Spatial mapping and correlation between healthy home coverage and tuberculosis incidence in Malang district

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ABSTRACT

Background: According to the Ministry of Health, 91% of active tuberculosis (TB) cases in Indonesia occur in crowded and slum areas. The Healthy Homes Program under the Healthy Indonesia Indicators (2010) aims to improve housing conditions in such areas to meet health standards. Malang District, with the second-highest housing density in East Java, ranks fifth in TB cases, suggesting residential exposure as a contributing factor.

Objectives: This study aims to map trends and examine the correlation between healthy home coverage and TB incidence in the Malang District Health Center Working Area 2019-2021.

Methods: The study was conducted in January-April 2023 at the Malang District Health Office with a unit of analysis of 39 health centers. The variables of this study were the coverage of healthy homes and the incidence of BTA-positive pulmonary TB. The study used a mixed ecological study and Pearson correlation test with secondary data from the Malang District Health Office and BPS.

Results: TB incidence showed a decreasing trend alongside increasing healthy home coverage. Nine health centers remained in high-incidence zones, and five exhibited poor housing coverage. Correlation analysis revealed a weak, negative relationship (r = -0.084). High TB incidence was still found in areas meeting healthy home criteria.

Conclusions: The incidence rate of BTA-positive pulmonary TB in the working area of the Malang District Health Center showed a downward trend for 3 years. Future research using individual data and other specific risk factors that may influence TB incidence is recommended.

Keywords: geographic information system, hospital coverage, tuberculosis.

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INTRODUCTION

Tuberculosis (TB) is an infectious disease that is still a public health problem in the world. TB is caused by the bacterium Mycobacterium tuberculosis, which primarily affects the lungs and is transmitted via airborne droplets. The World Health Organization (WHO) has tried to reduce TB's prevalence, incidence, and mortality rates. However, this infectious disease is still the top cause of death globally after COVID-19. The number of deaths from tuberculosis in 2019 was found to be around 1.2 million and has increased in 2020 to 1.3 million deaths (WHO, 2022). Nearly a quarter of the world's population has been infected with tuberculosis, with approximately 89% occurring in the adult and another 11% in children (WHO, 2022). In the Global Tuberculosis Report 2022, Indonesia is included in eight countries that account for two-thirds of the total tuberculosis cases in the world, with an estimated number of TB cases reaching 824,000 and the number of deaths totaling 93,000 or the equivalent of 11 deaths/hour. According to the Director of Communicable Disease Prevention and Control (P2PM) of the Indonesian Ministry of Health, of the estimated % of TB cases in Indonesia, only 49% have been found and treated. This indicates that around 500,000 other people have not been found, putting them at risk of becoming a source of transmission (Kemenkes RI, 2022). East Java Province is recorded as the third highest tuberculosis case nationally, with the number of cases in 2021 reaching 43,247 (Dinas Kesehatan Provinsi Jawa Timur, 2021). Based on BPS East Java data in 2020, Malang Regency was ranked 5th with the highest number of tuberculosis cases, totaling 1,807. In addition, the Treatment Coverage (TC) percentage in Malang Regency is only around 29%, indicating that many TB cases have not been reached by the program (Dinas Kesehatan Provinsi Jawa Timur, 2021).

Tuberculosis cases that have not been fully treated will affect the severity and increase cases due to transmission, where each patient can potentially infect 10 to 15 people (Budi et al., 2018). One of the selected SDGs monitoring TB incidence is ensuring access to adequate, safe, and affordable housing for the proportion of the urban population living in slums, informal settlements, or inadequate housing (WHO, 2022). Living in slums is a risk factor for TB transmission that is associated with disease progression. As many as 91% of active TB cases in Indonesia can be transmitted and attack healthy people around them, especially in slums, dense areas, and poor PHBS (Clean and Healthy Living Behavior) practices (Kemenkes RI, 2022). In a study by Lee et al. (2022), low-quality housing has a higher risk of TB development, which is associated with exposure, transmission, and incidence of TB. Poor housing quality indicates an inadequate indoor environment, such as house density, ventilation, lighting, and humidity. This is also supported by the research of Apriliani et al. (2020), who found that the physical condition of the house, which includes ventilation, roof condition, lighting, occupancy density, temperature, humidity, type of wall and floor of the house showed a relationship with the incidence of tuberculosis in the Simomulyo Health Center working area of Surabaya City.

The physical components of the house are part of the criteria for assessing healthy homes in the Healthy Indonesia Indicator Environment Program 2010. One of the goals of this program is to achieve settlements that meet health requirements in handling slums in urban and rural areas. The Environment Program aims to comprehensively maintain and improve the health of individuals, families, and

communities by creating a healthy environment. Environment or physical environment is an external factor that can cause disease in the community (Mahendrani et al., 2020). The occurrence of environmental shifts can make it easier for bacterial agents to attack the population or make the population vulnerable to disease. In this case, the home environment that interacts constantly with the population becomes a determinant that affects the health conditions of its residents (Purwaningrum et al., 2018). Healthy housing coverage is part of the ecological aspect in describing the quality of settlements in an area (Dewi et al., 2019). Based on Minister of Health's Decree No. 829/Menkes/SK/VII/1999, healthy housing requirements are determined based on the physical components of the house, occupancy density, presence or absence of infectious animals, waste disposal facilities, sanitation, and food storage.

