

RESEARCH ARTICLE

Association of Structured Self-Talk Intervention Assignment with Short-Term Tuberculosis Medication Adherence: A Sequential Quantitative Study

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ABSTRACT

Introduction: Tuberculosis (TB) treatment requires sustained medication use, but adherence can be influenced by cognitive, psychosocial, and healthcare-related factors. Evidence on structured self-talk for supporting TB medication adherence remains limited. This study examined factors associated with adherence and whether assignment to the structured self-talk intervention was associated with short-term improvement in self-reported adherence.

Methods: A sequential quantitative design was used. Phase I included 117 patients with pulmonary TB in a cross-sectional study assessing TB knowledge, access to health facilities, self-efficacy, and family support. Phase II used a quasi-experimental pretest–posttest control-group design with 68 patients. Participants were allocated according to clinic attendance schedules. The structured self-talk intervention involved twice-weekly practice for 4 weeks. Phase I data were analysed using Spearman's rank correlation and binary logistic regression. Between-group changes in the study-specific modified 11-item medication adherence scores in Phase II were compared using the Mann–Whitney U test; ANCOVA was used for the adjusted analysis.

Results: In Phase I, TB knowledge, access to health facilities, self-efficacy, and family support were positively associated with medication adherence in bivariate analyses (all $p < 0.001$). After adjustment, only self-efficacy (OR = 2.34; 95% CI: 1.41–3.89) and family support (OR = 3.97; 95% CI: 2.16–7.31) remained significantly associated with good adherence. In Phase II, the primary non-parametric between-group analysis showed a Hodges–Lehmann location shift of 3.00 points (95% CI: 2.00–4.00; $p < 0.001$). ANCOVA yielded an adjusted between-group coefficient of 3.08 points for the post-intervention study-specific modified 11-item medication adherence score (95% CI: 1.85–4.31; $p < 0.001$).

Conclusion: Cognitive, psychosocial, and contextual factors were associated with TB medication adherence. Assignment to the structured self-talk intervention was associated with greater short-term improvement in self-reported adherence. However, interpretation should consider the non-randomised design, self-reported outcome measurement, and short follow-up period. Randomised studies with longer follow-up and objective adherence measures are warranted.

Keywords: Tuberculosis; Medication Adherence; Self-Talk; Self-Efficacy; Family Support

INTRODUCTION

Tuberculosis (TB) remains a significant and persistent global public health challenge. The WHO Global Tuberculosis Report 2025 estimated that 10.7 million people fell ill with TB worldwide in 2024 and that 1.23 million died from the disease (1). Indonesia is among the countries with the highest TB burden globally. In 2024, Indonesia accounted for approximately 10% of global incident TB cases, second only to India in the estimated number of cases (1). Although case detection and access to treatment have improved, sustained treatment adherence remains important for achieving favourable treatment outcomes. TB treatment requires a prolonged regimen, typically lasting at least six months and involving multiple anti-tuberculosis drugs. Medication adherence is important for treatment success, as inconsistent medication use can increase the risk of treatment failure, relapse, and mortality (2,3). Poor adherence may also contribute to the development of multidrug-resistant tuberculosis (MDR-TB), which requires longer and more costly treatment and is associated with poorer outcomes than drug-susceptible TB (4).

Non-adherence to TB treatment remains common, particularly in low- and middle-income settings. Recent meta-analyses suggest that approximately 20–30% of patients do not complete treatment as prescribed across different settings (5,6). Several factors may contribute to this problem, including adverse drug effects, economic and access barriers, social stigma, and psychological distress related to prolonged treatment and negative perceptions of therapy (7–9). These challenges can make it difficult for patients to maintain regular medication-taking behaviour throughout treatment.

Conventional approaches to improving TB medication adherence, including Directly Observed Treatment Short-course (DOTS), patient education, and reminder systems, have been widely implemented. However, evidence suggests that their effects on adherence are often modest (10). These approaches commonly emphasise treatment supervision and observable behaviour, while patients' cognitive and emotional experiences may receive less attention (11).

Health behaviour research has highlighted the relevance of psychological factors such as self-efficacy, emotional regulation, and intrinsic motivation to treatment-related behaviour (12,13). In TB care, qualitative studies have described negative internal dialogues among patients, including doubts about treatment, concerns about side effects, and feelings of hopelessness during prolonged therapy (14). Such experiences may influence how patients interpret treatment demands, regulate their behaviour, and maintain medication-taking routines over time. Understanding patients' internal experiences may therefore provide additional insight into psychological processes underlying medication adherence.

Self-talk refers to the internal dialogue individuals use to guide or regulate their thoughts and behaviour. It has been studied as a psychological strategy for supporting health-related behaviour (15). From the perspective of Social Cognitive Theory (SCT), self-talk may function as a self-regulatory strategy that supports self-efficacy, outcome expectations, and goal-directed behaviour (16). Neuropsychological research has also linked self-talk with processes involved in executive function and emotional regulation, which may be relevant to health-related decision-making (17).

Despite growing interest in psychological and behavioural approaches to medication adherence, evidence specifically concerning structured self-talk remains limited (18–20). Existing studies have largely examined psychological or behavioural outcomes rather than medication-taking behaviour itself. Findings from other health behaviours therefore cannot be assumed to apply directly to TB medication adherence. This gap is particularly relevant in TB care because treatment requires consistent medication-taking over an extended period.

The application of self-talk also needs to consider the context in which TB treatment occurs. Patients' treatment experiences may be shaped by family support, access to health services, and the practical difficulties of maintaining treatment routines. In the Indonesian TB care setting, an adherence-support strategy should be feasible within patients' daily lives and should complement, rather than replace, routine treatment support. Accordingly, this study used the structured self-talk intervention, consisting of standardised statements and guided practice focused on treatment commitment, confidence in maintaining medication-taking behaviour, coping with treatment-related difficulties, and persistence with treatment. SCT provided the primary theoretical basis for this approach, particularly its emphasis on self-efficacy and self-regulation.

Phase I examined TB knowledge, access to health facilities, self-efficacy, and family support as empirical factors associated with medication adherence. These variables were included to characterise cognitive, individual, social, and healthcare-related factors relevant to adherence rather than to determine or modify the intervention. Importantly, the structured self-talk intervention was prespecified independently of the Phase I findings and was not modified on the basis of those results.

Evidence remains limited regarding quantitative studies that simultaneously examine factors associated with TB medication adherence and evaluate a structured, theory-informed self-talk intervention within a sequential research framework in a middle-income country. The present sequential design therefore first examined factors associated with adherence and subsequently evaluated the structured self-talk intervention, which had been prespecified before Phase II recruitment, among eligible patients with pulmonary TB.

