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Predictors of Pulmonary Tuberculosis Prevention in Surabaya, Indonesia

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ARTICLE INFO	**ABSTRACT**
	Background: Pulmonary tuberculosis (TB) continues to pose a critical public health challenge in Indonesia, characterized by high transmission rates, particularly within household settings. Despite extensive efforts to mitigate the spread of TB, persistent barriers such as low adherence to prevention and treatment protocols hinder progress. Identifying the factors that influence adherence is essential to optimizing the efficacy of intervention strategies. This study aims to investigate the key predictors influencing adherence to preventive measures for pulmonary TB transmission in Surabaya City.
	Methods: A quantitative research design employing a cross-sectional approach was utilized. Data were collected from 225 pulmonary TB patients attending community health centers in Surabaya City between September and December 2023. The variables examined included demographic characteristics, perceived benefits, barriers, susceptibility, severity, and self-efficacy. Statistical analysis was conducted using multiple logistic regression, with significance set at $p<0.05$. **Results:** Significant predictors of adherence included age (p=0.048; OR=0.413), gender (p=0.009; OR=0.328), socioeconomic status (p=0.033; OR=3.052), perceived benefits (p=0.009; OR=10.086), barriers (p=0.007; OR=0.704), and self-efficacy (p=0.005; OR=29.335). Patients aged above 45 years, those reporting higher perceived benefits, and those with greater self-efficacy demonstrated higher adherence to TB prevention measures. These findings underscore the importance of self-efficacy, perceived benefits, and socioeconomic factors as significant determinants of adherence. The study's contribution lies in its exploration of adherence predictors within a high-risk population, offering valuable insights to inform targeted public health interventions. **Conclusion:** Age, perceived benefits, barriers, and self-efficacy emerged as critical predictors of adherence to pulmonary TB prevention strategies in Surabaya City. Interventions aimed at strengthening self-efficacy and providing targeted educational programs for younger populations are recommended to enhance TB control efforts. Additionally, integrating these findings into broader public health frameworks, such as national TB control strategies, can amplify their impact and contribute to improved health outcomes

INTRODUCTION

Pulmonary Tuberculosis (TB) remains a significant public health challenge, with approximately one-third of the global population infected with Mycobacterium tuberculosis. The disease is transmitted through airborne particles, primarily when infected individuals cough and release bacteria into their surroundings. Previous studies, such as those conducted by Sreeramareddy et al. (2013), indicate that most TB transmissions occur within household

settings (1, 2). This highlights the low public awareness regarding preventive measures necessary to halt the spread of pulmonary TB. Consequently, a sound understanding and perception of TB prevention are critical in reducing the transmission of this disease.

Globally, pulmonary TB continues to impose a heavy health burden. According to the Global Tuberculosis Report 2023, Indonesia recorded approximately 1,060,000 pulmonary TB cases in 2023, with an annual mortality rate of 134,000. The Ministry of Health reported a 77% increase in TB case detection in 2023, totalling 820,789 cases, including 134,528 paediatric TB cases. Despite ongoing efforts, challenges such as low treatment adherence, underreporting, and insufficient preventive practices persist, contributing to the continued spread of TB within families and communities (3, 4).

The Health Belief Model (HBM) serves as a theoretical framework for analysing health behaviours, focusing on individual perceptions of disease severity, susceptibility, and the benefits of preventive actions. Previous research has demonstrated that various factors, including age, education level, socioeconomic status, and self-efficacy, significantly influence TB patients' adherence to treatment (5-10).

However, among these factors, limited research has investigated the most critical predictors influencing adherence to preventive measures for pulmonary TB transmission in specific regions. Identifying these predictive factors is crucial for improving community health and survival, as well as providing evidence-based foundations for public health interventions. Understanding these predictors will enable the design of more effective interventions to enhance TB control at both individual and community levels. Given the scarcity of recent research on predictors of adherence to TB prevention, this study addresses the critical gap in understanding by analysing the factors influencing adherence to pulmonary TB prevention in Surabaya City. It focuses on identifying key predictors such as demographic characteristics, perceived benefits, barriers, and self-efficacy, which are vital for designing targeted and effective public health interventions. The primary research questions guiding this study are: What demographic and psychological factors significantly influence adherence to pulmonary TB prevention measures? How do perceived benefits and barriers shape individual behaviours toward TB prevention? What role does self-efficacy play in promoting adherence to preventive measures? By enhancing our knowledge of these predictors, this research aims to contribute to reducing TB transmission rates and informing policy improvements for TB control at the community and national levels.

