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Original Article

Family-centered nursing-based supportive-educative intervention to improve knowledge, family support, and nutritional status among tuberculosis patients: A quasi-experimental study

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Abstract

Background: Tuberculosis (TB) remains a major public health concern requiring a comprehensive approach to patient care. Limited disease-related knowledge, inadequate family support, and poor nutritional status may hinder effective disease management. Integrating the Supportive-Educative System (SES) based on the Family-Centered Nursing (FCN) model may enhance patients' self-care capabilities through structured education and active family involvement.
Objective: To analyze differences in changes in TB-related knowledge, family support, and body mass index (BMI) between patients receiving an FCN-based SES intervention in addition to standard healthcare services and those receiving standard healthcare services alone.
Methods: This quantitative study employed a quasi-experimental pretest–posttest nonequivalent control group design conducted from March to September 2026 at Tanjung Agung Primary Health Center, Baturaja, and Ciracas Primary Health Center, East Jakarta, Indonesia. A total of 60 patients with tuberculosis (TB) were recruited using purposive sampling, comprising 30 participants in the intervention group and 30 in the control group. The intervention consisted of three focus group discussion (FGD) sessions, structured health education, active family involvement, and follow-up monitoring over three months. TB-related knowledge and family support were assessed using questionnaires, while nutritional status was evaluated based on body mass index (BMI). Between-group differences in change scores were analyzed using the Mann–Whitney U test.
Results: The intervention group demonstrated mean increases of 3.07 points in TB-related knowledge, 24.07 points in family support, and 1.28 kg/m^2 in BMI. In contrast, the control group exhibited corresponding mean changes of −0.40 points, 5.23 points, and 0.07 kg/m^2, respectively. The Mann–Whitney U test revealed statistically significant between-group differences in changes in TB-related knowledge, family support, and BMI (all $p < 0.001$).
Conclusion: The Family-Centered Nursing (FCN)-based Supportive-Educative System (SES) intervention, delivered as an adjunct to standard healthcare services, was associated with greater improvements in TB-related knowledge, family support, and BMI compared with standard care alone. This approach may serve as a promising complementary strategy in family and community nursing care for patients with TB. However, these findings should be interpreted with caution given the nonrandomized study design and the potential influence of confounding factors.

Background

Tuberculosis (TB) remains a major global public health concern, particularly in high-burden countries such as Indonesia. According to the Global Tuberculosis Report 2025, the World Health Organization (WHO) estimated that approximately 10.7 million people developed TB worldwide in 2024. Indonesia ranked second after India in terms of the number of TB cases and remained one of the major contributors to the global TB burden (WHO, 2025a). At the national level, the Indonesian Ministry of Health reported approximately 889,000 notified TB cases in 2023, highlighting persistent challenges in case detection, treatment continuity, and strengthening healthcare services for patients with TB (Kementerian Kesehatan Republik Indonesia, 2024). This substantial disease burden underscores the need for comprehensive healthcare approaches that extend beyond pharmacological treatment to incorporate health education, family support, and continuous monitoring of patients' health conditions.

Effective TB management requires active patient participation in long-term treatment, adherence to infection prevention practices, and the fulfillment of daily self-care needs. However, inadequate knowledge regarding the disease and its treatment may hinder patients' ability to engage in effective self-care. The WHO (2025c) recommends health education and counseling on TB and treatment adherence as essential components of comprehensive TB care. Effective educational interventions should not merely focus on information delivery but also consider individual needs, social circumstances, and the involvement of patients' support networks. Therefore, improving TB-related knowledge represents an important outcome for evaluating nursing interventions aimed at strengthening patients' capacity for disease self-management.

In addition to disease-related knowledge, family support plays a crucial role in maintaining continuity of care among patients with TB. Family members can facilitate medication adherence, assist with healthcare visits, provide adequate nutrition, monitor patients' health conditions, and offer emotional support throughout treatment. Conceptually, family support encompasses emotional, informational, instrumental, and appraisal support. Maynard et al. (2023), in a mixed-methods systematic review and meta-analysis, highlighted the relevance of psychosocial support interventions in patient-centered TB care, although their effectiveness varied according to intervention characteristics and implementation contexts. Similarly, the WHO (2022b) emphasized the importance of social support, counseling, and individualized assistance in promoting continuity of TB care. Accordingly, family members should be recognized not merely as treatment supporters but also as active partners in the delivery of daily care.