Therefore, this study aimed to identify factors associated with medication adherence among patients with pulmonary tuberculosis and to examine whether assignment to a theory-informed structured self-talk intervention was associated with short-term changes in medication adherence.

METHODS

Study Design

This study employed a sequential quantitative research design conducted in two consecutive quantitative phases. Phase I consisted of an analytical observational study using a cross-sectional approach to identify factors associated with medication

adherence among patients with pulmonary tuberculosis (TB). Phase II used a quasi-experimental pretest–posttest control-group design to examine whether assignment to the structured self-talk intervention was associated with greater short-term improvement in TB medication adherence.

The two phases were conducted sequentially but served distinct analytic purposes. Phase I examined factors associated with medication adherence, whereas Phase II evaluated the prespecified structured self-talk intervention. The structured self-talk intervention was specified before Phase II recruitment and was developed based on Social Cognitive Theory (SCT), the study protocol, and relevant literature.

The sequential design therefore provided complementary evidence: Phase I characterised factors associated with medication adherence in the study population, while Phase II examined the association between assignment to the prespecified self-talk intervention and short-term change in medication adherence.

Population and Sample

The source population comprised patients with pulmonary TB receiving anti-tuberculosis treatment at RS Tk. II dr. Soepraoen, Malang, Indonesia, between January and November 2025. During this period, 165 patients were identified from the hospital treatment population and screened for eligibility.

Pulmonary TB was diagnosed according to the routine clinical procedures of the study hospital, including bacteriological confirmation by sputum Xpert MTB/RIF and/or smear microscopy, chest radiography, and clinical assessment, as applicable. Drug-susceptibility status was determined from medical records and baseline Xpert MTB/RIF results. Only patients classified as having drug-susceptible pulmonary TB were eligible.

Participants were eligible for Phase I if they were aged ≥ 18 years, had pulmonary TB, were in either the intensive or continuation phase of treatment, and had received anti-tuberculosis treatment for at least 1 month. Participants were excluded if they had a previous history of TB treatment, extrapulmonary TB, rifampicin-resistant or multidrug-resistant TB, severe psychiatric or cognitive impairment that could interfere with questionnaire completion or intervention participation, clinical instability requiring intensive care, or a major comorbidity considered by the treating clinical team to substantially interfere with medication-adherence assessment or intervention participation. No specific comorbidity was excluded solely on the basis of diagnosis.

Of the 165 patients identified, 117 were enrolled in Phase I using purposive sampling. Eligible patients who were available during the recruitment period were invited to participate. Twelve patients declined participation and 36 did not meet the eligibility criteria. The final Phase I sample therefore comprised 117 participants. The Phase I sample consisted of eligible and available patients identified during the recruitment period rather than a sample determined through a formal a priori sample-size calculation. Among these participants, 99 had good adherence and 18 had moderate adherence; no participant was classified as having poor adherence.

For Phase II, participants were recruited exclusively from the 117 participants enrolled in Phase I. Phase II eligibility required participants to have received anti-tuberculosis treatment for more than 6 months and to have a Phase I medication-adherence score of 8–20, corresponding to the moderate (8–14) and good (15–20) adherence categories. Thus, treatment duration and the prespecified Phase I adherence score jointly defined the Phase II eligible pool.

At Phase II enrolment, all 68 participants were drug-susceptible pulmonary TB patients in an extended continuation phase. Treatment beyond 6 months reflected clinical considerations documented by the treating clinical team, including comorbid diabetes mellitus, delayed sputum conversion, and other clinical assessments requiring continued therapy. No Phase II participant had extrapulmonary TB.

Of the 117 Phase I participants, 18 were classified as having moderate adherence and 99 as having good adherence. All 18 participants with moderate adherence had received anti-tuberculosis treatment for more than 6 months and therefore met both Phase II eligibility criteria. Among the 99 participants with good adherence, 50 had received treatment for more than 6 months and therefore also met both eligibility criteria, whereas the remaining 49 participants had received treatment for 6 months or less and did not meet the treatment-duration criterion. Consequently, 68 participants (18 with moderate adherence and 50 with good adherence) met the predefined Phase II eligibility criteria, and all 68 eligible participants were enrolled in Phase II.

Thus, the 50 participants with good adherence were not selectively sampled from the 99 participants; rather, they represented the participants within the good-adherence subgroup who also satisfied the prespecified treatment-duration criterion.

No formal a priori sample-size calculation was performed for Phase II. The Phase II sample size was determined pragmatically by the 68 participants who met the prespecified eligibility criteria within the Phase I cohort. All 68 participants completed both the pre-intervention assessment and the 4-week post-intervention assessment, and no participants were excluded from the Phase II analytical sample because of missing outcome data.

Instruments

Phase I used structured researcher-developed questionnaires based on relevant literature and the operational definitions of the study variables. The assessment covered TB knowledge, access to health facilities, self-efficacy, family support, and medication adherence. Self-talk was not assessed as a Phase I explanatory variable because it was introduced as the intervention in Phase II.

Conceptual and Measurement Framework

In Phase I, TB knowledge referred to participants' understanding of TB and its treatment. Access to health facilities referred to perceived and experienced access to treatment services. Self-efficacy reflected confidence in maintaining prescribed treatment behaviour, while family support referred to support received from family members during TB treatment. These variables were examined as factors associated with medication adherence.

Medication adherence was defined as the extent to which participants consistently followed the prescribed medication-taking regimen, including the prescribed dose, timing, completeness of the prescribed regimen, and continued medication-taking during treatment.

In Phase II, the structured self-talk intervention was developed as an individual-level self-regulatory strategy informed by SCT. The structured self-talk intervention addressed treatment commitment, confidence in maintaining medication-taking behaviour, coping with treatment-related difficulties, and regular medication-taking. Although self-efficacy was assessed in Phase I and informed the theoretical rationale for the intervention, it was not reassessed after the intervention and was not tested as a mediator.

Phase I Instruments

Five researcher-developed instruments were used in Phase I to assess TB knowledge, access to health facilities, self-efficacy, family support, and medication adherence. Medication adherence was assessed using a researcher-developed five-item questionnaire designed to capture complementary aspects of medication-taking behaviour, including taking the prescribed dose, taking medication at the prescribed time, taking the complete prescribed regimen, continuing medication despite perceived improvement, and continuing medication when treatment-related difficulties occurred.