In East Java Province, the Healthy Homes program has not yet reached the national achievement target of 80% (Dinas Kesehatan Provinsi Jawa Timur, 2018). Malang Regency has the second-highest housing density in East Java (BPS, 2019). Hence, health risks and exposures in the home environment must be considered because people spend most of their time at home (Purwaningrum et al., 2018). According to Ministry of Health Regulation 67/2016, control of tuberculosis risk factors is carried out by maintaining and improving the quality of housing and its environment according to healthy housing standards. In this case, housing that does not meet health requirements can be a risk factor for tuberculosis transmission (Wulandari et al., 2015).

Previous studies on housing conditions have primarily focused on specific components associated with the incidence of tuberculosis. Research conducted by Apriliani et al. (2020) showed a significant relationship between the variable components of the physical condition of the house and the incidence of tuberculosis. Hence, a spatial and correlative study of healthy house coverage needs to be conducted. The study of healthy house coverage associated with the incidence of tuberculosis will provide an overview of the quality of housing in an area towards tuberculosis cases in the population as a whole. Puskesmas (Community Health Center), as a unit organizing public health efforts, plays an important role in improving the quality of health status in a promotive and preventive manner. Health services in each region have differences in health organization, but in essence, these efforts have the same goal of improving optimal health status. The health center, which is the subject of direct intervention, is responsible for health maintenance in its working area.

Spatial analysis and correlation of healthy house coverage to the incidence of tuberculosis in the working area of Puskesmas in Malang District has never been conducted. In addition, the healthy housing program, which has a general objective of improving health status, has never been directly linked to the incidence of tuberculosis in the Malang District Health Office. Considering that Malang District is the region with the top 5 highest TB cases and the second densest number of housing settlements in East Java, there is urgency in the research. This study will map and examine the correlation between the coverage of healthy houses and the incidence of tuberculosis in the Malang District Health Center working area in 2019-2021, where there is still no research that analyzes conditions in the last 3 years in aggregate. This study was conducted to determine the trend and level of correlation between the coverage of healthy houses and tuberculosis cases in the working area of the Malang District Health Center, which is expected to provide a preliminary

overview of key determinants of the control program and prevention of tuberculosis transmission in at-risk areas in the future.

METHODS

Study Design and Participants

This study used an observational research method with a spatial approach ecological study design. The ecological study approach was chosen because it can describe the condition and relationship between healthy house coverage and tuberculosis incidence in aggregate at the level of the Puskesmas working area. This approach enables spatial analysis and pattern identification to support area-based public health planning and intervention. In addition, ecological studies are efficient in terms of time and resources because they use secondary data already available in aggregate form.

This ecological study grouped data by location and time to examine using a mixed study to determine trends and describe the correlation with statistical analysis between the independent variable and the dependent variable so that later, it to represent the spatial relationship between healthy home coverage and TB incidence of BTA Positive Pulmonary TB in the Malang District Health Center Working Area in 2019-2021. The subject of this study is the incidence of BTA Positive Pulmonary TB. In contrast, the object of this study is healthy home coverage attribute data and spatial data of administrative maps of the Malang District Health Center working area for the 2019-2021 period. This research was conducted from January - April 2023 at the Malang District Health Office with a unit of analysis of 39 Puskesmas.

Ethical approval statement

This research met the Ethical Clearance test with certificate 081/HRECC.FODM/I/2023, at the Faculty of Dentistry, Airlangga University Surabaya, so that it can be ensured that the research process runs according to health ethical principles and guarantees scientific credibility to the public at large.

Research Instruments

This study's data type is quantitative secondary data using non-test instruments or documentation, which is collected by collecting data archived at the Malang District Health Office and the Malang District Statistics Center. Data on the incidence of BTA-positive pulmonary TB was obtained from the Malang District Health Office P2P Section Report for the 2019-2021 Period. Data on the coverage of healthy homes was obtained from the Malang District Health Office's Community Health Section Report 2019-2021 Period. Population-related data were obtained from the Central Bureau of Statistics of Malang District Annual Report for the 2019-2021 Period.

Data Analysis

The data obtained were then analyzed univariately, bivariately, and spatially. Univariate analysis aims to obtain an overview of each variable's distribution and statistical frequency. The Incidence Rate measure in this study was obtained from the number of incidents of BTA Positive Pulmonary TB divided by the total population of each Puskesmas and multiplied by 100,000 population. In contrast, Healthy Home Coverage was obtained from the number of healthy homes divided by the number of homes per Puskesmas multiplied by 100. Bivariate analysis in this study used the Shapiro-Wilk normality test, which was then carried out with the

Pearson product-moment correlation test. Spatial analysis was conducted with the QuantumQGIS (QGIS) software application program to determine whether there was a spatial relationship between variables. Healthy home coverage was categorized according to the 80% national target (MoH Decree No. 1202/MENKES/SK/VIII/2003) and classified using the Equal Quantile method in QGIS.