Nutritional status represents another important consideration in TB management. The relationship between TB and undernutrition is complex and bidirectional. TB infection may increase metabolic demands and reduce dietary intake, whereas undernutrition can impair immune responses and increase the risk of unfavorable treatment outcomes. Bhargava et al. (2023a), through the RATIONS study, demonstrated the importance of nutritional support in household-level TB control efforts. A related cohort study by Bhargava et al. (2023b) further examined the association between nutritional support and treatment outcomes among patients with pulmonary TB. Consistent with these findings, the WHO (2025c) recommends nutritional assessment and individualized counseling from diagnosis throughout the course of treatment, along with appropriate nutritional interventions for patients experiencing undernutrition. Body mass index (BMI) is a commonly used anthropometric indicator for monitoring changes in patients' body composition and nutritional condition. Nevertheless, BMI does not comprehensively reflect all dimensions of nutritional status and should not be interpreted as a direct indicator of TB treatment success.

Dorothea Orem's Self-Care Deficit Nursing Theory emphasizes the role of nurses in facilitating patients' self-care capabilities through education, guidance, support, and enhanced decision-making. This theoretical perspective is particularly relevant to TB management, as it supports improvements in disease-related knowledge, treatment adherence, infection prevention practices, and nutritional self-care. However, effective chronic disease management also depends on the availability and quality of family support. Integrating the Supportive-Educative System (SES) with Family-Centered Nursing (FCN) positions family members as active partners in identifying care needs, planning interventions, implementing care, and evaluating health outcomes. Such integration may strengthen patients' self-care capabilities while enhancing families' capacity to sustain continuity of care (Orem, 2001). This approach is consistent with WHO (2025b) recommendations emphasizing health education and counseling as integral components of TB care. In the present study, the integrated SES–FCN approach was operationalized through structured health education, three focus group discussion (FGD) sessions lasting 45–60 minutes each, strengthened family involvement, and BMI monitoring over a three-month period. Nevertheless, changes in BMI were considered multifactorial outcomes potentially influenced by disease progression, pharmacological treatment, nutritional intake, and other underlying health conditions. Although previous studies have highlighted the importance of health education, psychosocial support, family involvement, and nutritional interventions in TB management (Bhargava et al., 2023a, 2023b; Maynard et al., 2023; WHO, 2025b, 2025c), variations in intervention components and measured outcomes have left limited evidence regarding the potential benefits of integrating SES and FCN in simultaneously improving TB-related knowledge, family support, and BMI.

To address these gaps, this study aimed to examine between-group differences in changes in TB-related knowledge, family support, and BMI among patients receiving an FCN-based SES intervention in addition to standard healthcare services compared with those receiving standard healthcare services alone. The findings are expected to provide empirical evidence regarding the potential contribution of an integrated nursing approach to supporting TB management in primary healthcare settings.

Methods

Study Design

This study employed a quantitative approach using a quasi-experimental pretest–posttest nonequivalent control group design, as described by Shadish et al. (2002) and Polit and Beck (2017). This design involves comparing an intervention group and a nonrandomized control group, with outcome measurements conducted before and after the intervention. The design was used to examine between-group differences in changes in tuberculosis-related knowledge, family support, and body mass index (BMI) following the intervention. (Shadish et al., 2002; Polit & Beck, 2017).

Setting And Time

The study was conducted from March to September 2026 at Tanjung Agung Primary Health Center, Ogan Komering Ulu, South Sumatra (intervention group), and Ciracas Primary Health Center, East Jakarta (control group). These locations were selected based on the geographical distribution of the research team to facilitate study coordination, participant recruitment, and intervention implementation. The use of separate sites also aimed to minimize intervention contamination, although potential site-related differences were acknowledged.

Population And Sample

This study employed a non-probability purposive sampling technique, whereby participants were selected according to predefined inclusion and exclusion criteria. A total of 60 patients with TB were enrolled, comprising 30 participants in the intervention group at Tanjung Agung Primary Health Center, Baturaja, and 30 participants in the control group at Ciracas Primary Health Center, East Jakarta. The sample size was determined by the availability of eligible patients within the accessible population during the recruitment period, without a formal sample size calculation.