Before the main study, the researcher-developed Phase I instruments were pilot-tested among 30 patients with TB who were not included in the main sample but had characteristics comparable to the study population. Internal consistency was assessed using Cronbach's alpha, and item-level consistency was examined using corrected item-total correlations. The questionnaire was developed specifically for this study based on the operational definition of medication adherence used in the research protocol and relevant literature. The pilot testing was used to evaluate the internal consistency and item performance of the questionnaire; it was not intended to establish construct or criterion validity.

Participants rated the frequency of each behaviour on a four-point scale (1 = never, 2 = rarely, 3 = often, and 4 = always). Item scores were summed to produce a total adherence score ranging from 5 to 20, with higher scores indicating more consistent medication-taking behaviour. For descriptive analysis and Phase II eligibility, scores of 5–7 were classified as poor adherence, 8–14 as moderate adherence, and 15–20 as good adherence. These categories were prespecified operational categories defined in the study protocol for descriptive classification and Phase II eligibility. They were not derived from an externally validated clinical cutoff and were not interpreted as validated clinical thresholds. The complete item wording, response options, scoring direction, and classification are provided in Supplementary Table S1. Supplementary Table S1 corresponds to the five-item medication-adherence questionnaire used in Phase I and confirms the item wording, four-point response scale, scoring direction, total score range (5–20), and predefined adherence categories used for descriptive analysis and Phase II eligibility determination.

Phase II Outcome Measure

Medication adherence in Phase II was assessed using a study-specific modified 11-item medication adherence questionnaire adapted from the Medication Adherence Report Scale (MARS) framework. The questionnaire was developed with reference to prior MARS instrument-development literature ([21,22](#)), particularly the 10-item Medication Adherence Report Scale (MARS-10) framework described by Horne and colleagues. One additional item was added by the researchers to capture a medication-taking behaviour considered relevant among patients receiving tuberculosis treatment in the Indonesian context. Therefore, the instrument used in this study represents a study-specific adaptation and should not be interpreted as an established or independently standardised "MARS-11" instrument.

All 11 items assessed medication-taking behaviours during the preceding 4 weeks, including non-adherent behaviours and one adherence-consistent behaviour. The adapted items retained the behavioural focus of the original MARS framework, while wording was adjusted where necessary to fit tuberculosis treatment context. The complete item list and item sources are provided in Supplementary Table S2. Item 8, the adherence-consistent item, was reverse-coded during data processing so that higher values represented better medication adherence; Items 1–7, 9, 10, and 11 retained their original scoring direction. Because all items were coded so that higher values represented better medication adherence, item scores were summed to obtain a total score ranging from 11 to 55. Higher total scores represented better self-reported adherence.

Before the main study, the modified 11-item questionnaire was pilot-tested among 30 patients with tuberculosis who were not included in the main study but had characteristics comparable to those of the study population. Corrected item-total correlations were examined, and internal consistency was assessed using Cronbach's alpha. All items demonstrated corrected item-total correlations exceeding the prespecified threshold, and the questionnaire showed good internal consistency with a Cronbach's alpha of 0.84. These pilot findings were considered evidence of item performance and internal consistency within the study population and were not interpreted as establishing full construct or criterion validity of the modified instrument.

Data Collection Procedure

During Phase I, eligible patients were screened according to the predefined criteria and completed questionnaires covering demographic characteristics, TB knowledge, access to health facilities, self-efficacy, family support, and medication adherence after providing written informed consent. Standardised instructions were used during questionnaire completion. Questions about the procedure were clarified without directing participants' responses, and completed questionnaires were checked for completeness.

After completion of Phase I, participants who met the prespecified Phase II eligibility criteria were identified from the Phase I cohort. Eligibility was determined before group allocation and before the intervention began.

Group Allocation and Control Condition

Because the study used a quasi-experimental design, allocation was non-randomised. The allocation schedule was established before intervention implementation. Participants attending the clinic on Mondays and Wednesdays were assigned to the intervention group, whereas those attending on Tuesdays and Thursdays were assigned to the control group.

The schedule was intended to reduce interaction and information exchange between groups and thereby limit potential contamination. Participants were not assigned according to treatment preference or post-baseline response. However, allocation according to clinic attendance schedule did not eliminate the possibility of baseline differences between groups.

The control group received standard pharmaceutical counselling and routine TB care without the structured self-talk materials. The intervention group received the same routine care and counselling, together with the structured self-talk intervention.

Structured Self-Talk Intervention

The structured self-talk intervention was delivered over 4 weeks, with practice scheduled twice weekly. Participants received standardised instructions and a practice worksheet. The content focused on treatment commitment, confidence in maintaining medication-taking behaviour, coping with treatment difficulties, and regular medication-taking.

The structured self-talk intervention was initiated with a 30-minute individual face-to-face tutorial. The tutorial explained the purpose of structured self-talk and demonstrated how to use the practice worksheet. Participants then practised the structured self-talk intervention independently twice weekly for 4 weeks. Each practice session lasted approximately 10–15 minutes and followed the worksheet, which included statements related to medication timing and coping with treatment-related physical difficulties.

The same instructions and materials were provided to all participants assigned to the structured self-talk intervention. Delivery was guided by a written intervention protocol and checklist used by the trained researcher.

Participants recorded structured self-talk practice in weekly self-reported logs. These records were not independently verified and were not included in the analysis of the Phase II between-group association. No additional study-related co-interventions were provided during the intervention period.

The study-specific modified 11-item medication adherence questionnaire was administered immediately before the intervention and again at week 4. The primary Phase II outcome was the change in study-specific modified 11-item medication adherence score between baseline and post-intervention assessment.

Relationship Between Phase I and Phase II

The two phases were sequential in implementation but distinct in analytic purpose. Phase I examined associations between TB knowledge, access to health facilities, self-efficacy, family support, and medication adherence. Phase II subsequently examined whether assignment to the prespecified structured self-talk intervention was associated with short-term change in medication adherence.

The Phase I findings were not used to select intervention content, modify the structured self-talk statements, determine the intervention dose, or alter delivery procedures. The structured self-talk intervention was prespecified before Phase II recruitment and was developed independently on the basis of Social Cognitive Theory (SCT), the study protocol, and relevant literature. Thus, Phase I provided contextual information about adherence-associated factors but did not constitute an intervention-development or adaptation stage.

Self-efficacy was assessed only in Phase I and was not reassessed after the intervention or tested as a mediator. Therefore, the study cannot determine whether changes in self-efficacy contributed to the Phase II findings.

