

Original Article

Changes in adherence to tuberculosis transmission prevention practices following structured behavioral education among pulmonary tuberculosis patients: A single-group pre-post quasi-experimental study

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Abstract

Background: Pulmonary tuberculosis remains a public health problem because transmission may continue when patients do not consistently apply preventive practices. Although health education is commonly provided, evidence on structured behavioral education specifically targeting adherence to tuberculosis transmission-prevention practices remains limited, particularly in community-based tuberculosis services.

Objective: This study aimed to assess changes in adherence to tuberculosis transmission prevention practices following structured behavioral education among pulmonary tuberculosis patients.

Methods: A single-group pre-post quasi-experimental study was conducted among 44 pulmonary tuberculosis patients at the Community Lung Health Center of Ambon City. Participants were selected using purposive sampling. The intervention included structured education on tuberculosis transmission, mask use, cough etiquette, sputum disposal, environmental hygiene, home ventilation, and treatment adherence. Adherence was assessed using a structured questionnaire before the intervention and immediately after completion of the educational session; therefore, the post-test reflected short-term changes in adherence. Pre- and post-intervention scores were analyzed using the Wilcoxon signed-rank test.

Results: The mean adherence score increased from 77.67 ± 13.93 before the intervention to 85.34 ± 10.66 after the intervention. The proportion of participants with good adherence increased from 21 participants (47.7%) to 32 participants (72.7%). The Wilcoxon signed-rank test showed a statistically significant difference in adherence before and after the intervention ($p < 0.01$).

Conclusion: Adherence to tuberculosis transmission prevention practices improved following structured behavioral education. This intervention may be integrated into routine tuberculosis counseling in community lung health services.

Background

Tuberculosis (TB) remains a major global public health challenge and has returned as the leading cause of death from a single infectious agent after the COVID-19 pandemic. In 2023, an estimated 10.8 million people developed TB worldwide, and approximately 1.25 million deaths were attributed to the disease (WHO, 2025). Pulmonary TB is particularly important for disease control because transmission occurs through airborne particles released by infectious individuals. In this study, tuberculosis transmission-prevention practices were defined as patients' adherence to five preventive behaviors: proper mask use, cough etiquette, safe sputum disposal, environmental hygiene, and adequate home ventilation. Consistent adherence to these practices is important for reducing the risk of TB transmission within households and communities (Castro et al., 2025; Ismail et al., 2025; Li et al., 2024).

Indonesia is one of the highest TB-burden countries globally and remains a priority setting for TB control. Recent global estimates place Indonesia among the countries contributing substantially to the global TB caseload. National reports also indicate that TB continues to be a major public health concern in Indonesia, with ongoing transmission occurring in households and communities (Ministry of Health of the Republic of Indonesia, 2023). This situation highlights the need for interventions that address not only treatment completion but also daily preventive behaviors among patients with pulmonary TB.

Previous systematic reviews of TB care have primarily examined interventions aimed at improving treatment adherence and treatment success (Oliveira et al., 2025). Patient-centered approaches have been shown to support TB treatment adherence by addressing individual needs, perceived barriers, health literacy, and

social support (Arangba et al., 2025; Arulprakash et al., 2024; Kuo et al., 2023; Region et al., 2023). However, adherence to TB transmission-prevention practices has received less attention than adherence to anti-tuberculosis medication. In this study, adherence refers specifically to the consistent implementation of transmission-prevention behaviors, including mask use, cough etiquette, safe sputum disposal, environmental hygiene, and adequate home ventilation. Treatment adherence was not included in the primary outcome. This distinction is important because patients may remain a source of transmission when preventive practices are inconsistently implemented despite receiving anti-tuberculosis treatment.

Health education is commonly used in TB programs to improve patient knowledge and promote adherence. Nevertheless, routine education is often delivered in a general, brief, and non-standardized manner, which may limit its influence on behavioral change. Structured behavioral education offers a more focused approach by combining standardized content, clear behavioral targets, reinforcement, and practical guidance. The Health Belief Model was used only as a conceptual framework to explain how health education may influence preventive behavior. Its constructs, including perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy, were not directly measured in this study. Therefore, the study did not evaluate changes in Health Belief Model constructs as intervention outcomes (Bao et al., 2022; Clemencia et al., 2025; Id et al., 2024; Miladi, 2025). In the context of TB, education that strengthens patients' perceived risk of transmission, perceived benefits of prevention, and confidence to perform preventive practices may improve adherence to transmission prevention behaviors.

