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Original Article

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Optimising Medication Adherence in Drug-resistant Tuberculosis through Pharmacist-Led Counselling: A Prospective Interventional Study

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ABSTRACT

Introduction: Medication adherence describes how well patients follow their prescribed treatment in terms of dose, timing and frequency. The present study evaluated adherence patterns to identify areas where focused interventions such as patient education, counselling and improved support systems may be needed.

Aim: To assess medication adherence among patients with Drug-Resistant Tuberculosis (DR-TB) using a validated adherence assessment tool and to evaluate the impact of patient counselling through Patient Information Leaflets (PIL) on adherence-related outcomes.

Materials and Methods: A prospective interventional multicentre study was carried out among 133 patients diagnosed with DR-TB from April 2025 to March 2026 at the District Tuberculosis Centre, Belagavi, Karnataka, India. along with four associated centres in North Karnataka under the National Tuberculosis Elimination Programme (NTEP). Medication adherence was evaluated using a validated and structured adherence assessment tool. In addition, patient counselling was provided through specially designed PIL and adherence-related parameters were assessed and compared throughout the study period. The data were analysed using descriptive statistics, paired t-test, Wilcoxon's signed-rank test, correlation analysis and multiple linear regression.

Results: Among 136 patients screened, 133 eligible patients with DR-TB were enrolled and completed the study. Following individualised medication-adherence counselling, significant improvements were observed across all medication adherence domains ($p<0.001$). The greatest improvement was observed in the medical condition-related domain (mean difference=3.02; Cohen's dz=2.40), followed by the therapy-related domain (mean difference=1.92; Cohen's dz=1.37). Wilcoxon's signed-rank analysis demonstrated significant positive changes in 20 of 21 questionnaire items, with effect sizes ranging from 0.295 to 0.833. No significant change was observed for the item assessing delays in medication refilling due to financial constraints ($p=1.000$). Overall, the intervention resulted in a substantial improvement in medication adherence among DR-TB patients.

Conclusion: The intervention significantly improved adherence-related outcomes across multiple domains, independent of demographic factors. Pharmacist-led, patient-centred strategies may enhance DR-TB management and support effective Tuberculosis (TB) control.

Keywords: H-mono/poly resistant tuberculosis, Multidrug-resistant tuberculosis, Patient counselling, Pharmaceutical care, Rifampicin resistant tuberculosis

INTRODUCTION

The TB is a long-standing infectious disease that primarily affects the lungs and is caused by *Mycobacterium Tuberculosis*. DR-TB remains a major global public health challenge, with nearly half a million new cases reported annually worldwide. Although advances in diagnostic technologies and the introduction of shorter all-oral treatment regimens have improved DR-TB management, treatment success rates remain around 60%, which is considerably below the 75% target established by the World Health Organisation (WHO). Poor retention in care continues to hinder the effectiveness of DR-TB control programmes, leading to ongoing disease transmission, emergence of additional drug resistance and increased morbidity and mortality. Multiple factors contribute to treatment interruption, including socioeconomic constraints, limited access to healthcare services, overcrowded living conditions, psychosocial challenges and health system-related barriers. Understanding these factors from the perspectives of patients and their family members is essential for designing targeted interventions that can strengthen adherence, improve retention in care and enhance treatment outcomes [1].

India remains one of the highest TB burden countries in the world, accounting for nearly 21% of the global TB incidence. Of the estimated 9.4 million TB cases reported worldwide, approximately two million cases were contributed by India. The country has also been listed among the 22 high TB burden nations based on disease incidence. To combat this major public health challenge, the NTEP aims to achieve and sustain a cure rate of at least 85% among newly sputum-positive patients while maintaining a case detection rate of at least 70% within the community through early diagnosis and effective treatment strategies. Revised National Tuberculosis Control Programme was implemented across India as a fully centrally sponsored programme adopting the World Health Organisation-recommended Directly Observed Treatment Short-course (DOTS) strategy. Under this programme, free diagnostic and treatment services, including anti-tubercular medications, are provided to all TB patients. Sputum smear microscopy is primarily used for diagnosis to improve detection of infectious cases and reduce overreliance on chest radiography. Patients receive medications under direct supervision and are regularly monitored to ensure treatment completion and improve adherence [2].