METHOD

This study employed a quantitative design with a cross-sectional approach to analysed predictive factors influencing adherence to preventive measures among pulmonary tuberculosis (TB) patients. The participants included 225 pulmonary TB patients registered at public health centre's in Surabaya City. Data were collected between September 1 and December 30, 2023, from participants meeting the inclusion criteria, which included willingness to participate, being in the intensive or continuation phase of TB treatment, and being diagnosed with multidrug-resistant TB (MDR-TB).

Data on independent variables were collected using structured questionnaires covering demographic information, constructs of the Health Belief Model (HBM), and adherence behaviour. The instruments used included: Demographic Characteristics Questionnaire: Age: Categorized as 26–35 years, 36–45 years, and >45 years. Education: Categorized as low (elementary school), medium (junior and senior high school), and high (diploma, undergraduate, and postgraduate degrees). Gender: Classified as male or female. Ethnicity: Categorized as Javanese, Madurese, and Batak. Socioeconomic Status: Classified based on income into < IDR 1,000,000, IDR 1,000,000–3,000,000, and > IDR 3,000,000. HBM Questionnaire: Perceived Benefits: Comprising 10 questions with indicators on medical and psychosocial benefits of undergoing TB treatment. Perceived Barriers: Comprising 10 questions on practical and psychological barriers experienced during TB treatment. Perceived Severity: Comprising 10 questions with indicators of the severity of TB, both immediate/gradual and short-term/long-term impacts. Perceived Susceptibility: Comprising 10 questions with indicators including personal risk perception, awareness of risk factors, concern about disease likelihood, relative susceptibility, prior disease experiences, understanding of early symptoms, and social or informational context. Self-Efficacy Scale: Adapted from Bandura (2006). Pulmonary TB Adherence Scale: To measure adherence to pulmonary TB prevention behaviours.

To ensure the validity and reliability of the variables in this study, several validation procedures were applied to the instruments used for data collection: Content Validity The structured questionnaires were reviewed by a panel

of experts in public health, epidemiology, and behavioural science to ensure that the items accurately represented the constructs being measured (e.g., demographic characteristics, Health Belief Model constructs, and adherence behaviours). The questions were aligned with established theoretical frameworks, such as the Health Belief Model (HBM). Construct Validity The scales for Perceived Benefits, Perceived Barriers, Perceived Severity, Perceived Susceptibility, and Self-Efficacy were developed based on validated models and adapted to the context of TB prevention. For example, the Self-Efficacy Scale was adapted from Bandura (2006) to capture domain-specific confidence in TB prevention behaviours. Pilot Testing The instruments were pretested on a small sample from the target population to identify any ambiguities, cultural biases, or difficulties in comprehension. Feedback from this pilot test was used to refine the questions and improve their clarity and cultural relevance. Reliability Testing The internal consistency of each scale was assessed using Cronbach's alpha to ensure that the items measuring the same construct were highly correlated. A Cronbach's alpha value of ≥0.7 was considered acceptable for reliability. Face Validity The questionnaires were evaluated for readability and comprehension by members of the target population to confirm that the items were straightforward and understandable. Scoring and Classification Responses to items in each construct were scored and categorized to facilitate analysis. For example: Age, education, gender, ethnicity, and socioeconomic status were categorized to allow for group comparisons. Responses for HBM constructs (e.g., perceived benefits, barriers, severity, and susceptibility) were scored on a Likert scale, with higher scores reflecting stronger perceptions in each domain. Adherence Scale Validation the Pulmonary TB Adherence Scale was validated by comparing its outcomes with behavioural observations and self-reported adherence measures. This cross-validation ensured that the scale effectively captured actual preventive behaviours. By employing these validation procedures, the study ensured that the variables and constructs measured were both accurate and relevant for understanding adherence to pulmonary TB prevention measures.

Data were analysed to identify predictors influencing TB prevention adherence among patients at public health centres in Surabaya City using multiple logistic regression. The level of significance was set at $p < 0.05$. The informed consent form included statements ensuring participants could withdraw at any time, that data would be used exclusively for research purposes, and that participants' anonymity would be protected. Voluntary informed consent was obtained from all participants following a thorough explanation of the study.

Detailed documentation of the study protocol, data collection tools, and analysis methods ensures that the research can be reproduced by future studies. Data were anonymized and stored securely, with access limited to the research team, enhancing data integrity and participant confidentiality. These efforts collectively enhance the rigor of the study, minimize biases, and strengthen the validity and reliability of its findings, contributing to a robust evidence base for public health interventions targeting TB prevention adherence.

Ethical Approval

This study was approved by the Ethics Committee of Muhammadiyah University (Surabaya, Indonesia; 0414/KEPK/2023).