The inclusion criteria were as follows: (1) patients with TB who had been receiving anti-tuberculosis treatment for less than two months; (2) a baseline BMI below 18.5 kg/m^2; (3) the presence of a family member serving as the primary caregiver or directly observed treatment supporter (Pengawas Menelan Obat [PMO]); (4) the ability to communicate effectively; and (5) willingness to participate, as indicated by written informed consent. Patients with severe complications or cognitive impairments that could interfere with study participation were excluded.

Participants were assigned to the intervention or control group according to their respective healthcare facility, without randomization, to minimize potential intervention contamination between groups. All enrolled participants completed the study procedures, including baseline assessment, intervention or standard care, and post-intervention assessment, with no withdrawals or losses to follow-up. Consequently, all 60 participants (30 in the intervention group and 30 in the control group) were included in the final analysis.

Intervention

Both groups received standard TB care in accordance with the protocols of their respective healthcare facilities. Standard care included health education, scheduling of anti-tuberculosis medication, and supplementary nutritional support in the form of high-protein milk. The control group received routine care, including instructions on using the TB care module and completing monitoring forms. In addition to standard care, the intervention group participated in an FCN-based SES program delivered through three focus group discussion (FGD) sessions, each lasting 45–60 minutes. The first session included baseline assessment (pretest), TB-related health education, and identification of patient- and family-related care needs and challenges. The second session focused on nutritional education, care consultations, and the development of individualized daily meal plans. The third session involved the distribution of educational booklets, reinforcement of previously delivered educational content, and training on completing monitoring forms.

Following the three FGD sessions, both groups entered a three-month implementation and reinforcement period using educational modules and monitoring forms to document medication adherence and daily dietary plans. In the intervention group, follow-up monitoring was conducted twice monthly through the evaluation of monitoring records and BMI measurements. Participants in the control group performed self-monitoring using the educational module and monitoring forms as part of routine healthcare services. Post-intervention assessments of TB-related knowledge, family support, and BMI were conducted in both groups at the end of the third month.

Instruments

TB-related knowledge was assessed using a 15-item true–false questionnaire, with total scores ranging from 0 to 15. Higher scores indicated greater TB-related knowledge. The instrument was reported to have an item validity correlation coefficient (r) of 0.21 and a Cronbach's alpha reliability coefficient of 0.86.

Family support was measured using a 32-item questionnaire rated on a five-point Likert scale, with total scores ranging from 32 to 160. The questionnaire assessed four dimensions of family support: emotional, informational, instrumental, and appraisal support. The instrument was reported to have item validity correlation coefficients of $r \geq 0.374$ and a Cronbach's alpha reliability coefficient of 0.97 (Nainggolan, 2022).

BMI was calculated by dividing body weight in kilograms by the square of height in meters (kg/m^2). Body weight was measured using an OMRON Healthcare Body Composition Monitor HBF-214 digital scale, while height was measured using a standardized height-measuring device. The same measurement devices were consistently used for all participants, with calibration or accuracy checks performed before measurements.

Data Collection Procedures

Data collection began with baseline assessments (pretest) of TB-related knowledge, family support, and BMI in both groups. The intervention group received the FCN-based SES program through three FGD sessions, followed by a three-month implementation and monitoring period, with follow-up assessments conducted twice monthly. The control group received standard TB care supplemented by educational modules and monitoring forms. Post-intervention assessments were conducted in both groups after three months using the same instruments and measurement procedures as those employed at baseline.

Data Analysis

Data were analyzed using descriptive statistics, comparative analyses, and consideration of potential confounding factors. Participants' characteristics were summarized as frequencies and percentages for categorical variables and means and standard deviations for continuous variables. Baseline differences between groups were examined using the independent-samples t-test for age, the Chi-square test for categorical variables, and exact tests for educational level and marital status when expected cell frequencies were small. The Shapiro–Wilk test was used to assess the normality of data distributions, while Levene's test was applied to evaluate the homogeneity of variances. The results indicated that some change-score distributions did not meet the assumption of normality, while the variances of changes in family support and BMI were heterogeneous. Therefore, between-group differences in change scores (posttest minus pretest) for TB-related knowledge, family support, and BMI were analyzed using the Mann–Whitney U test. All statistical tests were two-tailed, with a significance level of $\alpha = 0.05$ and a 95% confidence level. The interpretation of findings considered potential selection bias and confounding factors arising from nonrandom group allocation and differences between the study settings.

