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From Knowledge to Treatment Adherence: A Pre-Post Questionnaire-Based Study among Tuberculosis Patients in Primary Healthcrae Centers

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Tuberculosis remains a major public health problem that requires serious attention, particularly with regard to treatment success, which is highly dependent on patient adherence. Low levels of treatment adherence are frequently associated with limited patient knowledge about the disease, the therapeutic process, and the potential risks of incomplete treatment. This study aims to analyze changes in patients' knowledge levels following an educational intervention and to examine the influence of knowledge on treatment adherence in tuberculosis management within primary healthcare settings. This study employed a quantitative approach with a pre-experimental one-group pre-post design. Data were collected using structured questionnaires administered before and after the intervention, involving 30 tuberculosis patients ($n = 30$) from 17 primary healthcare centers in Baubau City. Data analysis was conducted using descriptive statistics, paired t-test, and multiple linear regression analysis. The results showed a significant improvement in patients' knowledge and treatment adherence following the intervention, with the mean knowledge score increasing from 14.10 to 17.20 and statistically significant differences observed between pre- and post-intervention measurements ($p < 0.05$). Furthermore, regression analysis indicated that patient knowledge had a significant effect on treatment adherence ($\beta = 0.354$; $p = 0.015$), demonstrating that higher levels of knowledge contribute to better adherence behavior. These findings emphasize that enhancing patient knowledge is a key factor in the successful management of tuberculosis and should be supported through continuous, contextual, and behavior-oriented educational interventions aimed at achieving long-term behavioral change.

Keywords: Educational intervention, Patient knowledge, Treatment adherence, Tuberculosis management

INTRODUCTION

Tuberculosis (TB) remains one of the major public health problems worldwide, particularly in developing countries where the disease burden remains high. TB not only affects individual health status but also generates significant social and economic consequences, including reduced work productivity, increased treatment-related costs, and persistent social stigma toward affected individuals. The high incidence of TB indicates that disease control efforts continue to face substantial challenges, both in terms of healthcare system capacity and community behaviors related to prevention and treatment (Shi et al., 2024). The success of TB control programs is not determined solely by the availability of healthcare services and effective anti-tuberculosis drugs, but also depends heavily on patients' adherence to long-term treatment regimens. TB treatment requires a relatively prolonged duration and demands a high level of patient commitment to taking medication consistently

and in accordance with prescribed schedules (Abbas et al., 2023; Baker et al., 2025; Zheng, 2024). This requirement often becomes a major barrier, particularly for patients with limited knowledge, inadequate social support, or those experiencing adverse drug effects during therapy (Huang, 2022).

Non-adherence to TB treatment can result in serious consequences for both patients and the wider community. These consequences include treatment failure, disease relapse, and an increased risk of TB transmission to others within the surrounding environment. Furthermore, non-adherence may contribute to the emergence of drug-resistant TB, which requires longer treatment durations, incurs higher costs, and is associated with lower treatment success rates compared to drug-susceptible TB (Chen et al., 2022; Octavia et al., 2024). Therefore, improving patient adherence represents a critical component of sustainable

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tuberculosis management. Various strategies should be developed to enhance adherence, including continuous health education, patient support throughout the treatment period, and the strengthening of family and healthcare provider involvement (Octavia et al., 2024). A comprehensive, patient-centered approach is expected to improve treatment adherence, reduce therapy failure rates, and support the gradual achievement of TB elimination targets.

One of the key factors influencing treatment adherence is the level of patients' knowledge regarding tuberculosis, which includes an understanding of the causes and modes of transmission of the disease, the duration and phases of therapy, the benefits of adhering to treatment regularly, and the risks and consequences of suboptimal or incomplete treatment (Perwitasari et al., 2023). Adequate knowledge is expected to enhance patients' awareness of the importance of completing the full course of therapy, even when clinical symptoms have improved. With sufficient understanding, patients tend to develop a more rational perception of their illness, which in turn facilitates the formation of positive attitudes and a stronger commitment to adhering to treatment recommendations provided by healthcare professionals (Claassens et al., 2025). In addition to knowledge, other factors such as internal motivation, family support, socioeconomic conditions, medication side effects, and the quality of patient-provider interactions also influence adherence behaviours (Qu et al., 2022; Ricci-Maccarini et al., 2025). Therefore, a more systematic and comprehensive evaluation is required to assess the extent to which changes in knowledge translate into actual treatment adherence among patients with tuberculosis. Such evaluation is essential as a foundation for designing educational and supportive interventions that not only enhance knowledge but also effectively promote sustained behavioural change in treatment adherence (Valls-Bautista & Álvarez-Herrero, 2025).

Based on these considerations, a pre-post evaluation using questionnaire-based instruments represents a relevant and appropriate approach for assessing changes in patients' knowledge and treatment adherence in tuberculosis management (Aguilar et al., 2024; Harna et al., 2022; Wiranti et al., 2024). This approach enables researchers to quantitatively measure differences before and after educational interventions or TB management programs, while also identifying the relationship between improvements in knowledge and treatment adherence (Elnaby et al., 2025; Overbeck et al., 2024). Consequently, the findings of this study are expected to provide robust empirical evidence to support the development of more effective educational strategies and intervention programs aimed at enhancing treatment adherence among patients with tuberculosis.

The implementation of pre-post evaluations in tuberculosis management faces complex methodological and contextual challenges (AlHamawi et al., 2022; Berg

et al., 2025; Oamen et al., 2024). The assessment of treatment adherence relying on self-reported questionnaires is susceptible to social desirability bias and potential inaccuracies in patient responses (Hossain et al., 2024). Environmental factors such as social stigma, family support, economic pressures, and access to healthcare services play a critical role in shaping patient behavior, yet these factors are often not comprehensively addressed within existing evaluation frameworks (Dey et al., 2022; Zago et al., 2022). These challenges highlight the need for more systematic and empirically grounded evaluative approaches capable of bridging the gap between knowledge acquisition and actual treatment adherence in tuberculosis management (Tian & Wang, 2023).

Several previous studies have examined the relationship between knowledge, attitudes, and treatment adherence in tuberculosis management, yielding mixed findings. Studies conducted by (Ardenny et al., 2025; Çapuk & Aylaz, 2025) indicate that patients' knowledge of tuberculosis contributes to treatment adherence, although it does not consistently function as the primary determinant of treatment behavior. Other research has highlighted the significant influence of psychosocial and contextual factors, such as stigma and social support, on patient adherence (Berahim et al., 2025; Setyawati et al., 2025). Similar findings were reported by (Hosseini et al., 2025), who emphasized that adherence to tuberculosis treatment is shaped by a complex interaction of individual, family, and healthcare system factors. Educational-based studies have also demonstrated improvements in patient knowledge following interventions; however, their impact on treatment adherence has not been consistently sustained when measured longitudinally (Asokan et al., 2025; Mahapatra & Ford, 2024). Meanwhile, a study by (Sun et al., 2025) underscored the importance of pre-post evaluation designs using standardized instruments to more accurately capture behavioral change. Overall, these findings suggest the need for research that specifically evaluates the transformation of patient knowledge into treatment adherence through a valid and reliable questionnaire-based pre-post approach.