Despite the importance of infection-prevention behavior, evidence on structured behavioral education specifically targeting adherence to tuberculosis transmission-prevention practices remains limited. This study addresses this gap by evaluating a standardized, behavior-focused educational intervention aimed specifically at improving adherence to preventive practices that directly reduce household and community transmission. Most existing interventions have focused on treatment adherence rather than patient behaviors that directly reduce household and community transmission. Addressing this gap

is essential for strengthening patient-centered TB prevention strategies in high-burden settings.

Therefore, this study aimed to assess changes in adherence to tuberculosis transmission-prevention practices following structured behavioral education among patients with pulmonary tuberculosis at the Community Lung Health Center of Ambon City.

Methods

Study Design

This study employed a quantitative single-group pre-post quasi-experimental design to assess changes in adherence to tuberculosis transmission-prevention practices following structured behavioral education among patients with pulmonary tuberculosis. This design was selected to evaluate within-participant changes in adherence before and after the intervention under routine community-based tuberculosis service conditions.

Setting and Participants

The study was conducted at the Community Lung Health Center of Ambon City, Maluku Province, Indonesia, from March to April 2026. The target population consisted of patients with pulmonary tuberculosis receiving treatment at the facility. Participants were recruited using purposive sampling based on predefined eligibility criteria. During the study period, 44 patients were assessed for eligibility. All met the eligibility criteria and agreed to participate; therefore, no patients were excluded or declined participation.

The inclusion criteria were: (1) diagnosed with pulmonary tuberculosis, (2) aged 18 years or older, (3) receiving treatment at the Community Lung Health Center, (4) able to communicate in Bahasa Indonesia, and (5) willing to participate in the study. Patients with severe physical or cognitive impairments that prevented participation in the educational sessions were excluded. No a priori sample size calculation was performed because the study included all eligible patients available during the study period. All 44 participants completed both the pre-intervention and post-intervention assessments and were included in the final analysis.

Intervention

The intervention consisted of structured behavioral education designed to improve adherence to tuberculosis transmission-prevention practices. Each participant received one individual face-to-face educational session lasting approximately 30 minutes during a routine visit to the Community Lung Health Center. The intervention was delivered by the researcher, a registered nurse with experience in tuberculosis care and health education (Table 1).

The educational content focused on tuberculosis transmission and five targeted preventive behaviors: proper mask use, cough etiquette, safe

sputum disposal, environmental hygiene, and adequate home ventilation. The session was supported by a standardized educational module and leaflet developed based on national tuberculosis prevention guidelines and World Health Organization recommendations. Educational techniques included explanation, demonstration, guided discussion, clarification of misconceptions, and practical guidance on applying preventive behaviors in the household environment. Participants were encouraged to ask questions and discuss barriers to implementing the recommended practices. No additional educational reinforcement or follow-up session was provided before the post-intervention assessment.

Table 1. Structured Behavioral Education Intervention Components

Intervention component	Behavioral objective	Delivery method	Duration
Tuberculosis transmission	Improve understanding of TB transmission and prevention	Explanation and guided discussion	5 min
Proper mask use	Promote correct and consistent mask use	Explanation and demonstration	5 min
Cough etiquette	Promote appropriate respiratory hygiene	Explanation and demonstration	5 min
Safe sputum disposal	Promote safe handling and disposal of sputum	Explanation and practical guidance	5 min
Environmental hygiene	Promote appropriate household environmental hygiene	Explanation and guided discussion	5 min
Home ventilation	Promote adequate air circulation in the home	Explanation and practical guidance	5 min
Total			30 min

Instrument

Adherence to tuberculosis transmission-prevention practices was measured using a 10-item questionnaire adapted from (Mardhiyyah et al., 2026). The instrument assesses preventive behaviors related to mask use, cough etiquette, sputum disposal, household ventilation and environmental practices, healthcare-seeking behavior, and measures to reduce transmission within the household. Each item is rated on a four-point Likert scale ranging from 1 (never) to 4 (always), with higher scores indicating greater adherence to tuberculosis transmission-prevention practices. Because the original instrument was developed and administered in Bahasa Indonesia, no translation or cross-cultural adaptation was required.