The TB incidence data in the study was found to have met the national target of 65 per 100,000 population, so further classification was carried out with the QGIS application. The results of digitized mapping will visually display data on the map in centroid point size and polygon coloring. The centroid visualizes the variable incidence of BTA-positive pulmonary TB with a small size for low TB incidence (<29 per 100,000) and a large size for high incidence (≥29 per 100,000). Then, the coloring on the polygon maps the coverage of healthy homes with red areas for poor coverage (<74%), yellow for medium coverage (≥74%), and green for good coverage (≥80%).

RESULTS

The univariate analysis (Table 1) shows that the average incidence of BTA-positive pulmonary TB in the Malang District Health Center Working Area for 3 years was 28.77 per 100,000 population. In 2019, the minimum value of TB incidence was 14.84 per 100,000 population, and the maximum was 58.62 per 100,000 population. The minimum TB incidence value 2020 was 5.31 per 100,000 population, and the maximum was 54.93 per 100,000 population. In contrast, in 2021, the minimum TB incidence rate was 2.93 per 100,000, and the maximum was 42.95 per 100,000.

Table 1. Statistical Distribution of Incidence of BTA Positive Pulmonary TB and Coverage of Healthy Homes in the Work Area of Puskesmas Malang District in 2019-2021

Variable	Mean	SD	Min-Max	95% CI
Incidence of BTA Positive Pulmonary TB (%)				
2019	33,69	12,00	14,84 – 58,62	29,80 – 37,58
2020	27,75	9,54	5,31 – 54,93	24,66 – 30,85
2021	24,88	8,87	2,93 – 42,95	22,00 – 27,75
2019-2021	28,77	7,95	11,75 – 43,22	26,20 – 31,35
Healthy Home Coverage (%)				
2019	68,81	15,80	17,45 – 97,65	63,69 – 73,94
020	76,79	13,38	32,01 – 98,97	72,45 – 81,12
2021	87,86	11,32	63,33 – 100,00	84,19 – 91,53
2019-2021	77,82	12,08	38,25 – 98,87	73,90 – 81,73

The incidence rate reflects new and relapsed TB cases reported within a specific period (Kemenkes RI, 2016). Nationally, the TB incidence reduction target commitment developed by the Ministry of Health is ≤65 cases per 100,000 population (Kemenkes RI, 2020). This shows that the incidence of BTA-positive pulmonary TB in the work area of the Malang District Health Center is far from meeting the national target. TB control efforts are directed at accelerating elimination and ending the TB epidemic in Indonesia. Thus, the persistence of the TB incidence rate indicates the possibility of close contact cases that could be a risk of transmission. TB case-control in Indonesia is based on the DOTS (Directly Observed Treatment Shortcourse) strategy that focuses on case finding in TB patients (Mayopu, de Fretes, & Tauho, 2022). This strategy implements active and passive case findings of pulmonary TB patients. Active case-finding is done through contact case investigation and screening, while passive case-finding is done when patients visit health facilities.

Implementing the DOTS strategy is highly dependent on infrastructure in the case of pulmonary TB patients (Inayah et al., 2019). The low case-finding rate of pulmonary TB can be caused by a surveillance system that is not yet strong, the lack of capacity to diagnose the disease, and the lack of community access to health services (Rejeki et al., 2019).

In the Healthy Indonesia Indicators 2010, the target percentage of healthy homes is 80%. The average coverage of healthy homes in the Puskesmas work area of Malang District for the last 3 years in Table 1 is 77.82%, with the highest coverage in 2021 at 87.86%, followed by 2020 at 76.79% and the lowest in 2019 at 68.81%. In 2019, the minimum value of the percentage coverage of healthy homes was 17.45%, and the maximum was 97.65%. The minimum value of healthy home coverage in 2020 is 32.01%, with a maximum value of 98.97%. Meanwhile, in 2021, the minimum value is 63.33%, and the maximum is 100%. This indicates that healthy home coverage in Malang District has not fully met the national target. A healthy home refers to the physical structure of a dwelling, the extent to which it structurally enables physical health by providing shelter from elements of humidity, temperature, sanitation, lighting, and sufficient space capacity (WHO, 2018). Housing suitable for living must meet health requirements to protect residents and the community from danger or health problems. Poor housing conditions will cause health problems and disease transmission (Budi et al., 2018). Research conducted by Susanna & Achmadi (2019) states that assessing healthy homes in the field is only done on several houses. The high and low percentage of healthy homes is influenced by the condition of the assessed house (Olivionita et al., 2022). The conditions of the COVID-19 pandemic have also impacted health services at the Puskesmas. The existence of a pandemic causes changes in the internal policies of each Puskesmas in running the program (Hasanah et al., 2020). Special management strategies are sought to ensure the quality of health services and protect the community and health workers from exposure to COVID-19.

