The Effect of Population Density on The Risk of Tuberculosis in Densely Populated Environments

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Abstract

Background: Tuberculosis (TB) remains a significant global health challenge, with Indonesia ranking second globally in the number of Tuberculosis cases after India. High population density, particularly in slum areas with poor sanitation, plays a crucial role in facilitating TB transmission. These unhealthy environmental conditions significantly elevate transmission risks, especially in communities struggling with poverty. **Objectives:** This study aims to evaluate the relationship between population density and the risk of TB transmission in overcrowded neighborhoods. **Methods:** A literature review was conducted on studies published between 2019 and 2024, utilizing keywords related to tuberculosis, population density, and densely populated settlements. **Results:** High population density, especially in areas characterized by substandard housing and inadequate ventilation, substantially increases the risk of TB transmission. **Conclusion:** Overcrowded neighborhoods with poor housing conditions significantly contribute to the spread of TB. Addressing these issues through improved housing and sanitation is essential to reduce transmission rates and protect public health.

Keywords: Tuberculosis, Risk Factors, Population Density, Overcrowded Settlements.

Introduction

The World Health Organization (WHO) targeted a 20% reduction in tuberculosis prevalence by 2020. However, in 2021, the reduction achieved was less than 10%. In Indonesia, efforts to eliminate tuberculosis are ongoing, but targeted and sustained efforts are still needed to achieve the target. According to the Indonesian Ministry of Health, the country should be free of tuberculosis by 2035. In 2021, Southeast Asia accounted for nearly half of global tuberculosis cases, totaling 4.82 million or 45.4%. Eight countries were responsible for about 66% of the total global cases, with Indonesia (9.2%) ranked second after India. In addition, there were 969,000 cases of tuberculosis in Indonesia in 2021 according to the Global tuberculosis 2022 report, of which 44% were found in the most populated areas, including East Java, West Java, and Central Java.[1]

The pathogenesis of Tuberculosis begins when nuclear droplets containing *Mycobacterium tuberculosis* (MTB) are inhaled, where most of them are caught in the upper airway and only a small fraction reach the alveoli. Various risk factors can affect a person's susceptibility to these infections. Risk factors for tuberculosis can be divided into several main categories. Individual factors include gender, where men have a higher risk of contracting tuberculosis than women (57.6% of people with tuberculosis) due to heavier workloads and unhealthy lifestyles. Age also plays a role, with a higher prevalence in the adult and elderly groups, especially over 70 years old, who have greater vulnerability due to a decrease in the body's defense mechanisms, of which 78.05% of new cases occur in the age of 15-65 years. Education relates to an individual's understanding of tuberculosis prevention, where sufferers often come from low educational backgrounds Lifestyles, such as smoking and alcohol consumption, are also modifiable risk factors; About 68% of pulmonary tuberculosis patients are active smokers, and alcohol disrupts the immune system, increasing susceptibility to infection. In terms of the environment, air pollution has a significant relationship with the number of tuberculosis cases, while high population density, especially in slums with poor sanitation, contributes to the spread of tuberculosis, with a higher incidence rate in densely populated areas compared to low-density areas. Finally, low economic conditions hinder access to health care and increase the risk of incomplete treatment, contributing to the transmission of tuberculosis, especially in areas with high poverty rates. [2,3,4,5]

The purpose of this study is to evaluate the relationship between population density and the prevalence and spread of tuberculosis cases, especially in densely populated areas such as slums that have poor sanitation and inadequate housing. The study aims to identify the role of population density as a risk factor affecting the increase in the number of tuberculosis cases, as well as provide a more in-depth picture of the distribution of the disease in densely populated areas.

Method

This study uses literature review methods to identify, analyze, and synthesize research relevant to the topic of the influence of population density on the risk of tuberculosis transmission. The literature search process is conducted through several online databases, including PubMed, Google Scholar, and ScienceDirect, with publication criteria between 2019 and 2024. The keywords used in article searches are "Tuberculosis," "Risk Factors," "Population Density," and "Densely Populated Areas." The search results were then filtered based on relevance, data freshness, and availability of information regarding the association between population density and increased incidence of tuberculosis.

After the search and selection process, as many as 11 relevant journals were successfully identified for further analysis. These journals include observational studies, retrospective studies, and research reports on the impact of population density on the spread of tuberculosis in various regions, with a particular focus on urban areas with dense populations and inadequate housing conditions. The analysis of these journals was carried out comprehensively to draw conclusions related to the relationship between environmental conditions, housing density, and the risk of tuberculosis transmission in densely populated areas.