The original questionnaire underwent face-validity assessment by two experts with backgrounds in educational psychology and psychiatric nursing. Formal item-level or scale-level Content Validity Index (I-CVI/S-CVI) values were not reported in the original instrument; therefore, no such values are claimed in the present study. Internal consistency was evaluated using the baseline responses of the 44 participants included in this study. The 10-item scale demonstrated acceptable internal consistency, with a Cronbach's alpha coefficient of 0.774.

Data Collection

Baseline data were collected before the educational intervention (pre-test). Immediately after completion of the educational session, participants completed the same questionnaire as the post-test assessment. Therefore, the post-test

primarily reflected short-term changes in adherence rather than sustained behavioral adherence. Demographic characteristics, including age, sex, education level, and occupation, were also collected using a structured data form.

Data Analysis

Data were analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize participant characteristics and adherence scores. Normality was assessed using the Shapiro-Wilk test on the paired difference scores (post-test minus pre-test), rather than on the pre-test and post-test scores separately. The paired differences were not normally distributed ($W = 0.857$, $p < 0.001$). Therefore, the Wilcoxon signed-rank test was used to compare pre-intervention and post-intervention adherence scores. Statistical significance was set at $p < 0.05$.

Ethical Considerations

Ethical approval for this study was obtained from the Health Research Ethics Committee of STIKes Maluku Husada, Ambon, Indonesia (Approval No. 07/KEPK/STIK-MH/II/2026; approved on March 9, 2026). Permission to conduct the study was also obtained from the Community Lung Health Center of Ambon City.

All participants received information regarding the study objectives, procedures, benefits, and potential risks before enrollment. Written informed consent was obtained from all participants. Confidentiality and anonymity were maintained throughout the study by using participant codes and restricting data access to the research team. Participants were informed that their participation was voluntary and that they could withdraw from the study at any time without consequences for their treatment or access to healthcare services..

Results

A total of 44 patients with pulmonary tuberculosis completed both the pre-intervention and post-intervention assessments. Participant characteristics are presented in Table 2 to describe the composition of the study population. The sample included both male and female participants across different age, educational, and

occupational groups. More than half were female (54.5%), and most had completed senior high school education (61.4%). These characteristics provide important context for interpreting adherence because demographic and educational differences may influence patients' understanding and implementation of tuberculosis transmission-prevention practices. However, as this was a single-group study, no between-group comparisons of baseline characteristics were performed. The distribution of waste generation is shown in Table 2.

Table 2. Characteristics of participants (n = 44)

Characteristics	Category	n	%
Sex	Male	20	45.5
	Female	24	54.5
Age group	19–25 years	12	27.3
	26–35 years	9	20.5
	36–45 years	12	27.3
	46–55 years	11	25.0
Education level	Elementary school	2	4.5
	Junior high school	5	11.4
	Senior high school	27	61.4
	Higher education	10	22.7
Occupation	Farmer	10	22.7
	Driver	3	6.8
	Teacher	9	20.5
	Entrepreneur	4	9.1
	Trader	1	2.3
	Private employee	5	11.4
	Housewife	12	27.3

Table 3 showed changes in adherence categories before and after structured behavioral education are shown in Table 3. Before the intervention, 21 participants (47.7%) had good adherence, 17 (38.6%) had moderate adherence, and 6 (13.6%) had poor adherence. After the intervention, good adherence increased to 32 participants (72.7%), while moderate adherence decreased to 11 participants (25.0%) and poor adherence decreased to 1 participant (2.3%).

Table 3. Adherence categories before and after structured behavioral education

Adherence category	Pre-test n (%)	Post-test n (%)
Good	21 (47.7)	32 (72.7)
Moderate	17 (38.6)	11 (25.0)
Poor	6 (13.6)	1 (2.3)
Total	44 (100.0)	44 (100.0)

Table 4 presents the comparison of adherence scores before and after the intervention. The mean adherence score increased from 77.67 ± 13.93 before the intervention to 85.34 ± 10.66 after the intervention. The median score increased from 77.50 to 87.50. The Shapiro–Wilk test showed that the post-test adherence score was not normally distributed; therefore, the Wilcoxon signed-rank test was used. The analysis showed a statistically significant difference in adherence scores before and after structured behavioral education ($p < 0.001$).