Mapping the Distribution and Trends of Incident Cases of BTA Positive Pulmonary TB

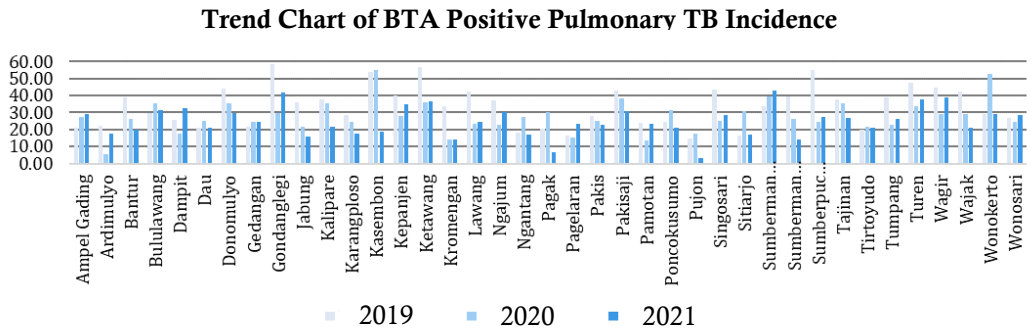

Figure 1. Trend Chart of BTA Positive Pulmonary TB Incidence in the Work Area of Malang District Health Center in 2019-2021

Figure 1 shows trends in the incidence of BTA-positive pulmonary TB per 100,000 population in 39 health centers in Malang District 2019-2021. There is a decrease in TB incidence from year to year in most areas. From the analysis, only 3 Puskesmas experienced an increase in cases, 11 Puskesmas decreased, and 25 others fluctuated and tended to decrease. This shows that the trend of BTA Positive Pulmonary TB incidence cases in the Puskesmas work area of Malang District in 2019-2021 tends to

decrease. Based on the data obtained, the CNR rate in the Malang District Health Center's work area decreased during 2019-2021 by 37%. The Covid-19 pandemic has caused a decrease in the number of new cases of TB in Indonesia. During the pandemic, Indonesia globally accounted for nearly 20% of the new TB case notification reduction (WHO, 2022).

Research by Cilloni et al. (2020) states that tracking patient contacts in discovering new TB cases is hampered during the Covid-19 pandemic. This is because resources related to all aspects of the healthcare system are maximized and focused on handling the pandemic (Damaranti et al., 2023). These limitations have an impact on TB management programs that were previously routinely carried out to be hampered. The transfer of TB diagnostic tools used for COVID-19 testing hindered case finding, thus affecting the decline in TB case notification (Togun et al., 2020). In addition, the implementation of regional quarantine causes people to delay visits to health facilities, which causes delays in TB diagnosis (Kant et al., 2021).