Previous studies have consistently reported that tuberculosis-related knowledge is associated with treatment adherence and that educational interventions can improve patients' understanding of the disease. However, most existing studies have predominantly employed cross-sectional or correlational designs, limiting their ability to explain how improvements in knowledge are transformed into actual adherence behavior over time. In addition, previous research has often examined cognitive factors separately from contextual and behavioral dimensions, resulting in an incomplete understanding of the mechanisms linking knowledge acquisition to sustained treatment adherence. Evidence derived from primary healthcare settings, particularly in

community-based tuberculosis programs in Indonesia, also remains limited. Therefore, a significant research gap exists regarding the longitudinal evaluation of how changes in patients' knowledge contribute to treatment adherence following educational interventions. Addressing this gap, the present study employs a questionnaire-based pre-post evaluation design to assess changes in both tuberculosis-related knowledge and treatment adherence among patients in primary healthcare centers in Baubau City. The novelty of this study lies in its focus on capturing the dynamic transformation of knowledge into adherence behavior through a pre-post approach, thereby providing contextual empirical evidence that extends beyond the predominantly cross-sectional findings reported in previous tuberculosis adherence research.

A significant research gap is evident in the predominance of correlational analyses, which remain limited in their ability to explain the underlying mechanisms through which specific factors influence patient adherence in depth. Moreover, the widespread use of cross-sectional designs constrains the capacity of existing studies to capture dynamic changes in adherence behavior over time (Ferdous, 2022). Methodological issues also pose a challenge, as questionnaire-based instruments employed in many studies tend to be largely descriptive and have not been optimally utilized as tools for evaluating behavioral change (Ruoslahti & Lonka, 2025; Walujo & Jannah, 2022). Comprehensive understanding is further hindered by the frequent separation of cognitive and social factors, resulting in an incomplete depiction of their interaction in shaping treatment adherence. Finally, the limited availability of contextual evidence, particularly within primary healthcare settings and community-based contexts highlights the need for more contextualized and integrative research approaches to strengthen understanding of tuberculosis treatment adherence (Chakraborty et al., 2022).

Tuberculosis management in primary healthcare centers in Baubau City continues to demonstrate a gap between improvements in patients' knowledge and sustained treatment adherence. The primary issue lies in the implementation of educational interventions that predominantly emphasize information delivery, while empirical evidence regarding actual changes in patients' adherence behavior has not been systematically documented. Challenges also arise in monitoring the dynamics of changes in knowledge and adherence, as evaluations are generally cross-sectional in nature and have not consistently applied pre-post designs. Furthermore, the use of questionnaire-based instruments in primary healthcare settings remains largely descriptive and has not been fully utilized as an evaluative tool capable of accurately capturing behavioral changes in patients within the social and healthcare service context of an urban setting such as Baubau City.

A questionnaire-based pre-post evaluation approach is proposed as a solution to address the gap between patient knowledge and treatment adherence in tuberculosis management. This design enables the systematic measurement of changes in patients' knowledge and adherence before and after educational interventions, thereby providing empirical evidence on the effectiveness of tuberculosis management practices implemented in primary healthcare centers. The use of standardized and validity-tested questionnaires also plays a crucial role in improving data accuracy and minimizing measurement bias. The integration of evaluation findings is expected to serve as a foundation for refining more contextualized and behavior-oriented educational and patient support strategies for tuberculosis care. Accordingly, the research problem is formulated to examine the extent to which improvements in patients' knowledge contribute to treatment adherence in tuberculosis management at primary healthcare centers in Baubau City. The distinct contribution of this study lies in its evaluative focus, which not only assesses patient conditions at a single point in time but also traces sequential changes through a pre-post design. The empirical evidence generated by this study has the potential to offer practical contributions to strengthening tuberculosis control programs in primary healthcare settings, while also enriching the scientific discourse on the transformation of knowledge into treatment adherence within urban contexts

METHODS

This study was conducted in 17 primary healthcare centers (Puskesmas) across Baubau City, representing the primary healthcare setting for tuberculosis management. The study participants consisted of 30 tuberculosis patients ($n = 30$) who were undergoing treatment during the study period. The sampling technique employed was purposive sampling, based on specific considerations aligned with the research objectives. The inclusion criteria comprised patients aged ≥ 18 years, registered as active tuberculosis patients undergoing anti-tuberculosis therapy, possessing adequate communication abilities, and willing to participate in all stages of the study, including the completion of both pretest and posttest questionnaires. In addition, patients who did not complete all stages of the study or who experienced health conditions that prevented optimal participation were excluded from the analysis. The relatively small sample size was primarily due to the limited number of active tuberculosis patients who met the inclusion criteria during the study period, as well as operational constraints in accessing respondents across different primary healthcare centers. Therefore, this study is categorized as a preliminary (pilot) study aimed at generating initial empirical evidence regarding changes in patient knowledge and treatment adherence within the context of primary healthcare services. The

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findings of this study are expected to serve as a foundation for future research with larger sample sizes and broader geographical coverage

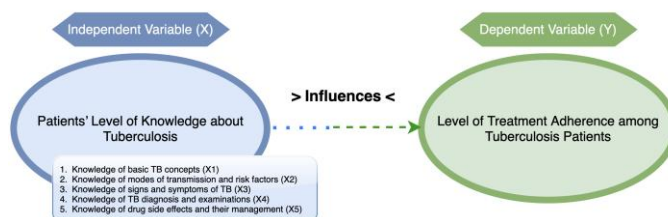


Figure 2. Research Variables

The figure illustrates the conceptual framework of the study, depicting the relationship between the independent and dependent variables. The independent variable (X) is patients' level of knowledge about tuberculosis, which comprises several knowledge dimensions, including knowledge of basic tuberculosis concepts, modes of transmission and risk factors, signs and symptoms of tuberculosis, tuberculosis diagnosis and examinations, as well as drug side effects and their

management (Nizamani et al., 2025) (Ardenny et al., 2025). This variable is assumed to exert a direct influence on the dependent variable (Y), namely the level of treatment adherence among tuberculosis patients (König & Suhr, 2023). The directional arrows in the diagram emphasize that an increase in patients' knowledge of tuberculosis is expected to promote better treatment adherence, thereby supporting treatment success and the sustainable control of tuberculosis.

