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New Approach to Mapping Regional Vulnerability in Controlling Tuberculosis in Indonesia

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Abstract

Tuberculosis (TB) is still a health problem in Indonesia because its prevalence ranks second in the world after India in 2023. Regional factors, inadequate health facilities, and limited resources (financial, human, and infrastructure) are challenges requiring innovation to help the government control TB. TB eradication efforts need to be made with a comprehensive and effective approach. One method used is to look at the vast territory of Indonesia; therefore, mapping the vulnerability of TB is highly recommended. Using a Geographic Information System is expected to help map the TB vulnerability areas in Indonesia. Given several epidemiological, socio-geographic, and environmental factors influencing TB, the question arises of how to map TB vulnerability areas in Indonesia. This study used a cross-sectional design, secondary data was collected from several sources, and a vulnerability analysis was performed by considering several socio-environmental epidemiological variables. Furthermore, after the analysis, the TB area vulnerability category would be obtained along with a map of TB vulnerability areas in Indonesia according to regional and district analysis units. This study produces a TB susceptibility index and map for Sumatra, Java-Bali, and other regions in Indonesia.

Keywords: Geographic Information System, Indonesia, tuberculosis vulnerability

Introduction

The problem of tuberculosis (TB) in Indonesia from year to year has not shown any decrease in morbidity and mortality rates. According to the 2023 Global TB report, Indonesia was ranked second with the highest prevalence in the world.[1] The Indonesian Ministry of Health has made various control efforts in this matter.[2] However, the problem of TB is not only a problem between diseases or agents in humans, but TB is a complex problem like other infectious diseases, where apart from the epidemiological elements considered, other elements are no less important. Health development cannot be separated from the health system, where all elements must be considered, including system components and several other influencing factors.[3]

Indonesia has a very large area of 5,193,250 km^2, starting from Sabang City at 95°E and Merauke District at 141°E (6°N-11°S and 95°E-141°E) and Weh Island (6°N) to Rote Island (11°S), with regional topography covering land and sea. Indonesia has a land area of 1,919,440 km^2 and 17,580 islands spread throughout the country, both from geographical locations located on two large continents (Asia and Australia) and two oceans (Pacific and Indian). Geomorphology, which includes various surface forms (lowlands, highlands, and mountains), will affect temperature, plant types, and mineral content, affecting population density and infrastructure development.[4] The TB eradication efforts in this regard need to be made with a comprehensive and effective approach. One method to use is to look at the vast territory of Indonesia; therefore, mapping TB vulnerability is a highly recommended method.[2,5] Mapping TB vulnerability aims to identify areas which are vulnerable to increased morbidity and mortality due to TB, so that prevention and control efforts for the disease

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can be carried out appropriately and efficiently.

Remote sensing-based TB vulnerability analysis uses data and information from satellite imagery and remote sensing technology.[6-8] It should be emphasized that remote sensing is one of the input and process variables in this study and does not stand alone. Other variables used in this study are epidemiology, social, environment, health services, and TB programs. Host epidemiological data are utilized to identify TB carriers or individuals, including characteristics of age, sex, occupation, diabetes mellitus, HIV/AIDS, exposure to cigarette smoke or smoking habit, household contact with TB patients, and other variables used in the study, as described in the method section. If available, several variables can utilize spatial information, such as population density, access to health services, and the environment.[9-15] After all input variables are obtained, either with remote sensing or other data support, a TB vulnerability modeling analysis will be carried out with district analysis units throughout Indonesia.

The benefits of remote sensing-based TB vulnerability analysis in Indonesia are (1) identifying areas at high risk of spreading TB; this can help the government through the Ministry of Health in efforts to control the disease effectively; (2) planning interventions and monitoring and evaluation programs for controlling TB, then making comparisons after intervention; (3) Geographic Information System (GIS) makes it possible to integrate data from various sources, including environmental and social health data, demographics, and geography. This allows for comprehensive and accurate analysis of influential factors to the spread of TB; (4) combining data and conducting TB control vulnerability modeling analysis, then visualizing the data in the form of maps, which makes it easier to understand and communicate information to stakeholders. The existing TB vulnerability mapping can help identify areas with high TB incidence so that control efforts will be targeted, effective, and focused on these areas.

Method

This study applied a cross-sectional approach. Secondary data analyzed were data coming from the 2023 TB Information System, 2023 Indonesia Health Survey, 2018 Indonesian Basic Health Research, 2019 Health Facility Research, 2019 Facilities and Infrastructure, 2023 Statistics Indonesia, and 2023 Meteorological, Climatological, and Geophysical Agency, with city/district analysis units in Indonesia. Apart from host variables already mentioned in the previous section, there were also agent variables, including TB-causing bacteria: drug-resistant TB bacteria and drug-sensitive TB bacteria.