Ethical Considerations

This study received ethical approval from the Research Ethics Committee of Poltekkes Kemenkes Palembang. Ethical principles applied included respect for human dignity by providing freedom to participate or refuse without coercion and providing informed consent forms. Confidentiality was maintained by not including respondent identities and using an anonymity system. The principle of beneficence was applied by providing respondents with information about factors affecting family support. The principle of justice was applied by treating all respondents fairly without special treatment and conducting research honestly, carefully, and professionally. Penelitian ini juga telah lulus kajian komite etik

Poltekkes Kemenkes Palembang dengan nomer DP.04.03/F.XXXII.10/3264/2026..

Results

A total of 60 patients with tuberculosis (TB) were included in the study, comprising 30 participants in the intervention group and 30 in the control group. All enrolled participants completed the study procedures, from baseline (pretest) to follow-up (posttest) assessments, with no reported dropouts. Thus, all 60 participants were included in the final analysis. Information regarding the number of patients screened, excluded, or declining participation was not available and requires verification against recruitment records. The completeness of outcome data also requires confirmation from the original dataset.

Table 1. Respondent Characteristics

Characteristic	Intervention (n=30)	Control (n=30)
Age (years)		
Mean ± SD	37,43 ± 9,95	41,70 ± 11,91
Age Group		
17 – 45 tahun	25 (83,3%)	20 (66,7%)
> 45 tahun	5 (16,7%)	10 (33,3%)
Gender		
Male	21 (70%)	16 (53,3%)
Female	9 (30%)	14 (46,7%)
Education		
Elementary	8 (26,7%)	8 (26,7%)
Junior high school	0	5 (16,7%)
Senior high school /equivalent	17 (56,7%)	16 (53,3%)
College	5 (16,7%)	1 (3,3%)
Marital status		
Married	27 (90,0%)	22 (73,3%)
Unmarried	3 (10,0%)	5 (16,7%)
Widow/widower	0	3 (10,0%)
Family Developmental Stage		
Family with adolescent children	14 (47%)	15 (50%)
Family with school-age children	10 (33%)	9 (30%)
Family with adult children	6 (20%)	6 (20%)
Economic Status		
Lower-middle	22 (73%)	21 (70%)
Upper-middle	8 (27%)	9 (30%)

As presented in Table 1, the mean age of participants was 37.43 with a standard deviation (SD) of 9.95 years in the intervention group and 41.70 ± 11.91 years in the control group. Most participants were aged 17–45 years, accounting for 25 (83.3%) and 20 (66.7%) participants in the intervention and control groups, respectively. Regarding sex, males predominated in both groups, comprising 21 (70.0%) participants in the intervention group and 16 (53.3%) in the control group. The majority had completed senior high school or an equivalent level of education, with 17 (56.7%) participants in the intervention group and 16 (53.3%) in the control group. Most participants were married, accounting for 27 (90.0%) and 22 (73.3%) participants, respectively. In terms of family developmental stage, families with adolescent children represented the largest proportion in both groups, comprising 14 (46.7%) participants in the intervention group and 15 (50.0%) in the control group, followed by families with school-aged children, accounting for 10 (33.3%) and 9 (30.0%) participants, respectively. Regarding socioeconomic status, most participants were classified as belonging to the lower-middle socioeconomic category, representing 22 (73.3%) participants in the intervention group and 21 (70.0%) in the control group.

Table 2. Mean Scores of TB-Related Knowledge, Family Support, and Body Mass Index (BMI) Before and After the Intervention in the Intervention and Control Groups

Variable	Group	Pretest		Posttets		Mean
		Mean	SD	Mean	SD	Difference
Knowledge	Intervention	10,03	1,54	13,10	1,32	+3,07
	Control	10,07	1,80	9,67	1,40	-0,40
Family support	Intervention	88,07	15,17	112,13	10,96	+24,07
	Control	90,50	13,04	95,73	13,63	+5,23
BMI	Intervention	17,23	0,16	18,51	0,28	+1,28
	Control	17,25	0,16	17,32	0,28	+0,07