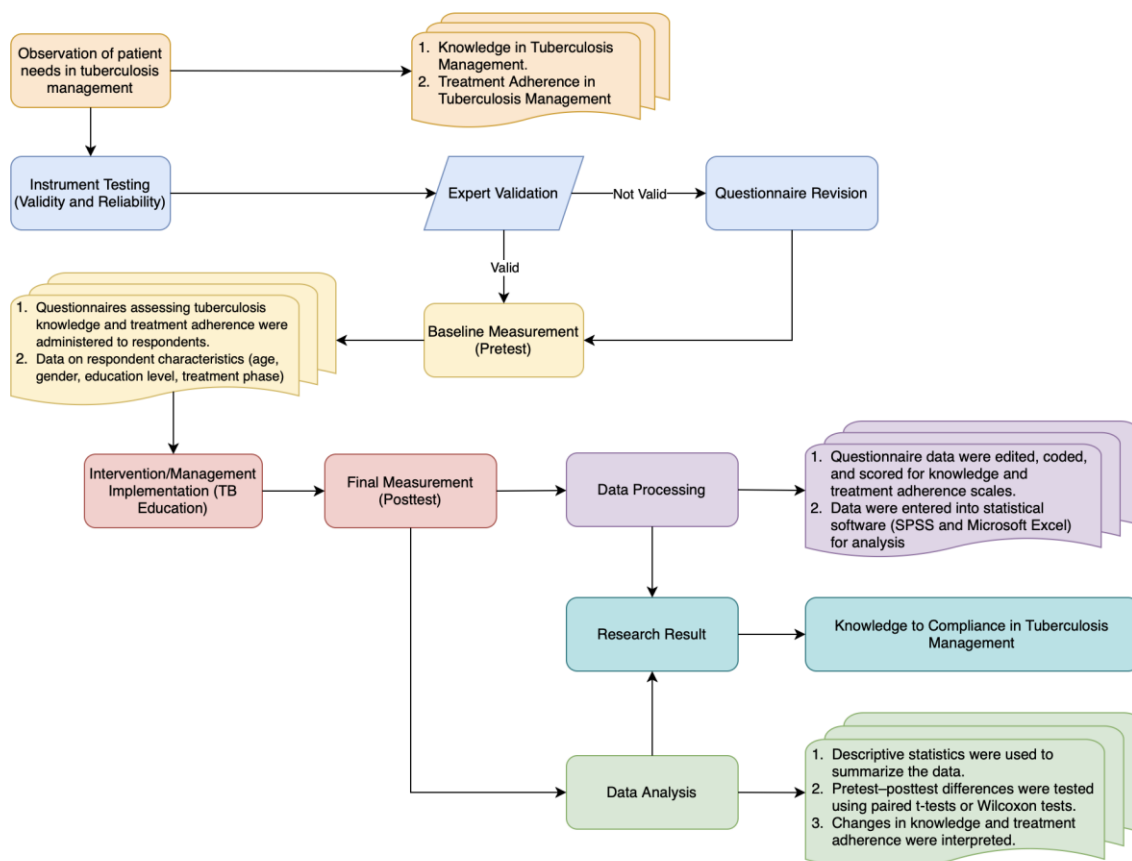


Figure 3. Research Process (Flow Diagram of the Study)

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Data were collected using structured questionnaires consisting of two instruments: a knowledge questionnaire and a treatment adherence questionnaire. The knowledge questionnaire covered several dimensions, including basic concepts of tuberculosis, modes of transmission and risk factors, signs and symptoms, diagnostic procedures and treatment, as well as drug side effects and their management (Solanki et al., 2022). The adherence questionnaire was designed to assess patients’ level of compliance with treatment regimens in accordance with healthcare providers’ recommendations. All items were measured using a Likert scale. Prior to data collection, the instruments underwent validity and reliability testing. Content validity was assessed through expert evaluation, while construct validity was examined using item–total correlation analysis. The reliability test results indicated good internal consistency, with Cronbach’s alpha values exceeding 0.70, suggesting that the instruments were sufficiently reliable for measuring the study variables.

The intervention implemented in this study consisted of a structured health education program on tuberculosis delivered to the respondents (Roja et al., 2022). The educational content included fundamental knowledge of tuberculosis, transmission pathways, clinical symptoms, treatment procedures, the importance of medication adherence, and the management of drug side effects. The intervention was delivered through lecture-based and interactive discussion methods, supported by educational media such as leaflets and visual presentation materials (Guzmán et al., 2024). Each educational session lasted approximately 45–60 minutes and was conducted by healthcare personnel with competencies in tuberculosis services at primary healthcare centers. The data collection process was carried out in two stages: pretest and posttest. The pretest was administered prior to the intervention to assess baseline levels of patients’ knowledge and treatment adherence. Following the educational

intervention, the posttest was conducted using the same instruments to measure changes in both variables.

Data analysis involved several data processing stages, including editing, coding, and scoring, to ensure data completeness and consistency {Formatting Citation}. The processed data were then entered into statistical software packages, such as SPSS and Microsoft Excel, for systematic analysis. Descriptive statistics were initially used to describe respondents’ characteristics and the distribution of knowledge and treatment adherence levels before and after the intervention. Subsequent analyses focused on testing differences between pretest and posttest results (Donkor et al., 2025). Statistical tests were selected based on data characteristics, using a paired t-test for normally distributed data or the Wilcoxon signed-rank test for non-normally distributed data (Davis et al., 2024). The results of these analyses were used to interpret changes in patients’ knowledge and treatment adherence in tuberculosis management. The final findings were presented as study outcomes illustrating the relationship between improvements in patient knowledge and adherence to tuberculosis treatment.

RESULTS AND DISCUSSION

Educational interventions in tuberculosis management at primary healthcare centers in Baubau City have proven to be effective in improving patients’ knowledge of tuberculosis and promoting increased treatment adherence. This improvement is evidenced by significant differences in knowledge and adherence scores between pre-intervention and post-intervention measurements. The statistical test results confirm that the observed changes are meaningful, indicating that the intervention produced a tangible impact on patient behavior. Furthermore, the increase in patients’ knowledge contributed positively to treatment adherence, demonstrating that strengthening cognitive aspects through educational interventions plays a critical role in supporting the successful management of tuberculosis in primary healthcare settings.

Table 1.
Descriptive Statistics of Patients’ Knowledge Levels about Tuberculosis

Knowledge Variable	Minimum	Maximum	Mean	Std. Deviation
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(X1) Knowledge of basic tuberculosis concepts	8	20	14.10	3.12
(X2) Knowledge of modes of transmission and risk factors	7	22	14.87	3.45
(X3) Knowledge of signs and symptoms of tuberculosis	9	24	16.03	3.68
(X4) Knowledge of tuberculosis examination and treatment	10	25	17.20	3.94
(X5) Knowledge of drug side effects and their management	6	21	13.56	3.27

Valid N (listwise) = 30

Table 1 presents the descriptive statistics of patients' knowledge levels about tuberculosis among 30 respondents. Overall, the minimum and maximum values across all knowledge variables indicate considerable variation in patients' understanding of tuberculosis-related information. The relatively wide score ranges suggest heterogeneous levels of knowledge across respondents, reflecting differences in comprehension of both theoretical and practical aspects of tuberculosis. Among the five knowledge domains, the highest mean score was observed in knowledge related to tuberculosis examination and treatment, indicating relatively better patient understanding of clinical management aspects. In contrast, the lowest mean score was found in knowledge of drug side effects and their management, highlighting a potential knowledge gap in areas directly associated with treatment safety and adherence. The standard deviation values demonstrate moderate variability across all domains, suggesting that patients' knowledge levels were not evenly distributed and may require targeted educational interventions to address specific deficiencies.

Variable (X1), knowledge of basic tuberculosis concepts, the mean score was 14.10 with a standard deviation of 3.12, and scores ranged from 8 to 20. These results indicate that, on average, patients' knowledge was at a moderate level, although some respondents demonstrated relatively low levels of understanding. The moderate standard deviation suggests a noticeable degree of variability in knowledge scores among patients. Variables (X2) and (X3) showed higher mean values compared to X1. Knowledge of modes of transmission and risk factors for tuberculosis (X2) had a mean score of 14.87 with a standard deviation of 3.45, while knowledge of signs and symptoms of tuberculosis (X3) yielded a mean of 16.03 and a standard deviation of 3.68. These findings indicate that most patients had a relatively better

understanding of disease transmission, risk factors, and clinical manifestations, although inter-individual variation in knowledge levels remained evident. The highest mean score was observed for variable (X4), knowledge of tuberculosis examination and treatment, with a mean of 17.20 and a standard deviation of 3.94, reflecting a comparatively stronger level of understanding in this domain. In contrast, variable (X5), knowledge of drug side effects and their management, recorded the lowest mean score at 13.56 with a standard deviation of 3.27 and a minimum score of 6. This finding indicates that patients' knowledge regarding anti-tuberculosis drug side effects and appropriate management remains limited and requires more focused and sustained educational interventions.