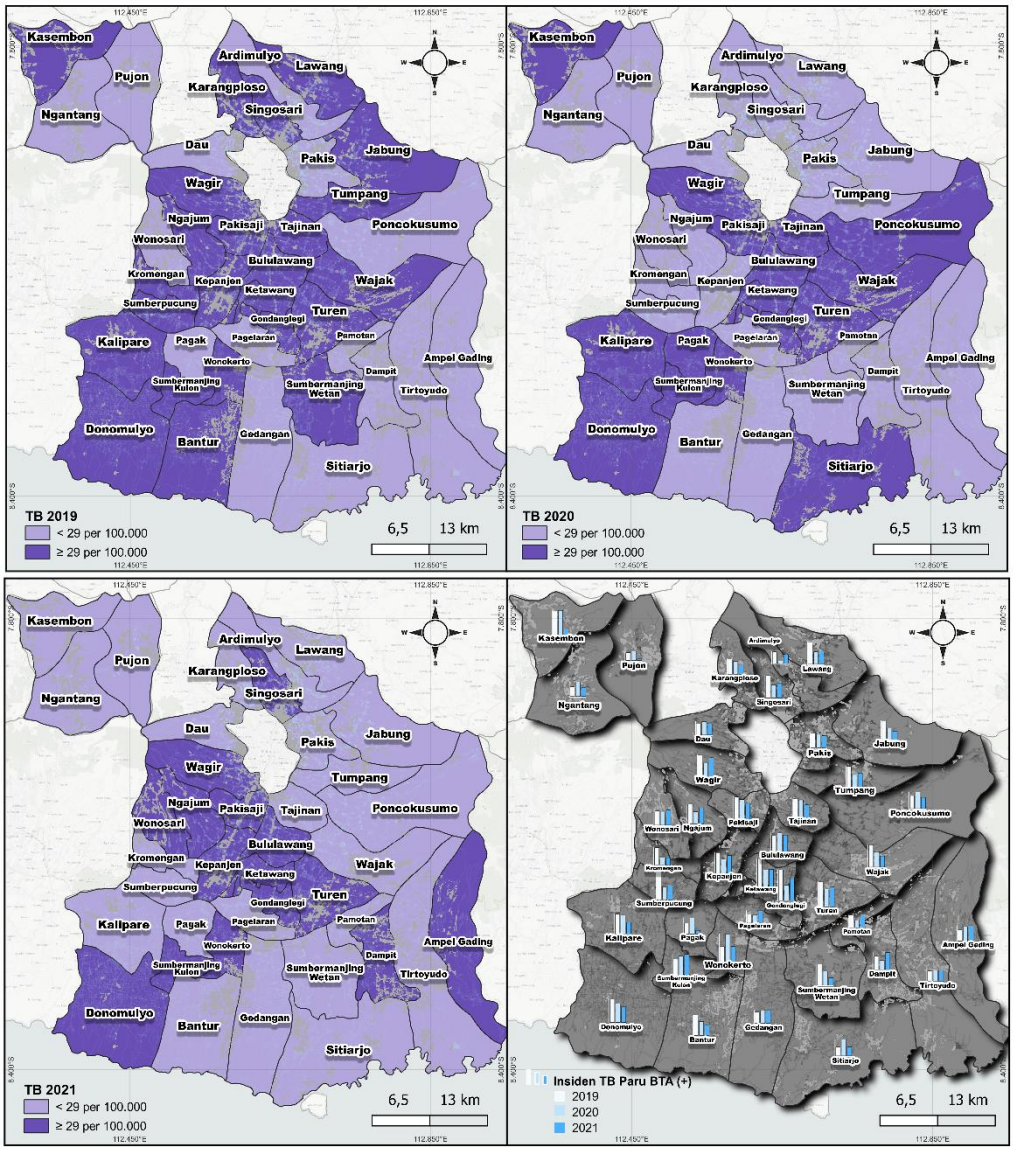

Figure 2. Mapping the Incidence of BTA Positive Pulmonary TB in the Work Area of Malang District Health Center in 2019-2021

Referring to Figure 2, concentrated zones indicate a high concentration of cases, while bright zones indicate low cases. The distribution of high-incidence cases of BTA-positive

pulmonary TB in 39 Puskesmas in Malang District is characterized by areas that have more concentrated zones (≥29) and low cases with lighter zones (<29). In 2019 (a), 24 Puskesmas were in the high case zone, and 15 Puskesmas were in the low case zone. By the end of 2021, areas with high case zones will be reduced to 15 health centers and low case zones to 24 health centers. The results show that the condition of the BTA Positive Lung TB Incident in Malang District has gradually improved from year to year. 9 Puskesmas are always in the high incidence zone, including Puskesmas Gondanglegi, Bululawang, Donomulyo, Ketawang, Pakisaji, Sumbermanjing Kulon, Turen, Wagir, and Wonokerto. The population distribution pattern in these nine areas has a higher productive age group population composition than other areas. According to the Ministry of Health, TB cases are primarily found in the productive age group (Kemenkes RI, 2023). This is because the productive age group has high mobility and social interaction compared to other age groups, allowing tuberculosis transmission (Pramono, 2021). Most of the 9 Puskesmas areas are also rural (Hardiyanti et al., 2018; Wijayanti et al., 2019). In Indonesia, the findings of perceived ease of access to health centers in urban communities are easier than in rural areas. According to Radandima et al. (2020), treatment coverage in urban areas will be easier regarding access to health services. Some of these Puskesmas have SPM percentages of less than 70%. These percentages indicate that the achievement of Puskesma's performance in providing standard services for people suspected of TB is not optimal. The severity of the disease affects the quality of life of the patient. This disease requires attention and care from various sectors to improve treatment compliance so that patients' quality of life is improving, reducing the risk of transmission.

Mapping Distribution and Trends in Healthy Home Coverage

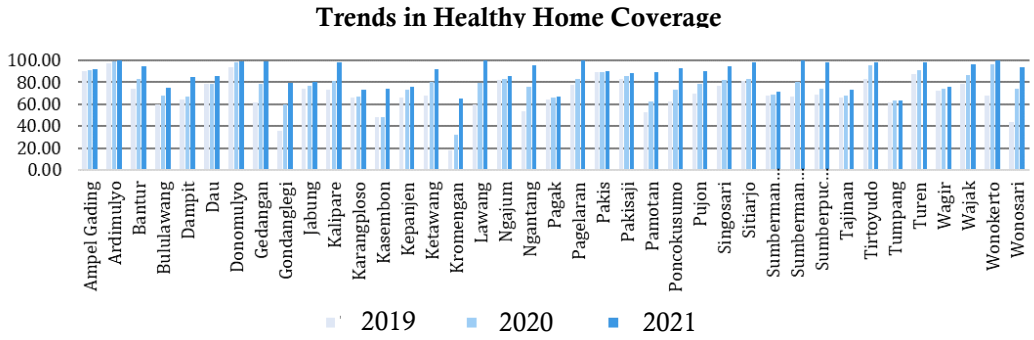

Figure 3. Trend Chart of Healthy Home Coverage in Puskesmas Work Areas in Malang District in 2019-2021

Based on Figure 3, the coverage of healthy homes in the Puskesmas work area of Malang District in 2019-2021 shows an overall increasing trend. Puskesmas Ardimulyo is the Puskesmas with the highest coverage of healthy homes from year to year, reaching 100%. In 2021, Puskesmas Lawang also reached the maximum coverage, followed by five other Puskesmas (Gedangan, Donomulyo, Wonokerto, Pagelaran, and Sumbermanjing Wetan). The analysis shows that the trend of healthy home coverage continues to increase yearly. This trend is due to the increase in the number of houses enrolled in the program in each Puskesmas in procuring the healthy home program. The number of houses fostered in 2020 was 92,244, which will increase to 100,926 in 2021. Good public knowledge of healthy homes will influence a higher chance of having a home meeting health requirements (Suwita, Syafri, & Fahri, 2019). A better level of knowledge will shape community behavior and support the achievement of healthy home criteria.