Table 2 shows the intervention group demonstrated increases in mean tuberculosis (TB)-related knowledge, family support, and body mass index (BMI) following the Family-Centered Nursing (FCN)-based Supportive-Educative System (SES) intervention. The mean knowledge score increased from 10.03 with a standard deviation (SD) of 1.54 to 13.10 with a standard deviation (SD) of 1.32, representing a mean increase of 3.07 points. In contrast, the control group exhibited a decrease from 10.07 with a standard deviation (SD) of 1.80 to 9.67 with a standard deviation (SD) of 1.40, with a mean change of −0.40 points. Regarding family support, the intervention group showed an increase in mean scores from 88.07 with a standard deviation (SD) of 15.17 to 112.13 with a standard deviation (SD) of 10.96, representing an improvement of 24.07 points. Meanwhile, the control group demonstrated a smaller increase, from 90.50 with a standard deviation (SD) of 13.04 to 95.73 with a standard deviation (SD) of 13.63, with a mean change of 5.23 points.

Similarly, the intervention group exhibited an increase in mean BMI from 17.23 with a standard deviation (SD) of 0.16 kg/m^2 to 18.51 with a standard deviation (SD) of 0.28 kg/m^2, corresponding to a mean increase of 1.28 kg/m^2. In comparison, the control group showed only a slight increase from 17.25 with a standard deviation (SD) of 0.16 kg/m^2 to 17.32 with a standard deviation (SD) of 0.28 kg/m^2, with a mean change of 0.07 kg/m^2. Descriptively, these findings indicate greater improvements in TB-related knowledge, family support, and BMI among participants receiving the FCN-based SES intervention compared with those receiving standard care. However, the statistical significance of these between-group differences was determined through subsequent inferential analyses.

Table 3. Results of the Shapiro–Wilk Normality Test and Levene's Test forHomogeneity of Variance on Change Scores

Variable	Shapiro–Wilk Intevention	Shapiro–Wilk Control	Levene (p)
Knowledge	0,035	0,140	0,553
Family Support	0,325	<0,001	<0,001
BMI	0,424	<0,001	0,004

As presented in Table 3, the Shapiro–Wilk normality test indicated that the change scores for TB-related knowledge were not normally distributed in the intervention group ($p = 0.035$), whereas those in the control group met the normality assumption ($p = 0.140$). For family support and BMI, the change scores in the intervention group showed no significant deviations from normality ($p = 0.325$ and $p = 0.424$, respectively). In contrast, both variables exhibited non-normal distributions in the control group (both $p < 0.001$).

Levene's test indicated that the variance of TB-related knowledge change scores did not differ significantly between the intervention and control groups ($p = 0.553$), indicating that the homogeneity of variance assumption was satisfied. However, significant differences in variance were observed for family support ($p < 0.001$) and BMI ($p = 0.004$), indicating violations of the homogeneity assumption.

Overall, the change scores for all three outcomes did not fully satisfy the normality assumptions, while family support and BMI also exhibited heterogeneity of variance. Therefore, the Mann–

Whitney U test was employed as a nonparametric approach to compare change scores between the intervention and control groups.

Table 4. Mann–Whitney U Test Results for Change Scores in the Intervention and Control Groups

Variable	Mann–Whitney U*	p-value	Statistical Significance
Knowledge	811,5	<0,001	Significant
Family Support	766,0	<0,001	Significant
BMI	895,0	<0,001	Significant

Table 4 shows statistically significant between-group differences in change scores across all study outcomes. For TB-related knowledge, the Mann–Whitney U statistic was 811.5 ($p < 0.001$). Similarly, significant differences were found in family support ($U = 766.0$, $p < 0.001$) and BMI ($U = 895.0$, $p < 0.001$). These findings indicate that changes in TB-related knowledge, family support, and BMI differed significantly between patients receiving the Family-Centered Nursing (FCN)-based Supportive-Educative System (SES) intervention in addition to standard healthcare services and those receiving standard care alone.

Overall, the intervention group demonstrated greater mean improvements in TB-related knowledge, family support, and BMI, accompanied by statistically significant between-group differences in change scores. These findings provide preliminary empirical evidence supporting the potential value of an integrated nursing approach combining supportive education with active family involvement in TB management within primary healthcare settings. Family engagement may facilitate disease management by strengthening patients' knowledge and providing continuous support throughout treatment, while changes in BMI reflect variations in nutritional status during the study period. However, given the nonrandomized design and the use of different healthcare facilities for the intervention and control groups, the observed differences cannot be attributed exclusively to the intervention, as facility-related characteristics and other potential confounding factors may have influenced the outcomes. Therefore, these findings should be interpreted cautiously and further validated through studies employing more rigorous research designs to establish the effectiveness of the intervention.