Environmental data was utilized to examine risk factors for TB, such as physical and social environments (temperature, humidity, sunlight, or air particulates), income level, poverty, slum housing, families living in healthy homes covering the housing density, sanitation, and air quality around the house, ownership of social security, and ownership of health insurance. Health services included the availability and readiness of health services, as well as population access to TB health services in the area. Intermediate and output indicators of the TB program in the Ministry of Health (in this study referred to as the Micro TB program) were financing (2023 TB Information System), TB governance/leadership (2023 TB Information System), logistics (2023 TB Information System), information systems (2023 TB Information System), screening of suspected TB patients, detection of Acid-Fast Bacilli (AFB) + TB patients, treated TB patients, TB patients who failed treatment (default), success rate (cure rate), and re-treated TB cases, drug-resistant TB cases starting second-line treatment, TB-HIV patients receiving antiretroviral (ARV) during TB treatment, the number of TB cases found in prisons or detention centers, number of children under five years of age receiving INH preventive treatment, TB cases found and reported by the community or community organizations, case notification rate (CNR) treated, coverage of treatment of all cases, coverage of detection of resistance cases, and success rate of treatment of drug-resistant TB patients, percentage of TB patients who knew their HIV status, financing (2023 TB Information System), TB Management/Leadership (2023 TB Information System), case detection rate (CDR), CNR, and Cure Rate.

Univariate analysis was performed on each variable to determine the distribution of the variables studied. Bivariate analysis was performed to determine the relationship between two variables and calculate OR using a 2 x 2 table at a confidence level of 0.05 and a confidence level of 95%. ($\alpha = 0.05$). Furthermore, risk or vulnerability analysis was conducted on each group or latent variable to create a map with a district analysis unit.

Results and Discussion

Since studies on TB vulnerability have not been found as a weakness of this study, a vulnerability determination method was used by following the steps applied to several vulnerability analyses conducted by the Regional Agency for

Disaster Management. It turns out that, for some remote sensing data, there was no support for this study; therefore, a mapping with the help of GIS was made so that later this data would be used as initial data for geospatial field monitoring. The results of this study are expected to obtain several values, which include host vulnerability to TB, vulnerability to TB, environmental vulnerability to TB, vulnerability to TB health services in Indonesia, and vulnerability to TB programs in Indonesia.

In host vulnerability, several studies mentioned people of productive age, men, people with TB contact, people with diabetes mellitus, people living with HIV or AIDS, and people with cigarette exposure.[12–15] While the vulnerability of the population to agents in Indonesia is a group of drug-sensitive and drug-resistant, it could be one or even several drug types.[13] Environmental vulnerability could be physical environment, such as exposure to air pollution. This could be caused by fuel used for cooking or outdoor environments continuously polluted, socioeconomic groups vulnerable to TB, for example, living in unhealthy houses, slums, or densely-populated settlements, poor population groups, and residents receiving assistance or social security. There are still differences in several indicators from several agencies, so when mapping input, a version will be created according to the indicators created by each agency.[13–15] Due to the vulnerability of health services to limited data completeness, the data processing results are health services and health centers. In the TB program, some TB successes will be influenced by logistics, finances, and several other constraints, which will be very interesting to discuss in more depth. Furthermore, a vulnerability map is made, which is expected to be considered in policy-making for TB control in Indonesia.

Conclusion

Vulnerability analysis using sensing, which is one of the input variables, is it not the only one? This is an important step in TB eradication in Indonesia and allows to identify areas with high levels of vulnerability and estimated factors for possible interventions applied to reduce vulnerability. The TB eradication program in Indonesia is expected to be successful and become a possible alternative to be implemented in Indonesia with proper implementation.

Abbreviations

TB: tuberculosis; GIS: Geographic Information System; CNR: case notification rate.

Ethics Approval and Consent to Participate

Ethics Approval on Health Research No. 128/KE.03/SK/07/2024.

Competing Interest

The authors declare that there is no conflict of interest.

Availability of Data and Materials

Not applicable.

Authors' Contribution

MHH is the researcher and idea originator/initiator; AH checks variables; D seeks references; HS for the writing completion; AA searches publications and references; MRK and MH observe far sensing and create a map; R, K, NEP, and DB making operational definition; CTP and MNFS analyzing service availability and readiness assessment for health services; YB, NEWS, DL analyzing the host and agent data.

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