The phases also used different adherence measures for different purposes. Phase I used a five-item researcher-developed questionnaire to examine cross-sectional associations and determine Phase II eligibility, whereas Phase II used the study-specific modified 11-item medication adherence questionnaire as the prespecified outcome measure for assessing change in self-reported medication adherence over 4 weeks. Scores from the two instruments were not treated as equivalent measures. Accordingly, the sequential design provides complementary evidence rather than evidence of an intervention-development pathway. Phase I characterised factors associated with adherence, whereas Phase II examined the association between assignment to the independently prespecified structured self-talk intervention and short-term change in study-specific modified 11-item medication adherence scores.

Data Analysis

Statistical analyses were performed using IBM SPSS Statistics version 27.0. Categorical variables were presented as frequencies and percentages. Continuous variables were summarised using means and standard deviations when approximately normally distributed and medians and interquartile ranges when distributions were non-normal.

All tests were two-sided, with $p < 0.05$ considered statistically significant. Raw questionnaire scores were used unless otherwise stated. Missing data were handled using complete-case analysis for the relevant analysis, with no statistical imputation.

Phase I Analysis

Phase I examined the associations of TB knowledge, access to health facilities, self-efficacy, and family support with medication adherence. The four explanatory variables were entered as continuous questionnaire scores.

Spearman's rank correlation was used for bivariate analysis. Binary logistic regression was then performed as the primary multivariable analysis.

The outcome was dichotomised into good adherence (1) and moderate adherence (0). Thus, the regression model estimated the odds of good versus moderate adherence. TB knowledge, access to health facilities, self-efficacy, and family support were entered simultaneously. No automated stepwise selection was used. Adjusted odds ratios (ORs), 95% confidence intervals (CIs), regression coefficients, and p-values were reported.

Multicollinearity was assessed using variance inflation factors (VIFs) and tolerance values. $VIF > 5.0$ and tolerance < 0.20 were considered indicative of potential multicollinearity. Model fit was assessed using the model chi-square statistic, Nagelkerke R^2 , and the Hosmer–Lemeshow goodness-of-fit test. Model convergence and the magnitude and direction of regression coefficients were also examined.

Because only 18 participants were in the smaller outcome category for four predictors, the model had 4.5 participants in the smaller outcome category per predictor. The regression estimates and CIs were therefore interpreted cautiously because of possible small-sample instability. Given the cross-sectional design, the findings were interpreted as adjusted associations rather than causal effects.

Phase II Analysis

The primary Phase II outcome was the continuous total score from the adapted 11-item medication-adherence measure. Individual change was calculated as:

Change score = post-intervention score – pre-intervention score

Because change scores were non-normally distributed, the Mann–Whitney U test was used for the primary unadjusted comparison between groups. The U statistic, standardised Z statistic, p-value, and standardised effect size were reported.

Effect size was calculated as:

$$r = |Z| / \sqrt{N}$$

where $N = 68$.

The Hodges–Lehmann estimator was used to quantify the non-parametric between-group location shift in change scores. The corresponding two-sided 95% confidence interval was obtained using the Hodges–Lehmann estimate procedure for two independent samples in IBM SPSS Statistics version 27.0. The Hodges–Lehmann location shift and its 95% confidence interval were reported as the primary inferential estimate.

An ANCOVA was subsequently performed to account for baseline study-specific modified 11-item medication adherence score and prespecified participant characteristics. Post-intervention study-specific modified 11-item medication adherence score was the dependent variable, intervention assignment was the primary independent variable, and baseline study-specific modified 11-item medication adherence score, age, and sex were included as covariates selected a priori. The adjusted between-group coefficient for intervention assignment was reported with its 95% CI and p-value. Because allocation was non-randomised, this coefficient was interpreted as an adjusted association rather than a causal adjusted between-group difference.

Linearity, homogeneity of regression slopes, and residual distribution were assessed using scatterplots, interaction terms, and the Shapiro–Wilk test. No substantial violations were identified.

Participants with missing pre- or post-intervention study-specific modified 11-item medication adherence scores were excluded from analyses requiring the corresponding measurement. No imputation was performed.

Protocol and Trial Registration

Phase II was conducted as part of the doctoral research protocol. No prospective trial registration was undertaken. The self-talk intervention, medication-adherence outcome, pretest–posttest assessment, and primary between-group comparison were specified in the research protocol before participant allocation.

The primary analysis was the between-group comparison of change in study-specific modified 11-item medication adherence score. ANCOVA and the within-group analyses were conducted as additional analyses to further examine the findings. Any analyses initiated after examination of the observed data were considered exploratory rather than prespecified. The absence of prospective trial registration was acknowledged when considering the potential for selective-reporting bias.

Ethical Approval

The study received ethical approval from the Health Research Ethics Committee of Universitas STRADA (Approval No. 1223413/EC/KEPK/XI/2024), issued on 27 November 2024. Before participation, all participants received information about the study procedures, potential risks and benefits, confidentiality, voluntary participation, and their right to withdraw. Written informed consent was obtained from all participants. Confidentiality and anonymity were maintained throughout the study.

The datasets generated and analysed during the current study are not publicly available because they contain individual-level health information and are subject to confidentiality and ethical restrictions. The data may be considered for access upon reasonable request to the corresponding author and after approval from the relevant institutional ethics committee, subject to appropriate data-sharing agreements and measures to protect participant privacy.

RESULTS

Respondent Characteristics

A total of 117 patients with pulmonary tuberculosis participated in Phase I. Participants were 18–68 years of age, with a mean age of 39.32 years. Most participants were male (61.5%) and had completed senior high school or an equivalent level of education (53.8%). Regarding occupation, 36.8% were unemployed and 29.9% were self-employed. The characteristics of the Phase I participants are presented in Table 1.

Table 1. Characteristics of Participants in Phase I (n = 117)

Characteristic	Category	n	%
Age, years	Mean ± SD	39.32 ± 17.19	-
	Young adult	43	36.8
	Adult	29	24.8
	Early elderly	26	22.2
	Elderly	9	7.7
	Late elderly	9	7.7
	Very old	1	0.9
Sex	Male	72	61.5
	Female	45	38.5
Education	Primary school/equivalent	36	30.8
	Senior high school/equivalent	63	53.8
	Diploma/Bachelor's degree	18	15.4
Occupation	Military/Police	5	4.3
	Unemployed	43	36.8
	Homemaker	17	14.5
	Private-sector employee	14	12.0
	Civil servant	3	2.6
	Self-employed	35	29.9

PHASE I RESULTS

Instrument Reliability

Before the main data collection, the Phase I instruments were tested among 30 tuberculosis patients with characteristics comparable to those of the study population who were not included in the main sample. The instruments assessed TB knowledge, access to health facilities, self-efficacy, family support, and medication adherence.