RESULTS
Characteristics of Pulmonary Tuberculosis Patients in Surabaya City (n=225)

Table 1 outlines the characteristics of respondents, including variables such as age, gender, education, ethnicity, socioeconomic status, perceived benefits, perceived barriers, perceived severity, perceived susceptibility, self-efficacy, and adherence to pulmonary TB prevention measures. Age: The majority of respondents (64.4%) were over 45 years old. Gender: The largest proportion of respondents were male, accounting for 55.6%. Education: Most respondents (55.6%) had a medium level of education, including junior high school and senior high school/vocational school. Ethnicity: The majority (57.8%) of respondents identified as Madurese. Socioeconomic Status: Respondents with incomes exceeding IDR 3,000,000 formed the largest group, accounting for 51.1%. Perceived Benefits: A positive perception of benefits was reported by 77.8% of respondents. Perceived Barriers: Positive perceptions regarding barriers were observed in 82.2% of respondents. Perceived Severity: Positive perceptions of severity were reported by 77.8% of respondents. Perceived Susceptibility: Positive perceptions of susceptibility were reported by 77.8% of respondents. Adherence to Prevention Measures: The majority of respondents (71.1%) demonstrated high adherence to TB prevention measures. Adherence to Treatment: High adherence to treatment was observed in 88.9%

of respondents. These characteristics highlight the demographic and psychosocial factors influencing TB prevention and treatment adherence among respondents in Surabaya City.

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Table 1. Distribution of Respondents Based on Age, Gender, Education, Ethnicity, Socioeconomic Status, Perceived Benefits, Perceived Barriers, Perceived Severity, Perceived Susceptibility, and Self-Efficacy among Pulmonary Tuberculosis Patients in Surabaya, Indonesia (n = 225)

Categories	Frequency	Percentage
Age (year)		
26-35	25	11.1
36-45	55	24.4
>45	145	64.4
Gender		
Male	125	55.6
Female	100	44.4
Education		
Elementary school	75	33.3
Junior and senior high school	125	55.6
diploma, undergraduate, and postgraduate degrees	25	11.1
Ethnicity		
Javanese	90	40.0
Madurese	130	57.8
Batak	5	2.2
Socioeconomic Status		
< IDR 1,000,000	35	15.6
IDR 1,000,000–3,000,000	75	33.3
> IDR 3,000,000	115	51.1
Perceived Benefits		
Negative	50	22.2
Positive	175	77.8
Perceived Barriers		0
Negative	40	17.8
Positive	185	82.2
Perceived Severity		
Negative	50	22.2
Positive	175	77.8
Perceived Susceptibility		
Negative	50	22.2
Positive	175	77.8
Self-Efficacy		
Low	50	22.2
High	175	77.8
Adherence to Transmission Prevention		
Low	65	28.9
High	160	71.1

Multivariate Analysis of Predictive Factors for Transmission Prevention Among Pulmonary Tuberculosis Patients in Surabaya City

The final analysis, utilizing multivariate logistic regression, is presented in Table 2. The results indicate significant predictors associated with adherence to TB transmission prevention measures. The following factors were identified: p-value = 0.048, OR = 0.413 for age; p-value = 0.009, OR = 0.328 for gender; p-value = 0.033, OR = 3.052 for socioeconomic status; p-value = 0.009, OR = 10.086 for perceived benefits; p-value = 0.007, OR = 0.704 for perceived barriers; and p-value = 0.005, OR = 29.335 for self-efficacy. These findings demonstrate significant

relationships between these predictors and the quality of life among patients undergoing haemodialysis for kidney failure

Table 2. Factors Influencing Transmission Prevention Among Pulmonary Tuberculosis Patients in Surabaya City (N=225)

Factors	Unstandardized Coefficients		Sig	Exp (B) (OR)
	B	Std. Error		
Age	0.885	0.766	0.048	0.413
Gender	1.113	1.095	0.009	0.328
Education	0.201	0.657	0.060	1.223
Ethnicity	1.662	1.171	0.056	5.268
Socioeconomic Status	1.116	0.742	0.033	3.052
Perceived Benefits	2.309	1.315	0.009	10.086
Perceived Barriers	0.351	1.437	0.007	0.704
Perceived Severity	1.563	1.414	0.069	0.209
Perceived Susceptibility	0.074	1.452	0.959	1.077
Self-Efficacy	3.379	1.197	0.005	29.336

DISCUSSION

The multivariate analysis results show a significant relationship between age and adherence to prevention measures. Most respondents in this study were over 45 years old, a demographic that often possesses experience and problem-solving skills in managing diseases. This maturity encourages them to be more vigilant about their surroundings, particularly family members, to prevent infection. Age reflects cognitive maturity shaped by past experiences and indicates that individuals have reached a state where physiological or organ maturity enables better decision-making in health-related situations (11, 12).