Table 4. Comparison of adherence scores before and after structured behavioral education

Variable	Pre-test	Post-test	p-value
Mean $\pm$ SD	77.67 $\pm$ 13.93	85.34 $\pm$ 10.66	<0.001
Median	77.50	87.50	
Minimum–maximum	50.00–100.00	55.00–100.00	

The Wilcoxon signed-rank test showed a statistically significant increase in adherence scores following structured behavioral education ($Z = -5.394$, $p < 0.001$). Of the 44 participants, 38 showed increased adherence scores, six had unchanged scores, and none showed a decrease. The effect size was large ($r = 0.81$), indicating a substantial magnitude of change in adherence scores between the pre-intervention and post-intervention assessments.

Discussion

This study found that adherence to tuberculosis transmission-prevention practices improved after structured behavioral education among patients with pulmonary tuberculosis. The proportion of participants with good adherence increased from 47.7% before the intervention to 72.7% after the intervention, while the mean adherence score increased by 7.67 percentage points, from 77.67 to 85.34. Given the possible score range of 25–100%, this change shifted the mean score from the moderate-adherence category (61–80%) to the good-adherence category (81–100%). The Wilcoxon signed-rank test also demonstrated a large effect size ($r = 0.81$), indicating a substantial magnitude of change. However, because no established minimal clinically important difference is available for this instrument, the improvement should be interpreted in terms of

statistical effect and change in adherence category rather than as a confirmed clinically meaningful threshold. These findings suggest that structured behavioral education may strengthen adherence to daily transmission-prevention practices through systematic information, behavioral reinforcement, and practical guidance (Daradkeh et al., 2025; Nkiene et al., 2026; Șoroagă, 2024). Pulmonary tuberculosis remains a major source of airborne transmission and continues to contribute substantially to the global infectious disease burden (Brüggemann et al., 2025; Jiang & Luo, 2026).

The improvement observed in this study may be explained by the structured nature of the intervention. Unlike general counseling, structured behavioral education provides standardized messages, clear behavioral targets, and repeated emphasis on practical actions such as mask use, cough etiquette, safe sputum disposal, environmental hygiene, home ventilation, and treatment adherence (Karolina et al., 2025; Tantely et al., 2025). Reducing tuberculosis transmission requires a combination of administrative measures, environmental controls, respiratory protection, patient education, and cough hygiene practices (Kong et al., 2026; Lima et al., 2025; Tsibiyane et al., 2026).

The present findings should be distinguished from evidence on adherence to anti-tuberculosis medication because the outcome of this study focused specifically on behaviors intended to reduce transmission. Previous studies have identified important gaps in respiratory hygiene and transmission-prevention practices, including cough etiquette, mask use, safe sputum disposal, and other infection-control behaviors among patients and households affected by tuberculosis (Kozhamkulov et al., 2025; Mbalilo & Nyabadza, 2026). These studies emphasize that knowledge of tuberculosis does not necessarily translate into consistent preventive practices and highlight the need for targeted health education to strengthen behaviors that directly interrupt transmission. The present study extends this evidence by demonstrating improved adherence to transmission-prevention practices following structured behavioral education.

The increase in good adherence after the intervention indicates that patients may respond positively when prevention messages are

delivered in a structured, practical, and behavior-oriented manner. This is important because patients may understand tuberculosis as an infectious disease but still fail to consistently apply preventive behaviors in daily life (Bao et al., 2022; Clemencia et al., 2025; Miladi, 2025). Medication adherence among pulmonary tuberculosis patients is influenced by knowledge, motivation, side effects, social support, and health-service factors, indicating that adherence is not merely a clinical issue but also a behavioral and contextual issue (Arangba et al., 2025; Arulprakash et al., 2024; Id et al., 2024).