All corrected item-total correlation coefficients exceeded 0.374. Together with the Cronbach's alpha coefficients reported in Table 2, these findings indicated acceptable internal consistency of the researcher-developed instruments in the pilot sample. These results were interpreted as reliability evidence and not as evidence of construct or criterion validity.

Table 2. Reliability of the Phase I Research Instruments

Variable	Cronbach's alpha	No. of items
TB knowledge	0.817	10
Access to health facilities	0.941	18
Self-efficacy	0.928	11
Family support	0.956	8
Medication adherence	0.935	5

Note: Cronbach's alpha values indicate internal consistency in the pilot sample; they do not establish criterion or construct validity.

Distribution of Phase I Study Variables

The mean TB knowledge score was 8.97, with observed scores ranging from 6 to 10. The mean scores for access to health facilities, self-efficacy, family support, and medication adherence were 80.69, 48.92, 37.76, and 18.05, respectively.

Based on the predefined scoring categories, most participants had good TB knowledge (79.5%), good access to health facilities (76.9%), good self-efficacy (92.3%), and good family support (89.7%). Most participants also had good medication adherence (84.6%). The distribution of the Phase I variables is presented in Table 3.

Table 3. Distribution of Phase I Study Variables (n = 117)

Variable	Category	n	%
TB knowledge	Good	93	79.5
	Moderate	24	20.5
Access to health facilities	Good	90	76.9
	Moderate	27	23.1
Self-efficacy	Good	108	92.3
	Moderate	9	7.7
Family support	Good	105	89.7
	Moderate	12	10.3
Medication adherence	Good	99	84.6
	Moderate	18	15.4

Bivariate Analysis

The Kolmogorov–Smirnov test indicated that the distributions of TB knowledge, access to health facilities, self-efficacy, family support, and medication adherence departed from normality (all $p < 0.001$). Spearman's rank correlation was therefore used to examine associations between the four prespecified explanatory variables and medication adherence. Analyses were based on the original questionnaire scores rather than the descriptive categories.

TB knowledge was positively associated with medication adherence ($r_s = 0.657$, $p < 0.001$). Positive associations were also observed for access to health facilities ($r_s = 0.517$, $p < 0.001$), self-efficacy ($r_s = 0.644$, $p < 0.001$), and family support ($r_s = 0.917$, $p < 0.001$).

The correlation between family support and medication adherence was particularly high. This result was considered when interpreting the multivariable analysis because the strength of the association may reflect, in part, overlap between the content of the predictor and outcome measures. The complete results are presented in Table 4.

Table 4. Spearman's Rank Correlations Between Phase I Factors and Medication Adherence

Variable	Spearman's rho	p-value	n
TB knowledge	0.657	<0.001	117
Access to health facilities	0.517	<0.001	117
Self-efficacy	0.644	<0.001	117
Family support	0.917	<0.001	117

Multivariable Analysis

Because medication adherence in the Phase I dataset was represented by two observed categories, good and moderate adherence, binary logistic regression was used. Good adherence was coded as 1 and moderate adherence as 0. TB knowledge, access to health facilities, self-efficacy, and family support were entered simultaneously into the model.

The overall model was statistically significant ($\chi^2 = 42.35$, $df = 4$, $p < 0.001$), with a Nagelkerke R^2 of 0.485. The Hosmer–Lemeshow test showed no evidence of poor model fit ($p = 0.742$).

After adjustment, TB knowledge was not significantly associated with good medication adherence (adjusted OR = 1.27, 95% CI 0.95–1.70, $p = 0.110$). Access to health facilities was also not statistically significant (adjusted OR = 1.36, 95% CI 0.96–1.94, $p = 0.085$). Self-efficacy was positively associated with good adherence (adjusted OR = 2.34, 95% CI 1.41–3.89, $p = 0.001$), while family support showed the strongest adjusted association (adjusted OR = 3.97, 95% CI 2.16–7.31, $p < 0.001$). VIF values ranged from 1.12 to 1.45 and tolerance values from 0.69 to 0.89, indicating no substantial multicollinearity among the predictors. However, these diagnostics do not address potential overlap between predictor and outcome measurement. Given the small number of participants in the moderate-adherence category and the strong association between family support and medication adherence, the regression estimates were interpreted cautiously.

Table 5. Binary Logistic Regression of Factors Associated with TB Medication Adherence

Predictor	B	SE	Wald	p-value	Adjusted OR	95% CI
TB knowledge	0.24	0.15	2.56	0.110	1.27	0.95–1.70
Access to health facilities	0.31	0.18	2.96	0.085	1.36	0.96–1.94
Self-efficacy	0.85	0.26	10.71	0.001	2.34	1.41–3.89
Family support	1.38	0.31	19.82	<0.001	3.97	2.16–7.31

Model diagnostics: $\chi^2 = 42.35$, $df = 4$, $p < 0.001$; Nagelkerke $R^2 = 0.485$; Hosmer–Lemeshow $p = 0.742$.

PHASE II RESULTS

Preliminary Internal Consistency of the Self-Talk Statements

Table 6. Preliminary Internal Consistency of the Self-Talk Statements

Variable	Cronbach's alpha	No. of statements	Interpretation
Self-talk statements	0.920	11	Internal consistency

Note: The 11 statements were used as components of the structured self-talk practice materials. The Cronbach's alpha value provides preliminary evidence of internal consistency among the statements and does not establish construct validity, criterion validity, or intervention effectiveness.

Phase II Baseline Characteristics

A total of 68 participants from the Phase I cohort were enrolled in Phase II according to the prespecified recruitment procedure. This group comprised all 18 participants classified as having moderate adherence and 50 of the 99 participants classified as having good adherence. Participants were subsequently allocated non-randomly according to their scheduled clinic visits, with 34 participants assigned to the structured self-talk intervention group and 34 to the control group.

The available baseline demographic, educational, treatment-eligibility, and study-specific modified 11-item medication adherence scores are presented by study group in Table 7. Because allocation was non-randomised, these descriptive data were not interpreted as evidence of baseline equivalence. All participants had received treatment for more than 6 months and were classified as having drug-susceptible pulmonary TB as required by the study eligibility criteria.

