Development of an Evidence-Based Tool to Assess the Relative Vulnerability of Different Communities to Tuberculosis

Slamet Isworo
Department of Environmental Health, Faculty of Health Sciences, Universitas Dian Nuswantoro, slamet.isworo@dsn.dinus.ac.id

Sri Handayani
Department of Public Health, Faculty of Health Sciences, Universitas Dian Nuswantoro, sri.handayani@dsn.dinus.ac.id

Reece Hinchcliff
School of Applied Psychology, Griffith Health Group, Griffith University, r.hinchcliff@griffith.edu.au

Zainal Arifin Hasibuan
Faculty of Computer Science, Universitas Dian Nuswantoro, zhasibua@dsn.dinus.ac.id

Follow this and additional works at: https://scholarhub.ui.ac.id/kesmas

Recommended Citation
Isworo S, Handayani S, Hinchcliff R, Hasibuan ZA. Development of an Evidence-Based Tool to Assess the Relative Vulnerability of Different Communities to Tuberculosis. Kesmas. 2023; 18(4): -
DOI: 10.21109/kesmas.v18i4.7357
Available at: https://scholarhub.ui.ac.id/kesmas/vol18/iss4/6

This Original Article is brought to you for free and open access by UI Scholars Hub. It has been accepted for inclusion in Kesmas by an authorized editor of UI Scholars Hub.
Development of an Evidence-Based Tool to Assess the Relative Vulnerability of Different Communities to Tuberculosis

Slamet Isworo1, Sri Handayani2*, Reece Hinchcliff3, Zainal A Hasibuan4

1Department of Environmental Health, Faculty of Health Sciences, Universitas Dian Nuswantoro, Semarang, Indonesia, 2Department of Public Health, Faculty of Health Sciences, Universitas Dian Nuswantoro, Semarang, Indonesia, 3School of Applied Psychology, Griffith Health Group, Griffith University, Queensland, Australia, 4Faculty of Computer Science, Universitas Dian Nuswantoro, Semarang, Indonesia

Abstract

Identifying specific tuberculosis (TB) vulnerabilities in populations based on their geographical, demographic, and epidemiological characteristics is an essential yet challenging requirement to help reduce and eliminate TB. Assessment tools that can accurately quantify the risks associated with key factors could be used to measure TB vulnerability efficiently and indicate the most appropriate range of interventions. This study aimed to develop TB vulnerability assessment tools based on a TB vulnerability assessment conceptual framework developed with Leximancer. Three steps to produce the tools were facet analysis, interpreting the facet to create a list of questions, and expert judgment to confirm the suitability of the questionnaire. The “everything is data” principle was used to identify the data sources and build the tools. The data came from multiple primary data sources, with a questionnaire survey and observational form, and secondary data from various governmental statistical departments in Indonesia to collect data related to demography, health indicators, climate, temperature, and air quality. These tools will be optimized at scale next year to evaluate their utility for prioritizing and prescribing health system responses to TB in different communities in Central Java Province.

Keywords: big data, Leximancer, tuberculosis, vulnerability assessment

Introduction

The World Health Organization released the End TB strategy to eliminate tuberculosis (TB) in 2055. The strategy aims to reduce TB incidence to 90%, reduce TB death-related diseases by 95%, and protect families from negative impacts.1 As of 2022, the target is still far from achieved as the reduction of TB incidence has only reached 10%, death-related TB has only reduced by 5.9%, and 48% of people with TB face catastrophic health expenditure.2 At the same time, countries with a high burden of TB, such as Indonesia (second highest TB incidence globally), also face additional challenges related to high rates of TB-HIV and TB multidrug resistance.2