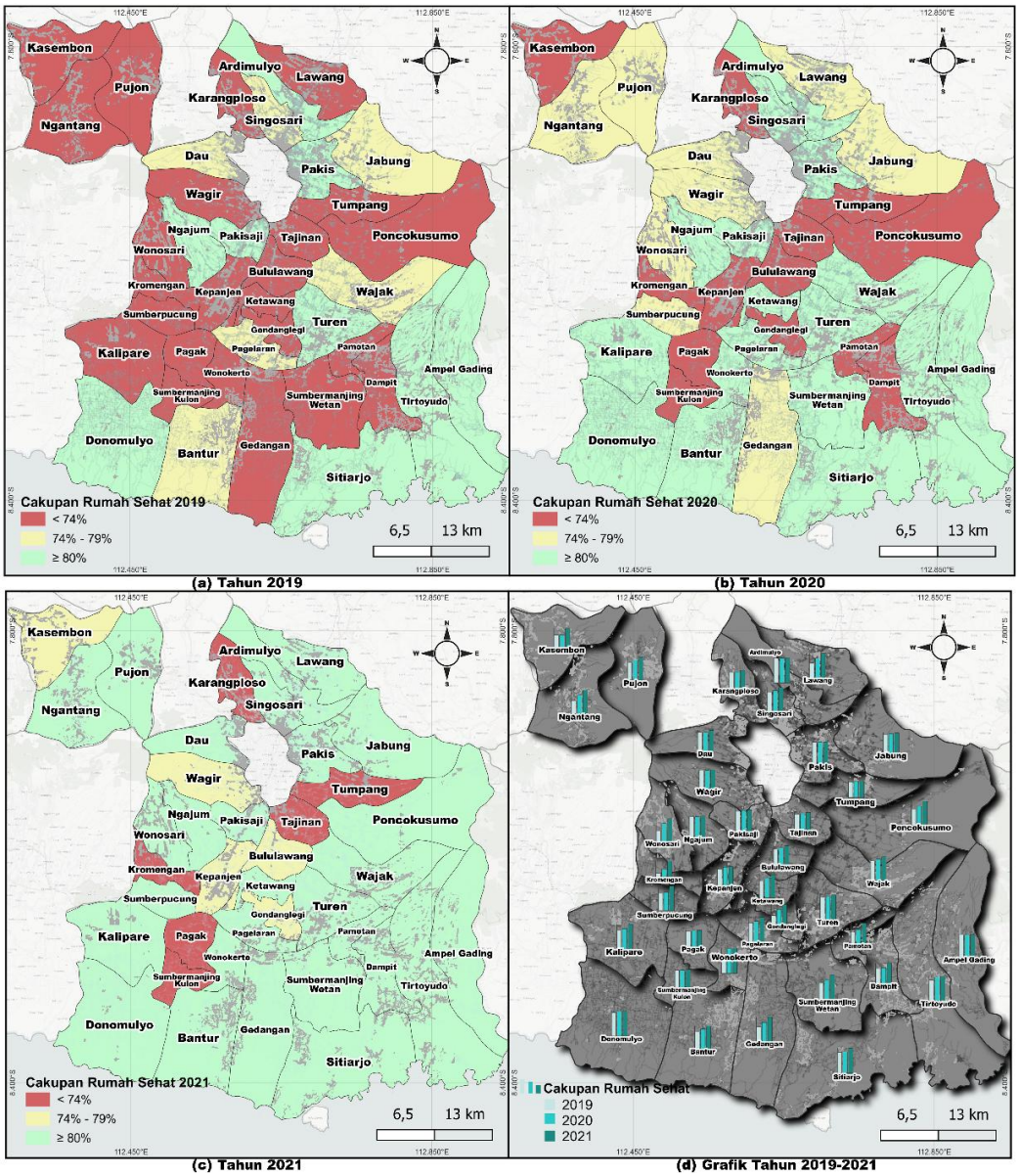

Figure 4. Mapping the Distribution of Healthy Home Coverage in the Health Center Work Area of Malang District in 2019-2021

The distribution of healthy home coverage mapping is categorized into three levels, namely, red (poor), yellow (medium), and green (good) zones. In 2019, the coverage of healthy homes in the Puskesmas working area of Malang Regency was dominated by the red zone, where there were 24 areas in poor condition, 6 in moderate condition, and 9 in good condition. The reduction of the red zone occurred in 2020 when there were 12 areas in poor condition, 12 in moderate condition, and 15 in good condition. An almost complete melting of the green zone was detected at the end of 2021, with 27 areas in good condition, seven in moderate condition, and five in poor condition. Areas in the poor zone for 3 years include Kromengan, Pagak, Sumbermanjing Kulon, Tajinan, Tumpang, and Karangploso health centers. These areas have high settlement densities. The population growth rate changes the environmental quality level in urban areas. Rapid population growth creates a greater need for space, resulting in uncontrolled settlements, illegal dwellings, or slums. This causes a decline in the quality of settlements, especially in urban areas. Farizki and Anurogo (2017) state that dense areas have poor settlement quality. Dense

settlements result in narrow road access, worsening air circulation, and poor lighting quality.