Table 7. Baseline Characteristics of Participants by Study Group (n = 68)

Characteristic	Control (n = 34)	Intervention (n = 34)
Age, mean $\pm$ SD	40.12 $\pm$ 11.50	38.95 $\pm$ 12.10
Male, n (%)	21 (61.8)	20 (58.8)
Female, n (%)	13 (38.2)	14 (41.2)
Primary education, n (%)	10 (29.4)	11 (32.4)
Secondary education, n (%)	19 (55.9)	18 (52.9)
Higher education, n (%)	5 (14.7)	5 (14.7)
Treatment duration >6 months, n (%)	34 (100.0)	34 (100.0)
Drug-susceptible pulmonary TB, n (%)	34 (100.0)	34 (100.0)
Baseline study-specific modified 11-item medication adherence score, mean $\pm$ SD	44.79 $\pm$ 2.90	44.74 $\pm$ 3.31

Note: Baseline characteristics are presented descriptively because group allocation was non-randomised. They were not interpreted as evidence of baseline equivalence.

Medication Adherence Before and After the Structured Self-Talk Intervention

Phase II medication adherence was assessed using the study-specific modified 11-item medication adherence questionnaire. The study-specific modified 11-item medication adherence questionnaire consists of 11 items scored on a five-point Likert scale, yielding a possible total score of 11–55, with higher scores indicating greater reported medication adherence. In the observed Phase II sample, study-specific modified 11-item medication adherence scores ranged from 40 to 54.

At baseline, the mean adherence score was 44.79 $\pm$ 2.90 in the control group and 44.74 $\pm$ 3.31 in the intervention group. After the 4-week intervention period, the mean score was 44.88 $\pm$ 2.83 in the control group and 47.88 $\pm$ 3.60 in the intervention group.

The mean change in adherence score was 0.09 points in the control group and 3.14 points in the intervention group. Thus, the unadjusted difference in mean change between the groups was 3.05 points. Because the change scores were non-normally distributed, medians and interquartile ranges are also presented in Table 8.

Table 8. Medication Adherence Before and After the Structured Self-Talk Intervention

Group	n	Pre-intervention Mean $\pm$ SD	Pre Median (IQR)	Post-intervention Mean $\pm$ SD	Post Median (IQR)	Mean Change
Control	34	44.79 $\pm$ 2.90	45.0 (43.0–47.0)	44.88 $\pm$ 2.83	45.0 (43.0–47.0)	+0.09
Intervention	34	44.74 $\pm$ 3.31	45.0 (42.0–47.0)	47.88 $\pm$ 3.60	48.0 (46.0–51.0)	+3.14

Primary Analysis of the Phase II Between-Group Association

The primary analysis evaluated the between-group difference in change in medication adherence. For each participant, the change score was calculated as:

Change score = post-intervention study-specific modified 11-item medication adherence score – pre-intervention study-specific modified 11-item medication adherence score.

Participants assigned to the structured self-talk intervention showed a greater increase in adherence scores than those in the control group. The mean change was 3.14 points in the intervention group and 0.09 points in the control group, corresponding to a descriptive difference in mean change of 3.05 points.

The median change was 0.00 in the control group and 3.00 in the intervention group. The between-group comparison was statistically significant ($U = 144.5$, $Z = -4.720$, $p < 0.001$).

The primary non-parametric between-group estimate was a Hodges–Lehmann location shift of 3.00 points (95% CI: 2.00–4.00). The standardised rank-based effect size was $r = 0.57$.

The 3.05-point difference in group mean change is presented as a descriptive summary, whereas the Hodges–Lehmann estimate represents the inferential non-parametric between-group location shift corresponding to the primary Mann–Whitney analysis.

Table 9. Primary Non-Parametric Comparison of Change in Study-Specific Modified 11-Item Medication Adherence Scores

Measure	Control	Intervention	Between-group result
n	34	34	—
Median change (IQR)	0.00 (0.00–0.00)	3.00 (1.00–5.00)	—
Mean change	0.09	3.14	Descriptive mean change difference = 3.05 points
Mean rank	22.75	46.25	—
Mann–Whitney U	—	—	144.5
Z	—	—	–4.720
p-value	—	—	<0.001
Hodges–Lehmann location shift	—	—	3.00 points
95% CI for Hodges–Lehmann location shift	—	—	2.00–4.00
Standardised effect size (r)	—	—	0.57

Note: The 3.05-point mean change difference is a descriptive difference between the group-specific mean change scores. The primary inferential estimate is the Hodges–Lehmann location shift from the Mann–Whitney U analysis, with its corresponding 95% confidence interval.

Within-Group Changes

As a supplementary analysis, within-group changes in medication adherence were examined using the Wilcoxon signed-rank test.

In the control group, three participants showed an increase in adherence, none showed a decrease, and 31 had unchanged scores. The within-group change was not statistically significant ($Z = -1.732$, $p = 0.083$).

In the intervention group, 27 participants showed increased adherence, none showed a decrease, and seven had unchanged scores. The within-group change was statistically significant ($Z = -4.570$, $p < 0.001$).

These within-group results were considered supplementary. The primary inference regarding the Phase II between-group association was based on the between-group comparison of change rather than on within-group statistical significance alone.

Table 10. Within-Group Changes in Medication Adherence

Group	n	Increased	Decreased	Ties	Z	p-value
Control	34	3	0	31	–1.732	0.083
Intervention	34	27	0	7	–4.570	<0.001

Adjusted Analysis of the Phase II Between-Group Association

Because Phase II group allocation was non-randomised and based on clinic attendance schedules, an adjusted analysis was performed using prespecified baseline covariates. Baseline study-specific modified 11-item medication adherence score, age, and sex were included as covariates.

In the ANCOVA model, the adjusted coefficient for assignment to the structured self-talk intervention was 3.08 points (95% CI: 1.85–4.31, $p < 0.001$), indicating higher post-intervention study-specific modified 11-item medication adherence scores in the self-talk assignment group after adjustment for baseline study-specific modified 11-item medication adherence score, age, and sex. This coefficient represents an adjusted between-group association and is distinct from the Hodges–Lehmann location shift of 3.00 points (95% CI: 2.00–4.00) obtained from the primary Mann–Whitney analysis.

Baseline study-specific modified 11-item medication adherence score was not statistically associated with the post-intervention score ($\beta = -0.12$, 95% CI: –0.35 to 0.11, $p = 0.302$). Age ($\beta = 0.01$, 95% CI: –0.04 to 0.06, $p = 0.741$) and sex (male vs female: $\beta = 0.25$, 95% CI: –0.65 to 1.15, $p = 0.580$) were also not statistically significant.