Indonesia’s TB control strategy for 2020-2024 focuses on finding and curing cases through integrated public–private mixed programs and strengthening diagnostic tools.3 The TB control strategy has been implemented in every city/district in Indonesia, producing variable outcomes.3 Previous studies have found significant variations in TB risk and outcomes based on the characteristics of communities residing in geographically defined areas.4-6 The implication is that to accelerate the End TB goal in Indonesia, specific interventions need to be developed and delivered based on each community’s unique level and type of TB vulnerability.7 Even though the vulnerability measurement based on an individual was developed, identifying specific TB vulnerabilities based on area is challenging as no specific guidance is available. Other factors include lacking practical tools and methods to support these efforts and variable access to the required data types.8

Developing TB vulnerability assessment tools that quantify the risks associated with unique factors within different communities may facilitate the accurate and efficient measurement of TB vulnerability and guide more effective health and social welfare interventions. Previous studies have proposed strategies to measure TB vulnerability only based on individual factors.8,9 Another study has measured TB vulnerability by solely relying on social factors analysis.10 Based on a prior evidence synthesis project,11 a framework to measure TB vulnerability based on geographical area was developed. This study aimed to extend that body of work by developing specific tools to measure TB vulnerability based on the previous-
ly-created TB vulnerability framework. This study would provide tools to measure the vulnerability of TB in the community and a guide to prioritize and prescribe health system responses to TB based on different risk factors in communities. The use of several concept components in the concept framework allows the comprehensive exploration of the risk factors and helps to establish robust tools for measuring vulnerability based on geographical area.

Method

The TB vulnerability assessment conceptual framework has five components: risk of TB transmission, damage caused by TB, available health facilities, TB burden, and TB awareness. These components required data from individual and health facilities–based data. The individual-based data were the risk of TB transmission (including the level of knowledge, environmental condition, and individual susceptibility), the damage caused by TB (economic impact and social support), and TB awareness (TB literacy). The health facilities–based data were TB burden (the number of TB cases) and the number of health facilities available in the area. The framework was built with Leximancer, a software under the license of Queensland University of Technology (QUT) Australia that uses machine-learning techniques to perform quantitative content analysis. The use of Leximancer as automatic content analysis helps data processing visualize conceptual maps by generating main concepts within the text and determining how they are related. Leximancer enables the analysis of more data more frequently.

While the output of the Leximancer analysis showed a collection of the most relevant concepts related to TB risk and reduction, along with their interconnections, these insights could not initially be directly converted into a questionnaire or any other tool that could be used practically to guide TB vulnerability assessment and reduction activities.

To extend this work, three further steps were undertaken to develop methodologically rigorous and practically useful tools: facet analysis, formulation of tools (a questionnaire, an observational form, and a secondary data list), and expert judgment. Facet analysis was undertaken to interpret concepts and translate them into tools (a questionnaire, an observational form, and a secondary data list) to measure each framework component. The resulting concepts were then organized into a logical classification to build a hierarchical structure. Several alternative methods were also undertaken to develop a facet: drawing from Leximancer’s topic guide as it is (clear description), structuring several concepts into a make-sense facet (need analysis), and digging deeper into sub-concepts to attain the meaning (need deeper analysis). The three alternatives were used when the concept was built with a more complex meaning of the sub-concept.

A questionnaire was developed in the second stage by interpreting the context created in the facet. One or more assertions were related to each context. The facet not only performed on the theme but also analyzed the quotation result. The questionnaire was created with a series of assertions, a Likert scale asking respondents how much they agree with each statement, and “yes” or “no” answers to knowledge questions. The type of respondent target for each setting and survey topic was likewise carefully examined. This process was repeated until every potential context for each candidate dimension had been discussed. A second analysis examined each question representing each prospective dimension to avoid making repetitive claims. The end outcome was a distributed array of statements for each potential dimension.

This procedure was repeated until each theme’s potential contexts had been examined. Further analysis was done to eliminate the likelihood of redundant responses by comparing each theme’s questionnaire statements. Based on the component’s candidates (risk of TB transmission, damage caused by TB, health facility, TB burden, and TB awareness) created in the previous stage, the resulting statements were automatically sorted into groups. This study employed additional clustering techniques to identify new representable groupings with synchronized and explicit concepts or dimensions. These results aligned with grouping questions with the least amount of redundancy.