Gender was also found to influence adherence to pulmonary TB prevention. This factor impacts adherence through biological, psychological, social, and cultural dimensions. Women tend to exhibit higher adherence due to heightened risk perception, social roles emphasizing health care, and greater access to information. However, individual variations within each gender must also be considered. Conversely, ethnicity and education did not consistently influence adherence to prevention measures, as these factors are indirect and mediated by other variables. Adherence is more closely linked to individual motivation, risk perception, trust in health information, and access to healthcare services.

Socioeconomic status or income influences adherence to prevention by affecting resource access, risk perception, and psychosocial pressures. Individuals with higher incomes are more likely to have the awareness, resources, and capacity to prioritize preventive actions than those with lower incomes. Health programs addressing socioeconomic factors could help bridge disparities in health outcomes (11, 12).

Perceived benefits and perceived barriers were found to have significant relationships with adherence to pulmonary TB transmission prevention. Perceived benefits play a critical role in motivating adherence when individuals believe the advantages of preventive actions outweigh perceived barriers. Barriers such as high costs, discomfort, or limited access to healthcare facilities can reduce motivation, even when preventive actions are highly beneficial. Perceived benefits can enhance perceived value, not only in terms of health protection but also through long-term cost efficiency and positive impacts on close relations. Moreover, they instill a sense of security, encouraging confidence in maintaining health. On the other hand, perceived barriers can lower motivation or create doubts, particularly when individuals lack adequate information or face logistical and psychological challenges (13-16).

Conversely, perceived severity and perceived susceptibility do not always influence adherence to disease prevention due to mechanisms such as defensive denial or risk normalization, distrust in the effectiveness of preventive measures, and the dominance of social, cultural, or logistical factors. The lack of influence from perceived severity may be attributed to individuals who downplay the seriousness of the disease to avoid excessive fear or anxiety (defensive denial). Additionally, uncertainty about consequences plays a role, as not everyone understands

the implications of the disease in the same way. Even when aware of the severity, individuals may fail to perceive a direct link between preventive actions and the reduction of adverse outcomes. Furthermore, a belief in the inadequacy of preventive measures can lead to non-adherence; some individuals might feel that, despite the seriousness of the disease, certain preventive actions are insufficiently effective, diminishing their motivation to comply.

Similarly, perceived susceptibility is influenced by several factors. For example, unrealistic optimism often leads individuals—especially younger or healthier ones—to believe they are "unlikely" to contract a particular disease, even when objective risks are high. Risk normalization is another factor, where individuals view the risk of illness as a normal part of life, reducing their perceived need for preventive actions. Perceived susceptibility that is too low or too high can also undermine adherence. When susceptibility is perceived as too low, individuals may believe their lifestyle or genetics protect them from illness, negating the need for preventive measures. Conversely, when susceptibility is perceived as excessively high, individuals may feel the disease risk is unavoidable, rendering preventive actions futile and leading to non-adherence (17-19)

Self-efficacy plays a critical role as a predictor of adherence to pulmonary tuberculosis (TB) transmission prevention. It refers to an individual's belief in their ability to perform the actions necessary to achieve specific goals. In the context of pulmonary TB prevention, individuals who believe in their capability to implement preventive measures—such as wearing masks, maintaining proper ventilation, or avoiding contact with TB patients—are more likely to exhibit higher levels of adherence (20). In situations where individuals face obstacles, such as limited access to masks or social stigma, self-efficacy enables them to remain committed to preventive behaviours. This is driven by the belief, characteristic of individuals with high self-efficacy, that they possess the ability to overcome these challenges effectively (21-23). Several other studies support the findings regarding the influence of self-efficacy on preventive behaviours. For example, Hafiz (2021) reported a significant relationship between self-efficacy and medication adherence among pulmonary tuberculosis patients, with a p-value of 0.042 (24), The study by Makhfudli et al. (2022) demonstrated a correlation between self-efficacy and medication adherence among tuberculosis patients (p = 0.000, r = 0.459)(25), The study by Seong and Lee (2022) demonstrated a relationship between self-efficacy and self-care among tuberculosis patients (r = 0.687, p = 0.000). Self-care is a component of adherence behaviour in tuberculosis treatment, particularly within the framework of behaviours related to health and personal well-being. Self-care refers to deliberate actions taken by individuals to maintain their physical, mental, and emotional health (26, 27) .