This analysis aims to identify the general tendencies of the data, the central tendency of scores, and the variability in respondents' understanding prior to conducting further statistical analyses. By examining the characteristics of the data at an early stage, researchers are able to assess the baseline level of patients' knowledge and identify potential gaps in understanding that require particular attention. In addition, the presentation of descriptive statistics serves as a foundation for interpreting the effectiveness of the educational intervention or program implemented. Information on mean values, data dispersion, and minimum and maximum scores provides important context for evaluating the extent to which patients' knowledge has been established and how it varies across individuals. Therefore, visualizing the distribution and characteristics of patients' knowledge levels regarding basic tuberculosis concepts allows the data to be presented more clearly and facilitates easier interpretation.

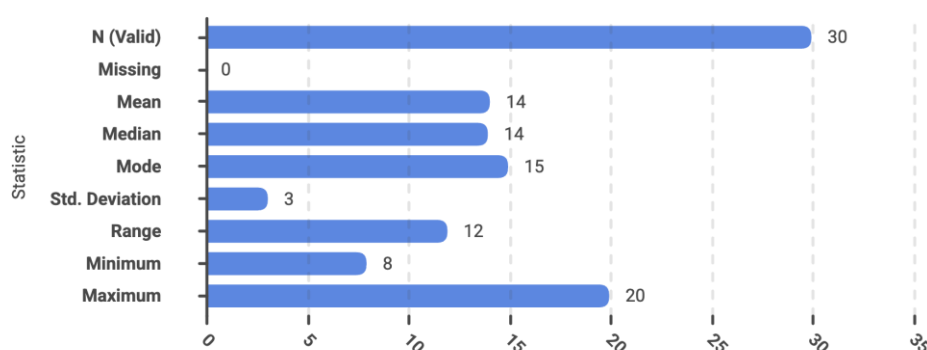


Figure 4. Descriptive Statistics for Knowledge of Basic Concepts of Tuberculosis

The descriptive statistical results for the variable *Knowledge of Basic Concepts of Tuberculosis* were obtained from 30 respondents. All data were deemed valid ($N = 30$) with no missing values

(missing = 0), indicating that the data collection process was conducted effectively and that the instrument successfully captured responses from all study participants. This completeness of data allows the

analysis to fully represent the respondents' knowledge levels. The mean and median values, both equal to 14, indicate a relatively symmetrical data distribution without extreme deviations. The consistency between the mean and median suggests that most respondents' knowledge levels were clustered around this value, which can be categorized as a moderate level of understanding of basic tuberculosis concepts. The mode value of 15 represents the most frequently occurring score among respondents, indicating that a substantial proportion of patients possessed knowledge levels slightly above the average. This finding suggests a general tendency toward a fairly adequate level of understanding, although it has not yet reached a high category. The standard deviation of 3 reflects a moderate level of variability, indicating differences in knowledge levels among respondents that are present but not extreme. Overall, while variations in understanding exist, most respondents' scores remain relatively close to the mean value.

The score range of 12, with a minimum value of 8 and a maximum value of 20, indicates a clear difference between respondents with the lowest and highest levels of knowledge. The relatively low minimum score suggests that some patients still have limited understanding of the basic concepts of tuberculosis, whereas the high maximum score reflects the presence of respondents who already possess a good level of knowledge. Overall, the descriptive statistical results presented in Figure 3

illustrate that patients' knowledge of basic tuberculosis concepts falls within a moderate category, with a fairly wide variation across respondents. These findings emphasize the importance of implementing more structured and sustained health education programs to improve patients' understanding in a more equitable manner, particularly for those who continue to demonstrate low levels of knowledge.

Descriptive statistical results are employed to provide an initial overview of changes in treatment adherence levels among tuberculosis (TB) patients before and after the implementation of the TB management program. These statistics illustrate the distribution of patients across adherence categories: low, moderate, and high, expressed as percentages. By comparing pre-intervention and post-intervention conditions, descriptive analysis reveals general trends and patterns in patient adherence without yet assessing statistical significance. The visualization below summarizes the influence of the TB management program on patient adherence behavior. The comparison highlights observable shifts in adherence levels, reflecting patients' responses to the educational, monitoring, and support components integrated into the program. Such descriptive findings serve as an essential foundation for subsequent inferential analyses and contribute to a clearer understanding of the program's practical impact on treatment adherence.

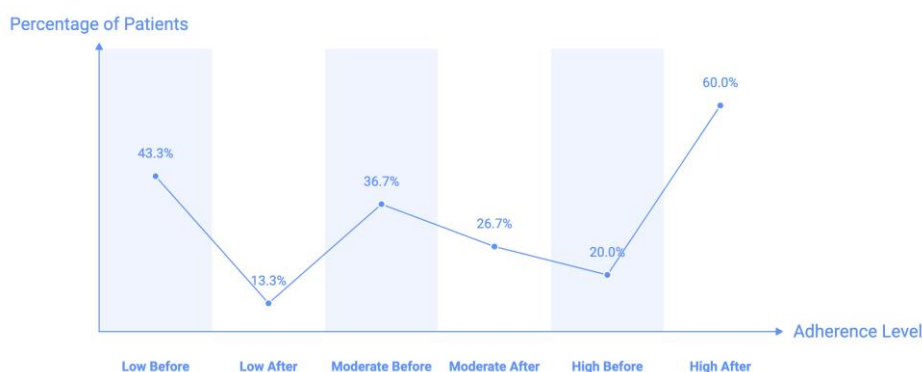


Figure 5. Descriptive Statistical Results of Tuberculosis Patients' Treatment Adherence Levels Before and After the TB Management Program

Based on the figure, a substantial decrease is observed in the proportion of patients with low adherence following the TB management program. Before the intervention, patients categorized as having low adherence accounted for 43.3%, whereas after the program this proportion declined sharply to 13.3%. This reduction indicates that the program was effective in addressing barriers that previously contributed to poor treatment compliance. In the moderate adherence category, the percentage of patients also shows a downward trend, decreasing from 36.7% before the program to 26.7% afterward. Although the decline is less pronounced than in the low adherence group, this shift

suggests that some patients who were previously moderately adherent progressed toward a higher level of adherence as a result of the intervention. Conversely, the high adherence category demonstrates a marked increase after the TB management program. Prior to the intervention, only 20.0% of patients were classified as having high adherence. Following the program, this figure rose significantly to 60.0%, indicating a strong positive shift toward optimal treatment compliance. Overall, the descriptive statistical results illustrate a clear redistribution of patients from lower and moderate adherence levels to high adherence after the implementation of the TB management program. These

findings suggest that the program played a critical role in improving patient commitment to TB treatment regimens, which is a key factor in treatment success, prevention of drug resistance, and overall TB control efforts.