Discussion

The findings showed that the mean age of participants was 37.43 with a standard deviation (SD) of 9.95 years in the intervention group and 41.70 with a standard deviation (SD) of 11.91 years in the control group. Most participants were aged 17–45 years, accounting for 83.3% of the intervention group and 66.7% of the control group. These findings indicate a predominance of patients of productive age, consistent with the global epidemiological pattern of tuberculosis (TB), which demonstrates a substantial disease burden among adults (WHO, 2025a). From a family nursing perspective, productive age has important implications for disease management, as patients must adhere to long-term treatment while fulfilling occupational and family responsibilities. Therefore, the Supportive-Educative System (SES) approach should consider individual needs, health information comprehension, and family involvement in supporting continuity of care.

Regarding sex distribution, male participants predominated in both groups, accounting for 70.0% of the intervention group and 53.3% of the control group. This distribution is consistent with WHO (2025a) findings indicating a higher TB burden among adult males than females. Most participants had completed senior high school or an equivalent level of education, representing 56.7% and 53.3% of the intervention and control groups, respectively. Educational attainment is an important consideration in delivering health information, as it may influence patients' ability to understand and implement care recommendations. Craciun et al. (2023) identified variations in community knowledge, attitudes, and practices regarding TB prevention and treatment, highlighting the importance of tailoring educational approaches to the needs and characteristics of target populations.

Most participants were married, accounting for 90.0% of the intervention group and 73.3% of the control group. This finding suggests the potential involvement of spouses as sources of support throughout treatment, although marital status does not necessarily reflect the quality of family support. Nazhofah and Hadi (2022) and Lutfian et al. (2025) emphasized the relevance of family

support in enhancing treatment motivation and continuity of care among patients with TB. Within the Family-Centered Nursing (FCN) approach, spouses and other family members can be actively involved as treatment supporters, providers of emotional support, and partners in meeting nutritional needs and monitoring patients' health conditions.

Regarding family developmental stage, the largest proportion of participants in both groups belonged to families with adolescent children, representing 46.7% of the intervention group and 50.0% of the control group. This finding suggests that many families were simultaneously managing child-rearing responsibilities and the care needs of family members with TB. Atkins et al. (2022) described how TB can affect family life through economic strain, stigma, and changes in family relationships. Therefore, family-based interventions should consider developmental tasks, role distribution, and available family resources to promote sustainable caregiving support.

In terms of socioeconomic status, most participants belonged to the lower-middle socioeconomic category, accounting for 73.3% of the intervention group and 70.0% of the control group. Socioeconomic circumstances are important considerations because limited resources may affect families' ability to provide nutritious food, meet transportation expenses, and maintain treatment continuity (Karran et al., 2023). Integrating SES with FCN may help families identify care needs and optimize available resources through nutritional education, medication management, and ongoing healthcare support.

Baseline comparisons revealed no statistically significant differences between the intervention and control groups across the assessed characteristics (all $p > 0.05$). However, these findings do not establish complete equivalence between groups, particularly because participants were allocated according to healthcare facility without randomization. Unmeasured clinical characteristics and environmental factors may still have influenced the study outcomes.

The findings demonstrated that the mean TB-related knowledge score in the intervention group increased from 10.03 with a standard deviation (SD) of 1.54 to 13.10 with a standard deviation (SD) of 1.32, representing a mean change of 3.07 points. In contrast, the control group exhibited a decrease from 10.07 with a standard deviation (SD) of 1.80 to 9.67 with a standard deviation (SD) of 1.40, corresponding to a mean change of −0.40 points. The Mann–Whitney U test comparing change scores revealed a statistically significant between-group difference ($p < 0.001$). These findings suggest that the addition of the FCN-based SES intervention was associated with greater improvements in TB-related knowledge compared with standard healthcare services alone.

The improvement in knowledge observed in the intervention group may be explained by the program's integration of structured education, focus group discussions, identification of patient- and family-related challenges, and reinforcement of learning through educational modules and continuous monitoring. This approach enabled patients not only to receive relevant information but also to discuss barriers encountered during disease management. Law et al. (2021) supported the importance of individualized education and counseling tailored to patients' needs in TB care. Similarly, Putra et al. (2023) highlighted the relevance of comprehensive health education in promoting family involvement in TB control activities, although their study evaluated different outcomes.