From a behavioral perspective, structured education may improve adherence by increasing patients' awareness of transmission risks, perceived benefits of prevention, and confidence in performing recommended behaviors (Ismail et al., 2025; Kuo et al., 2023; Region et al., 2023). The Health Belief Model explains that preventive behavior is influenced by perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy (Castro et al., 2025; Li et al., 2024). Therefore, education that directly addresses risk perception and practical barriers may be more likely to influence preventive practices than unstructured information alone (Bao et al., 2022; Id et al., 2024).

The absence of decreased adherence scores after the intervention further supports the potential usefulness of structured behavioral education as a feasible approach in routine tuberculosis services. Nevertheless, this result should be interpreted cautiously because the study did not include a control group, limiting the ability to establish causal relationships between the intervention and observed outcomes (Kastien-hilka et al., 2016; Mbalilo & Nyabadza, 2026; Miladi, 2025). Improvements may have been influenced by repeated measurement, increased attention from healthcare workers, or participants' desire to provide socially acceptable responses (Jiang & Luo, 2026; Karolina et al., 2025; Lima et al., 2025). Therefore, the findings suggest improvement following education but should not be interpreted as definitive evidence of intervention effectiveness.

The findings have practical implications for community-based tuberculosis services. Structured behavioral education can be integrated into routine tuberculosis counseling through

standardized leaflets, brief face-to-face sessions, demonstration of cough etiquette, mask-use reinforcement, and periodic adherence evaluation during follow-up visits (Daradkeh et al., 2025; Kozhamkulov et al., 2025; Șoroagă, 2024). This approach may help health workers deliver consistent messages and support patient engagement in transmission-prevention behaviors in high-burden settings where educational support remains a critical component of tuberculosis control programs (Jiang & Luo, 2026; Mardhiyyah et al., 2026; Okafor et al., 2026).

This study has several limitations. First, the single-group pre-post design limits causal inference because there was no comparison group, making it difficult to determine whether improvements were solely attributable to the intervention (Kozhamkulov et al., 2025; Tsibiyane et al., 2026). Second, the sample size was relatively small and recruited from a single community lung health center, which may limit the generalizability of the findings. Third, adherence was measured using self-reported data, which may be affected by recall bias and social desirability bias (Apoyo, 2025; Tantely et al., 2025). Fourth, the post-test was conducted shortly after the intervention, preventing assessment of the long-term sustainability of behavioral changes. Future studies should use randomized controlled designs, larger multicenter samples, objective adherence measures, and longer follow-up periods to evaluate whether improvements in adherence can be maintained over time (Daradkeh et al., 2025; Kastien-hilka et al., 2016).

Despite these limitations, this study provides preliminary evidence that structured behavioral education may improve adherence to tuberculosis transmission prevention practices among pulmonary tuberculosis patients. The study contributes to tuberculosis nursing and public health practice by shifting attention from medication adherence alone toward patient behaviors that support transmission prevention. Future tuberculosis control programs should consider structured, behavior-focused education as part of patient-centered counseling in community lung health services to strengthen adherence to prevention practices and support comprehensive tuberculosis control efforts (Dilas et al., 2023; World Health Organization, 2024).

Conclusion and Recommendation

This study demonstrated that structured behavioral education was associated with improved adherence to tuberculosis transmission-prevention practices among patients with pulmonary tuberculosis. The findings suggest that structured, practical, and behavior-focused education may strengthen patients' engagement in preventive practices, including proper mask use, cough etiquette, safe sputum disposal, environmental hygiene, and adequate home ventilation. These findings highlight the potential value of integrating structured behavioral education into routine nursing care and community-based tuberculosis prevention programs. Healthcare providers are encouraged to implement standardized educational modules, practical demonstrations, individualized counseling, and periodic reinforcement to promote consistent preventive behaviors. However, the findings should be interpreted cautiously because of the single-group study design, reliance on self-reported adherence, and immediate post-intervention assessment. Future studies should employ controlled designs, larger multicenter samples, objective behavioral assessments, and longer follow-up periods to establish intervention effectiveness, assess the sustainability of behavioral changes, and determine their potential contribution to reducing tuberculosis transmission.

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Declaration of conflict of interest

The authors declare no competing interests.

Declaration on the Use of AI

No AI tools were used in the preparation of this manuscript.

Data Availability Statement

Data sharing is not applicable to this article.

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