Statistical Significance of Pre- and Post-Intervention Differences

The statistical tests conducted to compare pre-intervention and post-intervention conditions revealed significant differences in both patients' knowledge scores and levels of treatment adherence. The obtained significance values (p-values) were below the established threshold ($p < 0.05$), indicating that the observed changes were not attributable to chance but rather represented a direct effect of the intervention. These findings confirm that the educational intervention had a statistically meaningful impact on improving patients' understanding of tuberculosis as well as enhancing their adherence to treatment. The significant post-intervention increases in both knowledge and adherence suggest that the educational program was effective and holds strong

potential as a sustainable strategy for improving treatment outcomes and supporting tuberculosis control efforts.

Normality testing is an essential preliminary step in quantitative data analysis to ensure that the data meet specific statistical assumptions. The results of the normality test determine the most appropriate type of comparative analysis to be applied in subsequent stages, namely whether parametric or nonparametric tests should be used. As such, this testing procedure constitutes a crucial methodological foundation for maintaining the validity and accuracy of the study's conclusions. In this study, normality testing was conducted using the Shapiro–Wilk test, which is recommended for small to moderate sample sizes ($n < 50$). The decision criteria were based on the significance value (p-value), where $p > 0.05$ indicates that the data are normally distributed, while $p < 0.05$ suggests a non-normal distribution. Through this approach, the distribution of pre-intervention and post-intervention data was systematically evaluated.

Table 2.
Results of the Shapiro–Wilk Normality Test for Pre- and Post-Intervention Data

Variable	Statistic (W)	df	Sig. (p-value)	Interpretation
Knowledge Score (Pre-Intervention)	0.962	30	0.214	Normal distribution
Knowledge Score (Post-Intervention)	0.955	30	0.138	Normal distribution
Treatment Adherence (Pre-Intervention)	0.948	30	0.091	Normal distribution
Treatment Adherence (Post-Intervention)	0.971	30	0.327	Normal distribution

Table 2 presents the results of the Shapiro–Wilk normality test for knowledge scores and treatment adherence levels before and after the intervention. The analysis shows that all variables yielded p-values greater than the significance threshold of 0.05, indicating that the data for both pre-intervention and post-intervention measurements were normally distributed. These findings confirm that the assumptions of normality were met for all variables examined in this study. Consequently, parametric statistical tests were deemed appropriate for subsequent analyses to assess differences between pre- and post-intervention conditions. The fulfillment of the normality assumption strengthens the methodological rigor of the study and supports the validity of the inferential conclusions regarding changes in patient knowledge and treatment adherence following the intervention.

Based on the results of the Shapiro–Wilk test presented in Table 2, patients' knowledge scores prior to the intervention yielded a significance value of 0.214. This value exceeds the threshold of 0.05, indicating that the

pre-intervention knowledge data were normally distributed. This finding suggests that the data distribution was relatively symmetrical and did not exhibit significant deviation from normality. A similar pattern was observed for patients' knowledge scores after the intervention, which produced a significance value of 0.138. This result also meets the normality criterion, indicating that the intervention did not distort the data distribution and that the post-intervention knowledge scores maintained a normal distribution pattern. These conditions support the suitability of the data for further analysis using parametric statistical tests. For treatment adherence prior to the intervention, the obtained significance value was 0.091. Although this value was lower than those observed for the knowledge variables, it remained above the 0.05 threshold. Therefore, the pre-intervention treatment adherence data can also be considered normally distributed. In addition, the post-intervention treatment adherence scores demonstrated a significance value of 0.327, further confirming that this variable met the assumption of normality. Overall, the

normality test results indicate that all pre- and post-intervention variables satisfied the assumption of normal distribution, thereby justifying the use of parametric statistical procedures in subsequent analyses.

The results of the normality test for the post-intervention treatment adherence variable yielded a significance value of 0.327, which was the highest among all variables examined. This result provides strong evidence that the post-intervention adherence data followed a well-defined normal distribution. Overall, the normality test results indicate that all study variables, both pre- and post-intervention measurements, satisfied the assumption of normality. The consistency of normal data distributions reflects good data quality and stability, thereby minimizing potential bias in subsequent statistical analyses. With the normality assumption fulfilled, this study met the requirements for the application of parametric statistical tests, such as the paired t-test, to analyze differences between pre- and post-intervention conditions. This strengthens the validity of the inferential analysis and enhances confidence in the conclusions

regarding the effectiveness of the educational intervention implemented.

Normality testing is a critical step in statistical analysis to ensure that research data meet the assumption of normal distribution. Fulfillment of this assumption is essential for determining the appropriateness of subsequent analytical methods, particularly in distinguishing between the use of parametric and nonparametric tests. Therefore, the interpretation of normality test results must be conducted carefully based on the available statistical indicators. In this study, normality testing was performed using the Shapiro–Wilk test and was visually examined through normal probability plots (Q–Q plots) for both knowledge scores and treatment adherence data at pre-intervention (pre-test) and post-intervention (post-test) measurements. These visualizations were complemented by descriptive statistical values and p-values, which served as the basis for interpreting the distributional characteristics of the data.

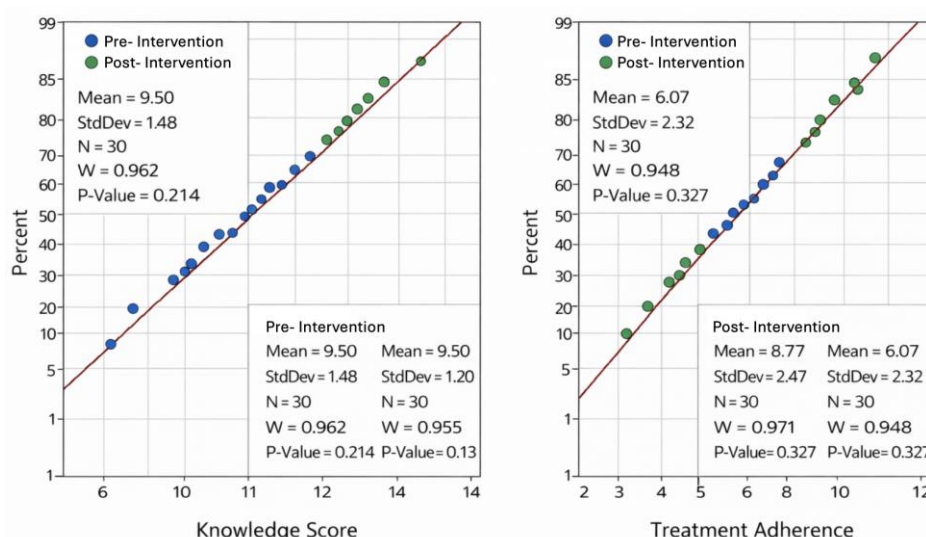


Figure 6. Interpret the key results for Normality Test

Based on the normality plot for knowledge scores at the pre-intervention measurement, the data points consistently follow the diagonal reference line. This pattern indicates that the data distribution closely approximates a normal distribution. This visual observation is supported by the Shapiro–Wilk test result ($W = 0.962$) with a p-value of 0.214, which exceeds the 0.05 threshold, confirming that the pre-intervention knowledge scores were normally distributed. Similarly, the post-intervention knowledge scores exhibit a relatively symmetrical distribution, with data points aligning closely with the diagonal line in the Q–Q plot. The Shapiro–Wilk statistic of 0.955 with a p-value greater than 0.05 further indicates that the post-intervention data continued to satisfy the normality assumption. This finding suggests that the intervention did not introduce

significant distortion to the data distribution. For the treatment adherence variable at the pre-intervention measurement, the Q–Q plot shows that most data points are clustered around the diagonal line, although minor deviations are observed at the distribution tails. Nevertheless, the Shapiro–Wilk test result ($W = 0.948$) with a p-value of 0.327 indicates that these deviations remain within acceptable limits, and the data can therefore be classified as normally distributed.