Discussion

Population Density

Historically, population density has been a major concern in housing studies. Occupancy density has been linked to a variety of important outcomes, including physical and mental health, family relationships, child development, educational attainment, and accidents at home. Given the various ways in which occupant density affects people's lives, it is not surprising that this density is associated with many problems, including the spread of infectious diseases. The number and

distribution of the population determines the level of population density in an area, which affects not only the speed of the spread of the disease but also the number of sufferers, especially in the event of sudden changes such as extraordinary events or limitations of health facilities. [67]

Density of Sitting Against Tuberculosis

Areas with high population density, especially in areas with slum dwellings, poor sanitation, and poor nutrition, are more vulnerable to the spread of infectious diseases such as tuberculosis. Crowded environment increases contact between individuals, accelerates disease transmission In addition, inadequate housing conditions become an ideal medium for the spread of tuberculosis germs, where environmental factors such as lack of sunlight, poor ventilation, high humidity, and unhealthy house temperatures contribute to germ resistance. This causes population density to increase the risk of airborne transmission of tuberculosis, as more and more people are susceptible to infection. Previous studies have shown that the incidence of tuberculosis tends to be higher in communities with high housing density, where poor hygiene allows germs to spread faster.[78]

High population density is closely related to an increased incidence of tuberculosis. Based on the research conducted, it was shown Rohman, 2020that in cities with a population density of more than 80 people/km², the incidence of tuberculosis was 4.18 times higher than in cities with lower density (P=0.000), and population density showed significance in univariate analysis. In addition, in the analysis of BTA-positive tuberculosis incidence, population density and other related variables emerged as significant predictors. Tuberculosis disease is spatially distributed in urban areas, with incidence rates ranging from 0.06% to 1.1%, mainly occurring in urban centers (99.3%).[7]

Based on the results of the research conducted, it can be concluded that the number of tuberculosis cases in the working area of the Bandarharjo Health Center in the January-December 2018 period was 46 cases spread across 4 urban villages. Spatial analysis showed that pulmonary tuberculosis cases occurred more in productive age (86.96%) and the majority were found in areas with low population density (69.6%) and high house density (100%). In addition, the areas with the highest level of Underprivileged Families are located in Dadapsari (8 points) and Tanjungmas (22 points) sub-districts, with percentages of 25.89% and 23.52%, respectively. These findings indicate a relationship between population density and the presence of pulmonary tuberculosis cases in the area.Nafsi dan Rahayu, 2020[10]

Higher levels of population density significantly increase the chances of living in sectors with "higher case density," even after adjusting for income and education, with odds ratios of 13.7. The highest case density is strongly related to population density. In addition, higher housing density increases the risk of tuberculosis, while excessive population density significantly increases the likelihood of infection.[9]

Limitations of Health Facilities in Handling Tuberculosis

In areas with high population density, the limitation of health facilities is an important factor that exacerbates the transmission of tuberculosis. Inadequate health facilities, such as health centers and clinics, are often overwhelmed by the high number of patients, especially in densely populated environments. This leads to delays in the diagnosis and treatment of tuberculosis, as well as the lack of long-term treatment monitoring needed to prevent further spread. Research shows that areas with a limited number of health facilities have higher incidence rates of tuberculosis, especially when the facilities are unable to handle the number of patients who exceed capacity [11]. [1]

In addition, the condition of inadequate health facilities in terms of isolation rooms and good ventilation increases the risk of tuberculosis transmission among patients who visit the place. Poor ventilation in waiting rooms and treatment rooms makes it easier to spread Mycobacterium tuberculosis through the air, increasing the risk of cross-infection, especially in densely populated areas with a limited number of health facilities. These limitations demonstrate the importance of improving health infrastructure and a more equitable distribution of medical facilities to reduce the risk of spreading tuberculosis in densely populated areas.

Conclusion

High population density, especially in neighborhoods with slums, poor sanitation, and poor access to nutrition, significantly increases the risk of tuberculosis transmission. Inadequate housing conditions, such as poor ventilation, lack of sunlight, high humidity, as well as unhealthy temperatures, create an ideal environment for tuberculosis germs to survive and spread. The denser an area is, the higher the interaction between individuals, which accelerates the transmission of diseases through the air and increases the risk of infection in the community.

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