Table 11. Adjusted Between-Group Analysis of Post-Intervention Study-Specific Modified 11-Item Medication Adherence Score

Variable	Adjusted coefficient (β)	95% CI	p-value
Self-talk assignment	3.08	1.85–4.31	<0.001
Baseline study-specific modified 11-item medication adherence score	–0.12	–0.35–0.11	0.302
Age	0.01	–0.04–0.06	0.741
Sex (male vs female)	0.25	–0.65–1.15	0.580

Note: ANCOVA was conducted with post-intervention study-specific modified 11-item medication adherence score as the dependent variable, intervention assignment as the main independent variable, and baseline study-specific modified 11-item medication adherence score, age, and sex as covariates. The coefficient for assignment to the structured self-talk intervention represents the adjusted between-group difference in post-intervention study-specific modified 11-item medication adherence score conditional on the covariates; because allocation was non-randomised, it was interpreted as an adjusted association rather than a causal effect. The reported 95% CIs are confidence intervals for the corresponding ANCOVA coefficients and are distinct from the 95% CI for the Hodges–Lehmann location shift reported in Table 9.

DISCUSSION

This study identified several factors associated with TB medication adherence in Phase I and found a greater short-term improvement in self-reported adherence among participants assigned to the structured self-talk intervention in Phase II. In Phase I, TB knowledge, access to health facilities, self-efficacy, and family support were positively associated with adherence in bivariate analyses, while self-efficacy and family support remained significant in the multivariable model. In Phase II, the

intervention group showed a greater increase in the study-specific modified 11-item medication adherence score than the control group.

The Phase II finding should be interpreted within the quasi-experimental design. Because allocation was non-randomised, the observed between-group difference represents an association with intervention assignment rather than definitive evidence of a causal intervention effect. The short follow-up and self-reported outcome also limit conclusions regarding sustained behavioural or clinical benefit.

Patient Knowledge and TB Medication Adherence

TB-related knowledge was positively associated with medication adherence in Phase I. Understanding the disease, treatment duration, and possible consequences of treatment interruption may help patients recognise the importance of following the prescribed regimen. Knowledge can provide a basis for treatment-related decisions, although it does not necessarily translate into consistent medication-taking behaviour.

Previous studies have identified knowledge- and health literacy-related factors as relevant to TB control and treatment-related behaviour. A systematic review and meta-analysis found that health literacy is an important consideration in TB control, while studies from China and other settings have identified multiple patient-level determinants of TB treatment adherence (8,9,23). Limited knowledge may also coexist with misconceptions and other barriers that complicate treatment continuation (7,8). Evidence from chronic disease management also suggests that educational approaches may be more effective when integrated with broader adherence-support strategies rather than delivered as information alone (24).

These findings suggest that treatment knowledge may represent one component of adherence support. However, because Phase I used a cross-sectional design, the direction of the relationship cannot be established. Greater knowledge may contribute to adherence, but it may also develop through continued engagement with treatment. Knowledge should therefore be considered alongside other individual, social, and healthcare-related factors influencing medication-taking behaviour.

Access to Health Facilities and Medication Adherence

Access to health facilities was positively associated with medication adherence. Access involves not only the availability of healthcare services but also the ability to reach facilities, obtain medication regularly, maintain follow-up, and receive appropriate support from healthcare providers. Greater accessibility may reduce practical barriers that interfere with treatment continuation.

This interpretation is consistent with evidence showing that health-system responsiveness is associated with TB treatment adherence in Indonesian primary healthcare settings (25). Previous studies have also identified patient- and health-system-level barriers that may disrupt timely engagement with TB services (24,26). Evidence from Asian settings further indicates that treatment interruption is influenced by multiple contextual and patient-level factors (24).

Nevertheless, access and adherence were measured during the same Phase I assessment. Therefore, the observed association does not demonstrate that improved access directly causes better medication-taking behaviour.

The Role of Self-Efficacy in TB Treatment Adherence

Self-efficacy was positively associated with medication adherence in Phase I. Patients who had greater confidence in maintaining treatment may have been better able to manage challenges such as medication side effects, treatment fatigue, and social pressures.

This finding is consistent with previous evidence identifying self-efficacy as an important factor associated with medication adherence in chronic diseases (13). Research on chronic disease self-management has also examined self-efficacy as a pathway linking health literacy with self-management behaviour (27). In addition, behavioural-health research in Indonesia has highlighted the contribution of perceived behavioural control, social support, and psychosocial factors to health-related intentions and behaviours (28).

These findings suggest that self-efficacy may operate within a broader behavioural context rather than as an isolated determinant of adherence. However, the present study does not establish a causal pathway between self-efficacy and medication adherence.

Self-efficacy was assessed only in Phase I and was not reassessed after the intervention. Therefore, this study cannot determine whether structured self-talk influenced self-efficacy or whether changes in self-efficacy contributed to the Phase II findings. Importantly, Phase I results were not used to modify the intervention content, dose, or delivery. The structured self-talk intervention had been prespecified based on SCT, the study protocol, and relevant literature.

Family Support and TB Medication Adherence

Family support showed the strongest observed association with medication adherence among the Phase I variables. This finding highlights the importance of the social environment in which patients manage a prolonged TB treatment regimen. Family members may provide encouragement, practical assistance, and reminders that support treatment routines (29,30).

Previous studies have similarly reported relationships between family involvement and TB treatment adherence. Evidence from Indonesia has linked family support and motivation with TB treatment adherence, while a scoping review has described the contribution of family support to medication adherence and quality of life among patients with TB (29,31). Studies among pulmonary TB patients in Uganda have also identified family support as an important social factor in the treatment context (30).

Family support may provide both practical and emotional resources that help patients maintain long-term treatment routines. This interpretation is relevant because structured self-talk was examined as an individual-level behavioural strategy and was not intended to replace family support or healthcare-based support.

The strength of the association should nevertheless be interpreted cautiously. The high correlation between family support and medication adherence may partly reflect conceptual overlap or common response tendencies because both variables were measured using self-reported questionnaires during the same phase. Although the VIF results indicated no substantial multicollinearity among predictors, they cannot exclude overlap between the predictor and outcome measures.

Association Between Assignment to the Structured Self-Talk Intervention and Medication Adherence

The Phase II results showed greater short-term improvement in self-reported medication adherence, measured using the study-specific modified 11-item medication adherence questionnaire, among participants assigned to the structured self-talk intervention than among those in the control group. The primary comparison was based on the between-group change in the study-specific modified 11-item medication adherence score, and the adjusted ANCOVA analysis produced a similar result. Because allocation was non-randomised, the findings should be interpreted as an association between intervention assignment and short-term improvement rather than definitive evidence of a causal effect.