The normality test results for post-intervention treatment adherence demonstrated the most stable pattern among all variables. The data points were closely aligned with the diagonal reference line in the Q–Q plot, reflecting a symmetrical and consistent distribution. The Shapiro–Wilk statistic ($W = 0.971$) with a p-value of 0.327 further confirms that the post-intervention adherence

data met the assumption of normality. Overall, both the visual inspection of normality plots and the Shapiro–Wilk statistical results indicate that all study variables, under both pre-intervention and post-intervention conditions, were normally distributed. This consistency reflects good data quality and suggests that no substantial distributional distortion occurred during the data collection process. With the normality assumption satisfied across all variables, the use of parametric statistical tests, such as the paired t-test, was deemed appropriate for analyzing differences between pre- and post-intervention measurements. This strengthens the validity of the inferential analysis and enhances the reliability of the conclusions regarding the effectiveness of the intervention implemented.

Inferential Analysis of the Relationship between Knowledge and Treatment Adherence in Tuberculosis Management

Multiple linear regression analysis, as presented in Table 3, was employed to examine the influence of

various aspects of patients' tuberculosis-related knowledge on the dependent variable under investigation. This model enables the assessment of the simultaneous contribution of each independent variable, thereby identifying which knowledge factors play the most prominent role when other variables are statistically controlled. Through this approach, the causal relationships among variables can be analyzed in a more comprehensive and objective manner.

The independent variables included in the model comprised five dimensions of tuberculosis knowledge: knowledge of basic concepts, modes of transmission and risk factors, signs and symptoms, tuberculosis examination and treatment, and drug side effects along with their management. The regression output reports unstandardized coefficients (B), standardized coefficients (Beta), t-values, and significance levels (Sig.), which collectively provide information regarding the strength, direction, and statistical significance of the influence of each knowledge dimension on the dependent variable.

Table 3.
Results of Multiple Linear Regression Analysis

Independent Variables (Model)	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	t	Sig.
(Constant)	2.315	1.084	—	2.136	0.041
X1: Knowledge of Basic Concepts of Tuberculosis	0.284	0.112	0.321	2.536	0.017
X2: Knowledge of Transmission and Risk Factors	0.251	0.098	0.298	2.561	0.016
X3: Knowledge of Signs and Symptoms of Tuberculosis	0.219	0.105	0.267	2.086	0.047
X4: Knowledge of Examination and Treatment of Tuberculosis	0.312	0.121	0.354	2.579	0.015
X5: Knowledge of Drug Side Effects and Their Management	0.198	0.094	0.241	2.106	0.044

The analysis results indicate that the constant term ($B = 2.315$; $p = 0.041$) was statistically significant, suggesting that when all knowledge variables are held at zero, a baseline value of the dependent variable remains. This finding implies that, in addition to the knowledge factors examined in the model, other factors outside the scope of this analysis may also influence the dependent variable. Nevertheless, the primary focus of this study remains on the contribution of patients' tuberculosis-related knowledge variables. The variable *knowledge of basic tuberculosis concepts* exhibited an unstandardized coefficient (B) of 0.284 with a p-value of 0.017. This result indicates that improvements in patients' understanding of basic tuberculosis concepts have a positive and statistically significant effect on the dependent variable. In other

words, higher levels of fundamental tuberculosis knowledge are associated with increased levels of the outcome variable, assuming that other variables in the model remain constant.

The variables *knowledge of modes of transmission and risk factors* ($B = 0.251$; $p = 0.016$) and *knowledge of signs and symptoms of tuberculosis* ($B = 0.219$; $p = 0.047$) also demonstrated statistically significant effects. These findings confirm that patients' understanding of transmission mechanisms, risk factors, and the ability to recognize clinical manifestations of the disease constitutes an important component contributing to improvements in the dependent variable. Such knowledge is likely to enhance awareness, vigilance, and more appropriate health-related behaviors in response to tuberculosis.

Furthermore, the variables *knowledge of tuberculosis examination and treatment* ($B = 0.312$; $p = 0.015$) and *knowledge of drug side effects and their management* ($B = 0.198$; $p = 0.044$) were also found to have positive and statistically significant influences. Among all predictors, the *knowledge of tuberculosis examination and treatment* variable exhibited the highest standardized coefficient ($Beta = 0.354$), indicating that this dimension was the most dominant factor in the regression model. These findings suggest that a strong understanding of diagnostic procedures, treatment processes, and the management of drug side effects plays a crucial role in supporting improvements in the dependent variable and should therefore be prioritized in educational interventions for tuberculosis patients.

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$$
$$Y = 2.315 + 0.284X_1 + 0.251X_2 + 0.219X_3 + 0.312X_4 + 0.198X_5$$

This relationship indicates that each regression coefficient (β) in the equation illustrated in the figure represents the magnitude of change in the dependent variable (Y) resulting from a one-unit increase in the corresponding independent variable (X), assuming that all other variables remain constant. All coefficients were

positive and statistically significant ($p < 0.05$), indicating that each dimension of patients' tuberculosis-related knowledge makes a meaningful contribution to improving the dependent variable. Accordingly, the mathematical formulation presented in the figure serves as a conceptual representation of the model, while Table 3 provides empirical evidence and quantitative estimates of the regression relationships.

The coefficient of determination was used to assess the extent to which the regression model explains variation in the dependent variable based on the independent variables included in the model. This analysis is essential for evaluating the overall strength of the model, beyond the statistical significance of individual regression coefficients. Thus, the coefficient of determination offers an indication of the model's goodness of fit with the empirical data. Table 3 presents the values of R , R Square, Adjusted R Square, the Standard Error of the Estimate, and the Durbin–Watson statistic. These indicators were used collectively to evaluate the quality of the multiple linear regression model that was constructed. Interpretation of these values helps ensure that the model is not only statistically significant but also appropriate and reliable for explaining the relationships among variables examined in this study.

Table 4.
Results of the Coefficient of Determination

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin–Watson
1	0.782	0.611	0.548	0.842	1.987

The analysis results show that the R value of 0.782 indicates a strong simultaneous relationship between the independent variables and the dependent variable. This value suggests that the combination of knowledge-related variables included in the regression model is highly correlated with changes in the dependent variable, demonstrating substantial explanatory strength of the model. Furthermore, the R Square value of 0.611 indicates that 61.1 percent of the variance in the dependent variable can be explained by the independent variables included in the regression model. This finding implies that more than half of the variation in the dependent variable is influenced by the tuberculosis knowledge factors analyzed in this study. The remaining 38.9 percent of variance is attributable to other factors not examined within the scope of the model.