These findings have significant implications for public health policies and interventions. Age-based strategies can be strengthened by providing education to younger age groups to enhance awareness and social responsibility in preventing pulmonary tuberculosis. Additionally, intervention programs aimed at improving self-efficacy through training and social support can boost adherence, particularly in addressing barriers such as social stigma or limited facilities. The adoption of community-based approaches that account for social norms can further reinforce adherence. In certain contexts, external regulations, such as mandatory mask-wearing or the provision of free preventive facilities, have proven effective, especially for individuals with low-risk perception.

The non-significance of education (p=0.060), perceived severity (p=0.069), and perceived susceptibility (p=0.959) as predictive factors for transmission prevention among pulmonary tuberculosis (TB) patients in Surabaya City can be attributed to several potential reasons: While education is often assumed to influence health behaviours, its non-significance in this study may indicate that educational attainment alone is not a direct determinant of adherence to TB prevention measures. Factors such as health literacy, which may not directly correlate with formal education levels, could play a more significant role. For example: Individuals with higher education may not always prioritize health behaviours if they perceive low personal risk or face practical barriers. Conversely, individuals with lower education may adhere well due to strong community-based interventions or social norms. The p-value approaching significance (p=0.060) suggests a potential indirect effect or influence mediated by other factors, such as socioeconomic status or access to health resources. Perceived severity, while an essential construct in the Health Belief Model, may not significantly predict adherence due to psychological coping mechanisms such as defensive denial or risk normalization: Defensive Denial: Patients may downplay the severity of TB to reduce fear or anxiety, leading to a disconnect between perceived severity and preventive behaviours. Risk Normalization: In communities with high TB prevalence, individuals may perceive the disease as a routine or inevitable occurrence, diminishing the motivational impact of its perceived severity. Additionally, perceived severity may not translate into action if individuals lack the resources, knowledge, or self-efficacy to take preventive steps. The extremely high p-value for

perceived susceptibility indicates no significant relationship with adherence in this context, potentially due to: Unrealistic Optimism: Many individuals, particularly younger or healthier ones, may underestimate their personal risk of contracting TB despite objective risks being high. Experience with TB: Those with prior exposure to TB cases (e.g., family members or neighbors) may perceive the risk as normalized and thus fail to see a need for strict preventive measures. Cultural or Social Influences: In some contexts, collective societal norms may overshadow individual susceptibility perceptions, making perceived susceptibility less relevant in predicting behaviour. Limited Role of Susceptibility in Motivation: Previous studies have found that perceived susceptibility is less effective in driving behaviour change compared to constructs like perceived benefits or self-efficacy.

This study provides valuable insights, emphasizing the need for further research involving populations with diverse socioeconomic, educational, and cultural backgrounds to ensure the generalizability of the findings. Future exploration should focus on the influence of social norms, access to information, and external regulation-based interventions on adherence. Developing training programs to enhance self-efficacy, particularly among populations with limited access to healthcare facilities, is essential. Longitudinal studies are needed to observe the dynamics of factors influencing adherence over time, including the impact of public health policies. Additionally, investigating strategies to bridge the intention-behaviour gap through approaches such as reward-based motivation or more intensive social support is crucial.

The limitations of this study's findings should be interpreted cautiously, particularly when applied to different contexts. To enhance the generalizability and validity of the results, further research involving more diverse populations and employing more comprehensive methodological approaches is strongly recommended. The integration of quantitative and qualitative methods could provide a deeper understanding of the factors influencing adherence to TB prevention measures.

CONCLUSION

This study identified that age, perceived benefits, barriers, and self-efficacy are significant predictors of adherence to pulmonary tuberculosis transmission prevention measures in Surabaya City. Older respondents, those with high perceived benefits, and strong self-efficacy demonstrated higher levels of adherence. Conversely, perceived barriers negatively impacted adherence. These findings underscore the importance of community-based approaches in public health interventions. Targeted education for younger age groups and programs aimed at enhancing self-efficacy should be prioritized to improve tuberculosis prevention adherence. Additionally, reducing barriers through better access to preventive facilities, such as masks and information, could have a positive impact. These strategies are expected to support more effective control of pulmonary tuberculosis at both individual and community levels. Further research is recommended to observe the dynamics of these factors over time and to expand the population scope with diverse demographics to enhance the generalizability of the findings. By addressing these actionable steps, policymakers and health providers can bridge the gap between research insights and practical implementation, ensuring a stronger and more effective response to pulmonary tuberculosis. Further research is recommended to observe the dynamics of these factors over time and to expand the population scope with diverse demographics to enhance the generalizability of the findings

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