Relationship between Healthy House Coverage and Tuberculosis Cases

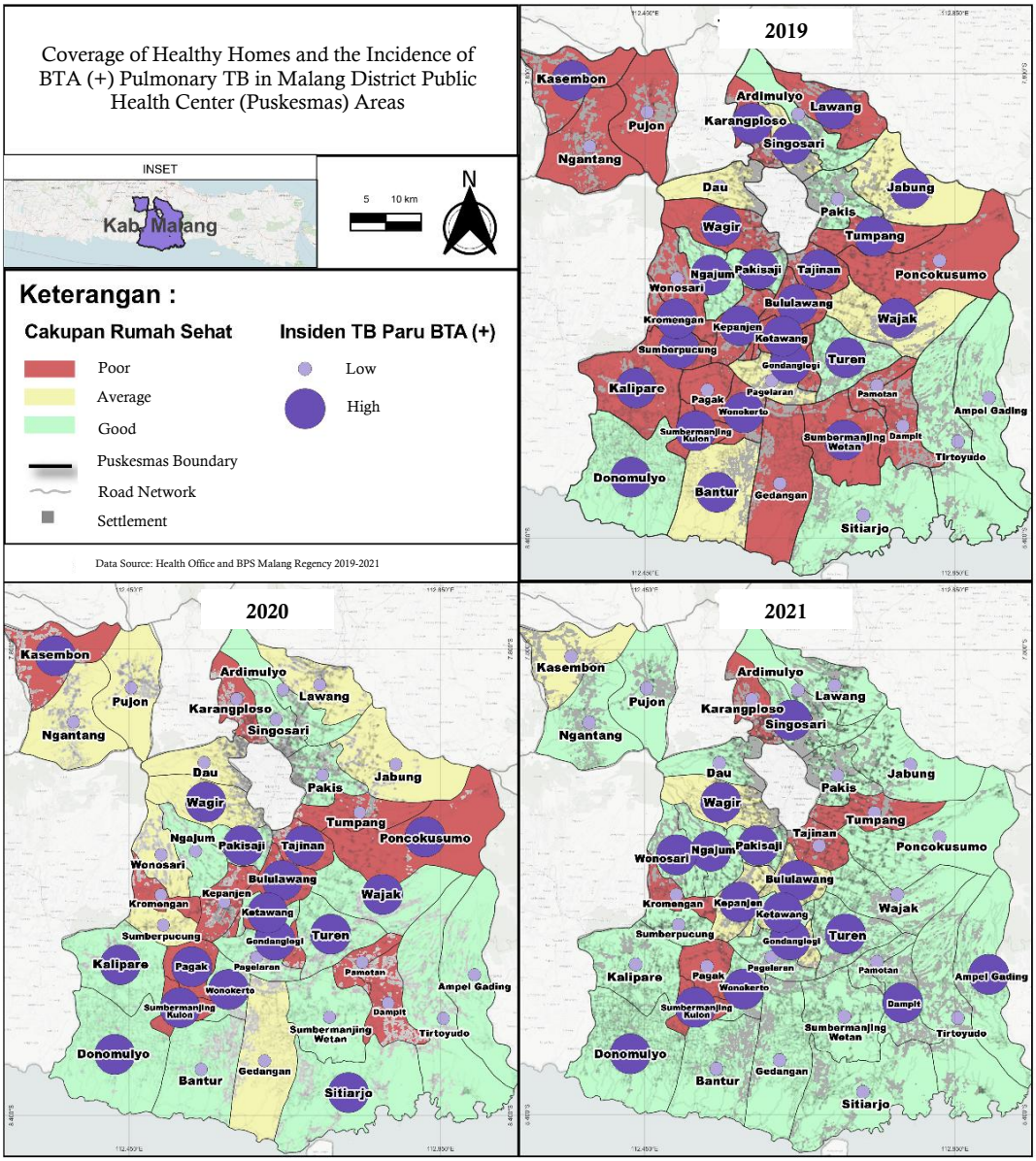

Figure 5. Spatial Analysis of Healthy Home Coverage on the Incidence of BTA Positive Pulmonary TB in the Work Area of Malang District Health Center in 2019-2021

Figure 5 shows that the distribution of zones of high TB incidence cases dominates many areas of coverage of healthy homes that meet the requirements. A study by Lee et al. (2022) stated that poor-quality housing has a higher risk of TB development associated with exposure, transmission, and TB incidence. High case zones in this study were found more in health centers with good coverage of healthy homes. Zones of high-incidence cases in eligible housing coverage were found in areas close to each other and densely populated with poor housing coverage. Population density and mobility that do not go hand in hand with awareness of preventing pulmonary TB transmission have become a problem in countries with high populations. Prolonged contact and exposure is a risk of transmission to 10-15 other people. The Puskesmas

that is of particular concern in this study is Puskesmas Sumbermanjing Kulon, which has poor house coverage and high incidence from year to year.