Theoretically, these findings align with the Supportive-Educative System within Orem's nursing theory, which emphasizes the nurse's role in facilitating self-care capabilities through education, guidance, support, and enhanced decision-making (Orem, 2001). Integration with FCN extends the educational process beyond individual patients by positioning families as active partners in care. Family members may help reinforce patients' understanding through repeated information, medication supervision, and support for implementing health-promoting behaviors at home. Thus, the observed differences in knowledge changes support the potential of family-based educational approaches to strengthen patients' capacity for TB self-management during treatment.

Regarding family support, the intervention group demonstrated an increase in mean scores from 88.07 with a standard deviation (SD) of 15.17 to 112.13 with a standard deviation (SD) of 10.96,

representing a mean improvement of 24.07 points. Meanwhile, the control group showed a smaller increase from 90.50 with a standard deviation (SD) of 13.04 to 95.73 with a standard deviation (SD) of 13.63, corresponding to a mean change of 5.23 points. The Mann–Whitney U test indicated a statistically significant between-group difference in family support change scores ($p < 0.001$). The greater improvement observed in the intervention group suggests that incorporating FCN-based SES into standard care was associated with enhanced family support throughout the study period.

These findings are consistent with Lutfian et al. (2025), who identified the importance of family support in maintaining treatment adherence and quality of life among patients with TB. Such support may be expressed through emotional encouragement, medication supervision, practical assistance, and reinforcement of health-promoting behaviors. Nazhofah and Hadi (2022) and Tasyakurillah (2023) also emphasized the relevance of family involvement in TB management. Furthermore, Lee and Lee (2024) identified associations between environmental, educational, and psychological factors and self-care behaviors among patients with TB. Collectively, these studies reinforce the importance of a supportive family environment in disease management.

The improvement in family support observed in the intervention group may be understood through the family empowerment process embedded in the FCN-based SES approach. Through discussions, education, and ongoing assistance, family members were actively involved in identifying patients' needs, understanding treatment regimens, planning nutritional intake, and monitoring health conditions. This approach may strengthen the emotional, informational, instrumental, and appraisal support received by patients. From an FCN perspective, families are recognized not merely as recipients of health information but also as active partners in healthcare decision-making and care implementation.

The increase in family support scores within the control group indicates that improvements may also occur during standard healthcare services. These changes may be associated with routine health education, families' accumulated caregiving experiences, and the educational modules and monitoring forms provided to both groups. However, these factors were not independently evaluated; therefore, their individual contributions remain uncertain. Nevertheless, the statistically significant between-group difference supports the potential added value of FCN-based SES in strengthening families' capacity to provide supportive care for patients with TB.

The findings also demonstrated an increase in mean BMI in the intervention group from 17.23 with a standard deviation (SD) of 0.16 kg/m^2 to 18.51 with a standard deviation (SD) of 0.28 kg/m^2, representing a mean improvement of 1.28 kg/m^2. In contrast, the control group showed a slight increase from 17.25 with a standard deviation (SD) of 0.16 kg/m^2 to 17.32 with a standard deviation (SD) of 0.28 kg/m^2, corresponding to a mean change of 0.07 kg/m^2. The Mann–Whitney U test revealed a statistically significant between-group difference in BMI change scores ($p < 0.001$). Descriptively, the mean BMI in the intervention group shifted from the underweight category to the lower threshold of the normal BMI category, whereas the control group's mean BMI remained within the underweight category. However, this change in group mean BMI does not indicate that all participants in the intervention group achieved normal nutritional status.

Changes in BMI are clinically relevant because the relationship between TB and undernutrition is bidirectional. TB infection may increase metabolic demands, reduce appetite, and contribute to weight loss, while undernutrition may impair immune responses and worsen disease progression. The WHO (2025c) emphasizes the importance of nutritional assessment, dietary counseling, and appropriate nutritional interventions as integral components of comprehensive TB care.

These findings are conceptually consistent with the systematic review by Grobler et al. (2016), which indicated that food provision or energy supplementation may improve body weight during TB treatment under certain conditions. The RATIONS study conducted by Bhargava et al. (2023) in India also emphasized the importance of nutritional support in TB management. Nevertheless, these studies focused on different intervention components. The present study evaluated an educational and family involvement

approach rather than the independent effectiveness of nutritional supplementation.