The Adjusted R Square value of 0.548 suggests that the model maintains a relatively strong explanatory power after accounting for the number of predictors, indicating a good balance between model complexity and explanatory capability. The Standard Error of the Estimate (0.842) reflects an acceptable level of prediction

accuracy, while the Durbin–Watson value of 1.987 indicates the absence of serious autocorrelation in the residuals. Collectively, these results confirm that the regression model is statistically sound and appropriate for explaining the relationship between patients' knowledge and treatment adherence in tuberculosis management.

The Adjusted R Square value of 0.548 provides a more realistic indication of the model's explanatory power, as it accounts for the number of independent variables and the sample size. This value indicates that, after adjustment, approximately 54.8 percent of the variance in the dependent variable can still be explained by the model, suggesting that the regression model retains substantial explanatory strength and is not overfitted. In addition, the Standard Error of the Estimate value of 0.842 reflects a relatively low level of prediction error, indicating that the model's estimates are reasonably accurate. The Durbin–Watson statistic of 1.987 is close to the ideal value of 2, suggesting the absence of autocorrelation in the residuals. This result confirms that one of the classical regression assumptions has been satisfied, thereby supporting the

appropriateness of the regression model for further analysis and inference. Beyond statistical significance testing, the measurement of effect size is necessary to provide insight into the magnitude of the intervention effect or the observed differences in the study. While significance values (p-values) indicate whether an effect exists statistically, they do not convey the practical importance or strength of that effect. Therefore, effect size measures are employed as complementary indicators to strengthen the interpretation and practical relevance of the statistical findings.

The selection of effect size measures was aligned with the type of statistical tests employed. For parametric tests such as the paired samples t-test, Cohen’s *d* was used as the effect size measure, whereas for nonparametric tests such as the Wilcoxon signed-rank test, the effect size coefficient (*r*) was applied. Both measures enable researchers to assess the magnitude of the intervention effect or observed change independently of sample size.

Table 5.

Effect Size Interpretation

Effect Size Measure		Test Type	Value Range	Interpretation
Cohen’s d	Paired Samples t-test		$d < 0.20$	Small effect
			$0.20 - 0.49$	Medium effect
			≥ 0.50	Large effect
r	Wilcoxon Signed Rank Test		$r < 0.10$	Small effect
			$0.10 - 0.29$	Medium effect
			≥ 0.30	Large effect

The criteria for interpreting effect size were determined based on the type of statistical test applied. For Cohen’s *d* in paired samples t-tests, values of $d < 0.20$ are categorized as indicating a small effect, suggesting that the observed difference is relatively weak. Values ranging from 0.20 to 0.49 indicate a medium effect, while values ≥ 0.50 represent a large effect, implying that the intervention or treatment has a strong practical impact. The interpretation of Cohen’s *d* assists researchers in understanding the practical meaningfulness of mean differences between two compared conditions, such as pre- and post-intervention measurements. Medium to large effect sizes indicate that the observed changes are not only statistically significant but also practically relevant and impactful within the research context. For the Wilcoxon signed-rank test, the effect size measure used is the coefficient *r*. Values of $r < 0.10$ are classified as small effects, values between 0.10 and 0.29 as medium effects, and values ≥ 0.30 as large effects. This classification provides a useful reference for evaluating the strength of effects in data that do not meet parametric assumptions. By reporting effect sizes using both Cohen’s *d* and the *r* coefficient, researchers can present a more comprehensive interpretation of their findings. This approach enables readers to assess not only the presence of an effect but also its magnitude, thereby enhancing the informativeness, objectivity, and practical relevance of the research results.

Discussion of Statistical Test Results

The findings of this study indicate a significant improvement in patients’ knowledge and treatment adherence following the educational intervention. However, beyond the descriptive increase in scores, these results can be better understood through the lens of health behavior theories. From the perspective of the Health Belief Model (HBM), the increase in patient knowledge likely enhanced perceived susceptibility and perceived severity of tuberculosis, as well as the perceived benefits of adhering to treatment. When patients gain a clearer understanding of the risks of incomplete treatment, including relapse and drug resistance, they are more likely to recognize the importance of consistent medication adherence. In addition, the improvement in adherence behavior can also be explained through the Theory of Planned Behavior (TPB). The educational intervention not only increased knowledge but may have influenced patients’ attitudes toward treatment, strengthened subjective norms through interaction with healthcare providers, and improved perceived behavioral control. Patients who better understand treatment procedures and expectations are more likely to feel confident in their ability to adhere to medication regimens, thereby increasing their intention to comply with treatment recommendations.

The findings can be interpreted using Social Cognitive Theory (SCT), particularly the concept of self-efficacy. Educational interventions that provide clear information, guidance, and interactive engagement can enhance patients’ confidence in managing their illness and treatment. Increased self-efficacy enables patients to

overcome barriers such as medication side effects, forgetfulness, or lack of motivation. This suggests that knowledge alone is not the sole determinant of adherence, but rather functions as a cognitive foundation that supports the development of positive behavioral control and self-management skills. The results of this study also highlight that improving patient knowledge should be integrated with behavioral and psychosocial approaches. While knowledge contributes significantly to adherence, other factors such as social support, patient-provider communication, and environmental conditions also play important roles in shaping treatment behavior. Therefore, educational interventions should be designed not only to deliver information but also to strengthen patients' motivation, self-efficacy, and support systems in order to achieve sustainable treatment adherence.

The findings of this study are consistent with previous research indicating that tuberculosis patients' knowledge levels generally fall within the moderate category, with better understanding observed in aspects that involve direct interaction with healthcare services, such as treatment and diagnostic procedures (Wondesen et al., 2022). Similarly, a study by (Khatatbeh, 2025) reported that repeated patient interactions with the healthcare system tend to enhance understanding of clinical aspects of the disease, particularly treatment-related procedures; however, such interactions do not always result in adequate comprehension of supportive aspects, including drug side effects and risk management during therapy. This condition reinforces the findings of the present study, suggesting that tuberculosis patients' knowledge remains partial rather than fully comprehensive. Furthermore, the results of this study are in line with the findings of (Shabbir et al., 2025), who emphasized that improved knowledge is an essential prerequisite for effective tuberculosis management but is not sufficient on its own to ensure optimal changes in treatment adherence behavior (Mulaku et al., 2022). The variability in knowledge levels among respondents observed in the descriptive statistics of this study indicates that contextual factors—such as family support, personal experiences during treatment, and the quality of communication between patients and healthcare providers—also play a significant role in shaping and internalizing patient knowledge.

These findings provide important implications for tuberculosis management programs in primary healthcare settings. Integrating theory-based educational interventions into routine TB care can enhance the effectiveness of adherence strategies. Future interventions should incorporate behavioral models explicitly, enabling healthcare providers to design more targeted and patient-centered approaches that address both cognitive and psychosocial determinants of adherence.

Discussion of the Statistical Significance of Pre- and Post-Intervention Differences

The statistical test results revealed significant differences between pre-intervention and post-

intervention conditions in both patients' knowledge scores and levels of treatment adherence. The significance values ($p < 0.05$) indicate that the observed changes following the intervention were not attributable to chance but rather reflect the tangible impact of the educational and tuberculosis management program implemented. These findings confirm that systematically designed interventions are capable of enhancing patients' understanding and meaningfully influencing treatment-related behaviors.