In the third step, five experts were invited to evaluate the critical components that resulted from the facet analysis. These experts consist of three lecturers with at least four years of TB research experience until 2022; the lecturers were experts on TB study related to management and intervention. Two worked in the TB field in the Semarang City (Central Java Province, Indonesia) health office, with at least six years of experience until 2022. These two experts were the head of the TB program and the field chief of the TB intervention program in the Semarang City health office. The experts were invited to a meeting, informed of the results of the measurement tools (questionnaire, observation form, and secondary data form), and asked to select each list of questions represented in each TB vulnerability assessment tool component (risk of TB transmission, damage caused by TB, health facility, burden of TB, and awareness of TB).

Results

Figure 1 shows the sample of facet analysis results, for example, how the facet regarding health facilities built the context of services, facilities, systems, and policy. Besides creating the theme for the analysis output,
Leximancer produced quotations based on the paper analyzed. Table 1 outlines the quotation analysis used to build a context conclusion. For example, the quotation “… Treatment completion is understood to depend, in part, on immigrant knowledge and attitudes toward latent TB infection (LTBI)…” concludes as level of knowledge context. This result was part of the facet analysis using quotation analysis.

Table 2 shows how the context conclusion is defined (Table 1), and the list of questions and data sources are built. For example, the level of knowledge has three list topics for questions and can be gathered through the survey. The final result of the tools produced three instruments: a questionnaire, an observational form, and a secondary data form (Table 5).

Table 4 presents the observational form for collecting primary data on tuberculosis vulnerability assessment, while Table 5 provides a list of secondary data sources required to measure tuberculosis vulnerability assessment (see below). Table 5 lists the secondary data sources that will be used to supplement the primary data and provide additional insights into tuberculosis vulnerability.

**Discussion**

This study showed how to measure TB vulnerability with a big data approach to enable the prioritization of specific interventions. The assessment tools produced in this study were based on the big data concept (data gathered from multiple sources) with the principle that “everything is data.” While novel to Indonesia, this approach has been applied commonly for disease prevention and control in China and various other countries.
demonstrating its utility for efficiently and effectively detecting infectious and chronic diseases.\textsuperscript{17} The study’s findings revealed that big data analytics applications have been beneficial in managing chronic diseases in different stages and could potentially ease the burden of chronic illnesses. Big data analytics have demonstrated the ability to extract insight from massive data sets and improve out-
The tools outlined in this study will be able to measure disease burden and, through subsequent action, lower the burden and reduce the cost of prevention and treatment. Compared to existing instruments, the tools created in this study focused not only on specific factors but also on measuring the complex parameters that can increase the chance of TB transmission. These tools will be able to provide a broader view of risk factors related to TB transmission and combine the analysis with machine learning to give more insight into how all the factors in combination increase the TB vulnerability of communities. A previous tool was provided only for measuring vulnerability in specific conditions related to individual or social vulnerability. That has a high chance of failing to acknowledge and account for other factors that may contribute to vulnerability, such as environmental conditions.

Concerning TB prevention at both the global and national levels, one size does not fit all. The mapping of geographical vulnerability, enabled through the tools developed in this study, will help TB program managers identify specific risk factors and build a bespoke array of interventions to decrease TB transmission in specific communities. For example, an education program could be the priority in areas with low TB knowledge, and community engagement may need to be increased in communities with high TB stigma. The same approach has been successfully applied to the education field, resulting in seven clusters of students and providing different interventions based on the risk of each cluster.