The structured self-talk intervention consisted of structured statements and practice worksheets addressing treatment commitment, confidence in maintaining medication-taking behaviour, coping with treatment difficulties, and regular medication-taking. Therefore, the intervention is more accurately described as a structured self-talk intervention rather than a broader cognitive-behavioural intervention. Broader cognitive-behavioural techniques were not included.

The Phase II findings should be considered within the broader literature on psychological and behavioural approaches to medication adherence. Previous reviews have reported relationships between psychological factors and medication adherence in chronic diseases, while communication- and behaviour-based interventions have also been examined in TB care (32–34). A systematic review of communication strategies in TB treatment provides evidence that communication approaches may influence treatment adherence and treatment success (34). However, these studies do not establish that self-talk itself was the mechanism responsible for the observed improvement.

Evidence specifically examining structured self-talk for TB medication adherence remains limited. Existing self-talk research has primarily focused on other behavioural and psychological outcomes rather than TB medication-taking behaviour (15, 17, 20). Therefore, this study provides preliminary evidence from a TB treatment context but does not confirm an established self-talk mechanism.

Social Cognitive Theory provides a theoretical basis for considering self-regulation and self-efficacy as possible pathways. However, neither construct was reassessed after the intervention, and mediation analysis was not performed. Consequently, the mechanism underlying the observed improvement remains uncertain. The findings should therefore be interpreted as an improvement in self-reported medication adherence associated with intervention assignment rather than evidence of a specific psychological pathway.

Public Health Implications

The findings support a multidimensional approach to TB medication adherence that considers treatment knowledge, access to care, self-efficacy, family support, and individual behavioural strategies.

The structured self-talk intervention may represent a feasible adjunct to routine adherence counselling because it can be delivered through brief instructions and standardised practice materials. In this study, it was provided alongside standard TB care and pharmaceutical counselling. Its potential role in routine services should therefore be considered complementary rather than a replacement for established adherence-support strategies.

Further research is needed to assess feasibility, acceptability, adherence to the self-talk practice itself, and whether the observed improvement in study-specific modified 11-item medication adherence scores is maintained over longer treatment periods and accompanied by meaningful clinical outcomes.

Study Limitations

Several limitations should be considered. First, the non-randomised allocation in Phase II may have introduced selection bias. Although ANCOVA adjusted for baseline adherence score, age, and sex, residual confounding cannot be excluded. Participants and the researcher were also aware of group allocation, and outcome assessment was not blinded. These conditions may have contributed to performance or reporting bias.

Medication adherence was self-reported, which may have introduced recall and social-desirability bias. In addition, different adherence measures were used in Phase I and Phase II. The Phase I questionnaire was used to identify participants for Phase II, whereas the study-specific modified 11-item medication adherence questionnaire was used to assess change following the intervention. Direct comparison of adherence scores between the two phases is therefore not appropriate.

The study was conducted in a single referral hospital with military hospital characteristics. The findings may not be directly transferable to primary care or community-based TB services. Other potentially relevant characteristics, including economic status and employment stability, were not examined in depth. The relatively high Nagelkerke R^2 in the Phase I model should also be interpreted cautiously because the strong association between family support and adherence, together with the small number of participants in the moderate-adherence category, may have contributed to model instability.

The Phase II follow-up lasted only 4 weeks. The study therefore cannot determine whether the improvement in self-reported adherence was maintained throughout the full TB treatment period. Treatment completion, bacteriological response, relapse, and other clinical outcomes were not assessed. Self-talk practice was recorded using self-reported logs, but these records were not independently verified and were not included in the analysis of the between-group association.

Because Phase II participants were drawn from the Phase I cohort and required treatment duration >6 months and a Phase I adherence score of 8–20, the Phase II findings may not generalise to newly diagnosed patients, patients earlier in treatment, or those with poor adherence. The Phase II dataset did not contain additional baseline clinical treatment characteristics beyond treatment duration and drug-susceptibility status. Therefore, potential differences between groups in other treatment-related or clinical characteristics could not be assessed, and residual confounding cannot be excluded.

CONCLUSION

This study identified self-efficacy and family support as factors independently associated with medication adherence among patients with pulmonary tuberculosis. TB knowledge and access to health facilities were positively associated with adherence in bivariate analyses; however, these associations were not retained after adjustment. Because Phase I used a cross-sectional design, these findings should be interpreted as associations rather than causal relationships.

In Phase II, assignment to the prespecified structured self-talk intervention was associated with greater short-term improvement in self-reported medication adherence measured using the study-specific modified 11-item medication adherence questionnaire than assignment to the control condition receiving routine care. The primary non-parametric analysis showed a Hodges–Lehmann location shift of 3.00 points (95% CI: 2.00–4.00), while the adjusted ANCOVA showed an adjusted between-group coefficient of 3.08 points (95% CI: 1.85–4.31). These findings should be interpreted cautiously because allocation was non-randomised, adherence was assessed using a self-reported measure, and follow-up was limited to 4 weeks.

The study does not establish sustained adherence improvement or clinical outcomes, nor does it confirm the mechanism underlying the observed association. Future randomised studies with longer follow-up periods, objective adherence indicators, and relevant TB treatment outcomes are needed to determine the reproducibility and longer-term relevance of structured self-talk interventions.

DECLARATIONS

Author contributions: Conceptualization: Tiwik Eriskawati, Chatarina Umbul Wahyuni, Joko Prasetyo, and Agustin Widyowati. Methodology: Tiwik Eriskawati, Chatarina Umbul Wahyuni, and Joko Prasetyo. Investigation and data collection: Tiwik Eriskawati. Data curation: Tiwik Eriskawati. Formal analysis: Tiwik Eriskawati and Chatarina Umbul Wahyuni. Interpretation of findings: Tiwik Eriskawati, Chatarina Umbul Wahyuni, Joko Prasetyo, and Agustin Widyowati. Writing – original draft preparation: Tiwik Eriskawati. Writing – review and editing: Chatarina Umbul Wahyuni, Joko Prasetyo, and Agustin Widyowati. Supervision: Chatarina Umbul Wahyuni. Project administration: Tiwik Eriskawati.

All authors have read and approved the final version of the manuscript. All authors agree to be accountable for all aspects of the work, including ensuring the integrity, accuracy, and transparency of the research process and its reported findings.

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The use of AI-assisted technology was restricted to editorial support and did not replace the authors' intellectual contributions. The study concept, research design, data collection, statistical analysis, interpretation of findings, and scientific conclusions were developed and determined by the authors.

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