According to the CDC (2013), four factors determine the probability of transmission: susceptibility, transmission rate, environment, and exposure. The transmission level is directly related to the number of TB bacilli released into the air. Patients who emit many bacilli are more infectious than patients who emit few or no bacilli. Long duration of exposure, frequency of continuous exposure, and proximity result in a high risk of transmission. Proximity to the patient is also a transmission factor related to population density and occupancy. Afifiani, Wardani, and Kristini's (2021) research shows that TB incidents' distribution pattern gathers in high-density areas. This may be due to the proximity of houses. High housing density is associated with a greater risk of TB, while high population density can significantly increase the occurrence of infection (Rohman, 2020). This high incidence may also be supported by the topographic conditions of Malang Regency, which is a highland area surrounded by mountains and hills so that temperature, air humidity, and oxygen density can further affect the viability of Mycobacterium Tuberculosis (Hartanto et al., 2019).

Table 2. Correlation of Healthy Home Coverage with the Incidence of BTA Positive Pulmonary TB in the Puskesmas Work Area of Malang District in 2019-2021

Year	Sig. Value	Correlation Coefficient (r)
2019	0,399	-0, 139
2020	0,890	0,023
2021	0,518	0,107
2019-2021	0,609	-0,084

From the results of the Pearson correlation test (Table 2), it was found that there was no significant relationship between the coverage of healthy homes and the incidence of BTA Positive Pulmonary TB in the working area of the Malang District Health Center in 2019 (Sig value = 0.399), 2020 (Sig value = 0.89), and 2021 (Sig value = 0.518). The correlation between the coverage of healthy homes and the incidence of BTA-positive pulmonary TB during the 3 years showed weak strength and negative relationship direction (r = -0.084).

DISCUSSION

The direction of this relationship indicates that the higher the coverage of healthy homes, the lower the incidence of BTA-positive pulmonary TB. This aligns with research by Susanna & Achmadi (2019), which found no significant relationship between healthy home coverage and TB incidence. Referring to the previous graph, the trend of both variables shows that the coverage of healthy homes is improving, followed by a low incidence of TB. However, from the classified distribution, Puskesmas working areas with good house coverage with high incidence are more than those with low zones. Then, some areas with poor house coverage are in the low incidence category. The spatial analysis results show no relationship between the coverage of healthy homes and the incidence of BTA Positive Pulmonary TB in the Puskesmas Working Area of Malang District.

Based on research by Apriliani et al. (2020), the physical conditions of the house that affect the proliferation of TB bacteria include occupant density, lighting, ventilation, flooring, humidity, and temperature. However, this may be due to the

fact that not all indicators of healthy home coverage are directly related to TB incidence.

This study is limited to Temporal Ambiguity, where the results cannot prove that the exposure preceded the disease. The secondary data used in the study makes limited information from existing data. The results of population-based or aggregate ecological studies cannot represent each individual, so the presence or absence of a relationship at the population level is not necessarily the same at the individual level. However, this study can serve as a strategy for policymakers to determine which health centers should focus on strengthening TB management and intensifying TB case findings. Puskesmas needs to detect, monitor, and treat TB cases in the long term. Capacity building for TB services such as drug distribution and increasing and training the number of health workers and drug swallowing supervisors at risk health centers is very influential in eliminating TB cases (Amaliyah & Wahyono, 2021). The involvement of health workers and community groups such as cadres and PMOs contributes to increasing awareness and knowledge about TB, so the mapping in this study helps determine achievement targets at each Puskesmas. The PHBS (Clean and Healthy Lifestyle) program intervention seeks to empower the active role of each household in practicing clean and healthy living behaviors (Natsir, 2019). Advocacy, community development, and community movement approaches in PHBS can improve knowledge, attitudes, and behaviors, optimizing the quality of health in each Puskesmas. Community involvement in efforts to practice PHBS plays a role in helping to prevent TB transmission.

Limitations of the study

However, this approach has some limitations. One of them is the possibility of ecological fallacy, which is an error in concluding at the individual level based on the results of group data analysis. This means that the relationship found at the aggregate level may not necessarily reflect the same relationship at the individual level. Therefore, the results of this study cannot be used to infer individual causal relationships between housing quality and TB risk; it can only be used as an initial overview to support policymaking and prioritization of interventions in high-risk areas.

CONCLUSIONS

The findings of this study, from both trend and spatial analyses, show that while the coverage of healthy homes tends to increase, the incidence of TB does not always decrease significantly in all regions. These findings suggest that while housing conditions contribute to TB risk, they do not independently account for observed transmission patterns, highlighting the need to consider broader social and behavioral determinants. This result is consistent with the social ecology theory of public health, which states that determinants of health include structural, environmental, and individual behavioral factors. Therefore, it is important to consider the interaction between various determinants in understanding the spread of TB in a region.

DATA AVAILABILITY

The data used in this study are secondary data obtained from the Malang District Health Office and the Malang District Statistics Center Agency for the 2019-2021

period. The data is not publicly available but can be accessed upon reasonable request by the correspondence author with permission from the agency that owns the data.

FUNDING

This research did not receive external funding.

CONFLICT OF INTEREST

The authors declare that there is no potential conflict of interest in conducting this research or in preparing this scientific article.

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