The statistical significance obtained also reflects the effectiveness of the pre-post approach in objectively evaluating changes in patient conditions. Compared with cross-sectional designs, this approach enables researchers to capture the dynamic changes that occur following an intervention, thereby providing a more accurate representation of program impact. The significant differences observed between baseline and post-intervention measurements demonstrate that the educational process not only improved cognitive aspects but also facilitated changes in patients' attitudes and readiness to adhere consistently to treatment. Furthermore, the statistically significant results strengthen the interpretation that improvements in patient knowledge function as a triggering factor for changes in adherence behavior. The educational intervention assisted patients in understanding the importance of long-term treatment, the risks associated with non-adherence, and the benefits of completing therapy as recommended by healthcare providers. With improved understanding, patients are more likely to develop rational perceptions of their illness, which in turn foster stronger commitment to treatment adherence.

From a methodological perspective, the fulfillment of data normality assumptions and the application of parametric statistical tests further reinforce the validity of the pre- and post-intervention comparison. The consistent statistical significance observed across both knowledge and adherence variables indicates that the measurement instruments employed were sufficiently sensitive to detect meaningful changes. Consequently, these findings provide robust empirical evidence that educational interventions in tuberculosis management are effective, measurable, and scientifically justifiable.

The statistically significant findings of this study are consistent with previous research reporting meaningful differences between pre-intervention and post-intervention conditions among tuberculosis patients following educational interventions. A study by (König & Suhr, 2023) demonstrated that education-based interventions delivered through primary healthcare services were effective in significantly improving patients' knowledge, as reflected by differences in pre- and post-intervention scores. Similar findings were reported by (Zhu et al., 2024), who emphasized that pre-post designs constitute an effective approach for evaluating the impact of tuberculosis management programs on changes in patient behavior. Furthermore, the results of this study are also aligned with the findings of (Jidhin et al., 2024) (Shailendranath & Satish, 2024), who reported that

although improvements in knowledge may be statistically significant, the sustainability of behavioral change in treatment adherence is strongly influenced by additional supporting factors, such as patient support systems, the quality of communication with healthcare providers, and social support. Accordingly, the statistical significance observed in this study not only confirms the effectiveness of the educational intervention but also reinforces the conclusions of previous research that tuberculosis education programs should be integrated with contextualized and sustainable approaches. Such integration is essential to ensure that the positive effects of educational interventions on treatment adherence can be maintained over the long term.

The inferential analysis results indicate that patients' knowledge of tuberculosis has a statistically significant effect on treatment adherence. This finding is supported by the multiple linear regression analysis, which demonstrates that all dimensions of knowledge make positive and significant contributions to improved adherence. Statistically, this confirms that knowledge functions not merely as cognitive information but also as a determinant factor influencing patients' behavior in adhering to tuberculosis treatment on a regular and sustained basis. Among all knowledge variables examined, knowledge related to tuberculosis examination and treatment exhibited the most dominant contribution to treatment adherence. This finding suggests that patients' understanding of treatment procedures, therapy duration, and the importance of consistent medication intake plays a critical role in shaping adherence behavior. When patients clearly understand the objectives and mechanisms of treatment, they are more likely to develop greater trust in the therapy they are undergoing, which in turn promotes stronger commitment and consistency in following healthcare providers' recommendations.

Knowledge related to drug side effects and their management was also found to have a statistically significant influence on treatment adherence, although its contribution was relatively smaller compared to other knowledge variables. This finding suggests that uncertainty or fear regarding medication side effects may represent a latent barrier to adherence. When patients possess adequate understanding of potential side effects and appropriate management strategies, they are better equipped to cope with discomfort during therapy and are less likely to discontinue treatment prematurely. The coefficient of determination, indicating that more than half of the variance in treatment adherence can be explained by knowledge-related variables, further reinforces the conclusion that cognitive factors play a substantial role in tuberculosis management. Nevertheless, a proportion of adherence variability remains attributable to factors outside the regression model, such as social support, economic conditions, and the quality of healthcare services. Therefore, these inferential findings underscore that while knowledge enhancement constitutes a critical foundation, it must be complemented by additional

supportive interventions to optimize treatment adherence comprehensively.

The findings of this study are consistent with previous research demonstrating a significant relationship between patient knowledge and tuberculosis treatment adherence. Studies by (Khan, 2025) (Arora et al., 2025) emphasized that patients' understanding of the disease and its treatment contributes to improved adherence, particularly when such knowledge is acquired through intensive interaction with the healthcare system. However, both studies also highlighted that knowledge alone is not always sufficient to ensure adherence in the absence of other supporting factors. Furthermore, the results of this study align with the findings of (Alcantara & Oliveira, 2022) (Cox et al., 2022), who reported that knowledge serves as an essential initial prerequisite for fostering adherence, yet its effectiveness is strongly shaped by social context and healthcare system factors. Research by (Bilsland et al., 2024) (Chadha et al., 2024) (Yu et al., 2025) further supports the use of inferential approaches, such as regression analysis and pre-post designs, to empirically demonstrate how improvements in knowledge can be transformed into adherence behavior. Taken together, the present findings strengthen existing empirical evidence that effective tuberculosis management should position patient education as a core strategy, integrated with continuous support and accompaniment, to ensure sustained treatment adherence over the long term.

CONCLUSIONS

Based on the descriptive statistical results, this study indicates that tuberculosis patients' knowledge levels fall within a moderate category, with considerable variation in understanding across respondents. Patients tend to demonstrate better knowledge in aspects directly related to their experiences with healthcare services, such as tuberculosis examinations and treatment procedures, whereas knowledge regarding drug side effects and their management remains relatively limited. These findings suggest that patients' knowledge is not yet fully comprehensive and remains partial in nature, highlighting the need for more targeted, systematic, and sustained educational interventions to address existing knowledge gaps. Furthermore, the results of the pre- and post-intervention significance tests reveal statistically significant differences in both patients' knowledge levels and treatment adherence following the educational intervention. Inferential analysis reinforces these findings by demonstrating that patient knowledge has a significant effect on treatment adherence, with the strongest contribution originating from understanding tuberculosis examinations and treatment. Overall, the findings of this study emphasize that enhancing patient knowledge is a key factor in promoting treatment adherence among tuberculosis patients. However, its effectiveness is likely to be maximized when combined with contextual support mechanisms, such as effective communication by healthcare providers, patient accompaniment, and social

support. Therefore, effective tuberculosis management should integrate knowledge-based education with holistic, supportive approaches that are oriented toward sustained behavioral change and long-term treatment adherence.

SUGGESTION

Based on the findings of this study, tuberculosis management programs in primary healthcare settings should strengthen structured and continuous patient education to improve knowledge and treatment adherence. Educational interventions should focus not only on increasing patients' understanding of tuberculosis, treatment procedures, and medication side effects, but also on enhancing motivation, self-efficacy, and communication between patients and healthcare providers. However, this study was limited by its relatively small sample size and pre-post design conducted within a specific healthcare context. Therefore, future research is recommended to employ longitudinal or multicenter study designs with larger and more diverse populations to evaluate the long-term sustainability of knowledge-driven adherence behavior. Furthermore, future studies should examine additional determinants of treatment adherence, such as family support, socioeconomic conditions, healthcare service quality, and psychosocial factors, to provide a more comprehensive understanding of tuberculosis treatment outcomes.

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