One potential bias that might occur in this study was cognitive bias, where the experts’ prior knowledge and experience in TB study and intervention might influence their evaluation of the measurement tools. There could also be confirmation bias if the experts only select questions or components that align with their preexisting beliefs or assumptions about TB vulnerability. To minimize the bias, the experts were provided with clear instructions for evaluating the measurement tools and encouraged to base their decisions on available evidence rather than personal opinion or experience. Additionally, a diverse group of experts from various backgrounds was consulted to ensure a broader perspective. Future study is required to explore the validity of the instruments and the framework component in measuring the degree of vulnerability of TB in communities. The big data approach and end-to-end methodology will be used for future investigation.

Conclusion
The application of big data, data linkage, and machine learning has the potential to greatly strengthen current approaches to identifying and reducing TB in vulnerable communities. While the project findings contribute to the increasing body of evidence and practical tools that can facilitate this goal, there are several limitations: there are few expert participants, and the tools have not yet been utilized for policy development purposes, impeding the ability (at this stage) to rigorously determine their validity and reliability, in practice. Future studies are underway to address this limitation.

Abbreviations
TB: Tuberculosis; LTBI: Latent Tuberculosis Infection.

Ethics Approval and Consent to Participate
This study was approved by the Institutional Review Board of Universitas Negeri Semarang (No. 315/KEPK/EC/2023) and performed following the principles of the Declaration of Helsinki. Informed consent was waived because of the retrospective nature of this study.

Competing Interest
The authors declared that there are no significant competing financial, professional, or personal interests that might have affected the performance or presentation of the work described in this manuscript.

Table 4. Observational Form of Tuberculosis Vulnerability Assessment

<table>
<thead>
<tr>
<th>Subject</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humidity</td>
<td>Numeric</td>
</tr>
<tr>
<td>Temperature</td>
<td>Numeric</td>
</tr>
<tr>
<td>Ventilation condition</td>
<td>Bad</td>
</tr>
<tr>
<td></td>
<td>Good</td>
</tr>
<tr>
<td>Floor condition</td>
<td>Soil</td>
</tr>
<tr>
<td></td>
<td>Tile</td>
</tr>
<tr>
<td></td>
<td>Carpet</td>
</tr>
<tr>
<td>Building condition</td>
<td>Permanent</td>
</tr>
<tr>
<td></td>
<td>Semi-permanent</td>
</tr>
<tr>
<td></td>
<td>Wood</td>
</tr>
<tr>
<td>House density</td>
<td>Numeric</td>
</tr>
</tbody>
</table>

Table 5. Secondary Data List for Tuberculosis Vulnerability Assessment

<table>
<thead>
<tr>
<th>Data</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poverty level based on city</td>
<td>Statistics Indonesia</td>
</tr>
<tr>
<td>Population density based on city</td>
<td>Statistics Indonesia</td>
</tr>
<tr>
<td>Number of clinics based on city</td>
<td>Health Office</td>
</tr>
<tr>
<td>Number of doctor practices based on city</td>
<td>Health Office</td>
</tr>
<tr>
<td>Number of pharmacies based on city</td>
<td>Health Office</td>
</tr>
<tr>
<td>Number of other health facilities based on city</td>
<td>Health Office</td>
</tr>
<tr>
<td>Incidence of tuberculosis based on city</td>
<td>Health Office</td>
</tr>
</tbody>
</table>

Availability of Data and Materials
The datasets are not publicly available but are available from the corresponding author upon reasonable request.

Authors’ Contribution
Conceptualization: SI, ZAH, SH; Data curation: SH, ZAH, SI; Formal analysis: all authors; Funding acquisition: SI, SH; Investigation: SI, SH; Methodology: SH, ZAH, RH; Project administration: SH; Resources: RH; Software: RH; Supervision: RH; Validation: ZAH; Visualization: SH; Writing—original draft: SH, SI; Writing—review and editing: all authors.

Acknowledgment
This study was supported by the Research Grant “Program Hibah Penelitian Fundamental Reguler DIKTI,” Ministry of Research, Technology and Higher Education, of the Republic of Indonesia. Contract number 065/A38-04/UDN-09/VII/2023.

References