In the present study, both groups received standard healthcare services, including high-protein milk supplementation. The intervention group additionally received nutritional education, care consultations, daily meal planning, and regular monitoring. These components may have helped patients and families better understand nutritional requirements, organize dietary practices, and monitor changes in physical condition. However, because actual dietary intake, adherence to nutritional supplementation, and changes in clinical status were not independently assessed as study outcomes, the mechanisms underlying the observed differences in BMI improvements cannot be conclusively determined.

From an FCN perspective, family involvement may contribute to meeting patients' nutritional needs through food provision, meal planning, mealtime assistance, and body weight monitoring. The SES approach enables nurses to provide individualized education according to patients' health conditions and families' economic capacities. Nevertheless, BMI improvement remains a multifactorial outcome potentially influenced by anti-tuberculosis treatment, clinical recovery, nutritional intake, and socioeconomic circumstances. Therefore, the observed between-group difference in BMI changes supports the potential role of FCN-based SES as a complementary approach to nutritional recovery but does not establish that these improvements were attributable solely to the intervention.

Overall, the findings demonstrated statistically significant between-group differences in changes in TB-related knowledge, family support, and BMI among patients receiving FCN-based SES in addition to standard healthcare services compared with those receiving standard care alone (all $p < 0.001$). These findings address the study objective and support the potential integration of educational interventions and family empowerment strategies into TB care at primary healthcare facilities. In family and community nursing practice, this approach may be implemented through structured education, collaborative discussions involving patients and families, nutritional care planning, and continuous monitoring of care activities.

This study has several limitations, including its nonrandomized quasi-experimental design, relatively small sample size ($n = 60$), and the use of two different healthcare facilities for the intervention and control groups. These methodological characteristics introduce potential selection bias and confounding related to differences in patient characteristics and healthcare services across facilities. Furthermore, the intervention group received more intensive support and monitoring, making it difficult to distinguish the individual contributions of each intervention component. The absence of statistically significant baseline differences in the measured characteristics does not eliminate the possibility of imbalance in unmeasured factors. Additionally, the Mann–Whitney U analysis did not provide covariate-adjusted estimates of intervention effects. Therefore, future studies employing more rigorous research designs, comprehensive assessments of dietary intake and clinical characteristics, and appropriate adjustment for potential confounders are needed to strengthen the evidence regarding the effectiveness of FCN-based SES in TB management.

Conclusion and Recommendation

The Supportive-Educative System (SES) intervention based on Family-Centered Nursing (FCN), delivered as an adjunct to standard healthcare services, was associated with statistically significant between-group differences in changes in tuberculosis (TB)-related knowledge, family support, and body mass index (BMI) (all $p < 0.001$). The intervention group demonstrated mean increases of 3.07 points in TB-related knowledge, 24.07 points in family support, and 1.28 kg/m^2 in BMI, compared with corresponding changes of −0.40 points, 5.23 points, and 0.07 kg/m^2 in the control group. These findings suggest the potential value of FCN-based SES in improving disease-related knowledge, strengthening family support, and promoting nutritional recovery among patients with TB. However, the findings should be interpreted cautiously due to the nonrandomized study design and potential confounding factors.

Integrating FCN-based SES into primary healthcare services is recommended as a complementary approach to TB management through structured health education, family empowerment, and regular monitoring of treatment adherence and nutritional status. Future studies should employ randomized

controlled trials with larger sample sizes, longer follow-up periods, and appropriate adjustment for potential confounders, particularly dietary intake, nutritional supplementation, treatment adherence, and patients' clinical characteristics, to provide stronger evidence regarding the effectiveness of this intervention in TB management.

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Declaration of conflict of interest

The authors declare no competing interests. There is no financial, personal, or professional relationship that could influence the study design, data collection, analysis, interpretation, or manuscript writing.

Declaration on the Use of AI

AI-assisted tools were used in the preparation of this manuscript for language editing and formatting purposes only. The intellectual content, including research design, data collection, analysis, interpretation, and conclusions, was developed solely by the authors. The final manuscript has been reviewed and approved by all authors, who take full responsibility for its content. No AI tools were used for generating research data, analysis, or scientific conclusions.

Data Availability Statement

Data sharing is not applicable to this article.

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