduce the incidence of TB.

CONCLUSION

Population density was found to be associated with the number of tuberculosis (TB) cases in the Selogiri Community Health Center area in 2023. The higher the population density in a given area, the greater the number of TB cases observed. Villages with relatively higher population densities such as Kaliancar and Jendi recorded a greater number of TB cases, suggesting that densely populated environments may facilitate the transmission of *Mycobacterium tuberculosis*. Public health programs should prioritize TB prevention efforts in densely populated areas by improving housing ventilation, promoting early case detection, and strengthening community awareness to reduce transmission risk.

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CONFLICT OF INTEREST

All the author declare that they have no conflict of interest.

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