The increasing issue of DR-TB complicates efforts to control the disease. Among these, Multidrug-Resistant Tuberculosis (MDR-TB) is particularly dangerous since it undermines the efficacy of conventional treatment methods and compromises TB control initiatives. Particularly in high-burden nations like Indonesia, TB

continues to be a major worldwide health concern. The World Health Organisation (WHO) identifies improper or incomplete treatment as a major cause of resistance to anti-TB medications. One of the most important factors behind this issue is poor adherence to treatment. The treatment is less effective when people don't take their drugs as directed, whether because of personal habits, ignorance, or outside obstacles. This allows bacteria to persist and become resistant. This issue is not limited to low-resource environments; social and economic considerations can nevertheless impede continuous commitment to therapy in more developed areas as well. The global push toward the end TB strategy, which targets the elimination of TB by 2030, highlights the urgency of reducing both incidence and mortality rates. The strategy sets clear goals, including lowering TB incidence to 65 cases per 100,000 population and reducing deaths to six per 100,000. Reaching these milestones requires a broad and coordinated effort that addresses the many barriers to effective TB control, especially in high-burden settings such as Indonesia [3].

Treatment adherence is essential for effective TB control and elimination in India. Poor adherence leads to unfavourable outcomes such as treatment failure, relapse and continued transmission of drug-resistant strains. This issue is particularly critical in DR-TB, where inconsistent treatment further worsens resistance and complicates management. For TB to be effectively controlled and eventually eradicated in India, treatment adherence is essential. When patients do not follow their prescribed medication regimen consistently, it can lead to unfavourable outcomes, including treatment failure, disease relapse and continued transmission of drug-resistant strains. In the case of DR-TB, maintaining adherence becomes even more critical, as incomplete or irregular treatment further complicates disease management and accelerates the development of resistance [4].

Patient counselling plays a pivotal role in improving treatment adherence among patients with DR-TB. Factors such as poor awareness regarding the disease, inadequate family support and behavioural challenges often contribute to treatment interruption and unsuccessful outcomes. Effective counselling helps patients better understand their treatment regimen, enhances motivation, addresses psychological and social concerns and encourages consistent medication adherence. In this regard, trained MDR-TB counsellors are essential in providing continuous education, emotional support and patient-centred guidance, thereby contributing to improved treatment outcomes and overall quality of care [5].

In contrast, limited attention has been given to treatment adherence among patients with co-existing DR-TB/Human Immunodeficiency Viruses (HIV). Evidence from early studies, particularly in settings such as South Africa, suggests that individuals with Extensively Drug-Resistant TB (XDR-TB) and HIV tend to have lower adherence to TB treatment compared to adherence observed with Antiretroviral Therapy (ART). This imbalance, where ART adherence is relatively high but TB treatment adherence is poor, may help improve survival outcomes without effectively treating TB. As a result, it can lead to continued disease transmission and limit overall treatment success [6].

Although previous studies have evaluated counselling interventions in TB patients, limited evidence is available regarding pharmacist-led counselling on medication adherence among DR-TB patients in North Karnataka, India. By examining adherence levels, the present study also seeks to highlight areas where targeted interventions may be required, such as patient education, counselling and support systems. Therefore, the present study aimed to evaluate the impact of pharmacist-led counselling using PIL on medication adherence among DR-TB patients. Ultimately, the findings are intended to support strategies that improve treatment compliance, enhance clinical outcomes, reduce the risk of transmission and minimise the development and spread of more resistant forms of TB.

MATERIALS AND METHODS

A prospective, interventional multicentre study was conducted among patients receiving treatment for DR-TB, from April 2025 to March 2026. The study sites included the District Tuberculosis Centre in Belagavi and four affiliated Primary Health Centres located in Belagavi district, North Karnataka, India. The present study was conducted as the part of a PhD research project. The Institutional Human Ethics Committee (Ref. No. KAHER/EC/24-25/D-743) provided ethical clearance and the State Tuberculosis Centre, Department of Health and Family Welfare, Karnataka (Ref. No. LEVIRAKSHAKE/NTEP/PPM/02/2025-26) provided the required administrative approval under the NTEP program.

A consecutive sampling technique was adopted for the study, wherein all patients meeting the predefined inclusion and exclusion criteria during the study period were recruited for participation. A total of 136 patients were screened among which three patients were having less than 18 years of age therefore these patients were excluded from the study. The study included patients receiving standardised therapy for DR-TB and validated methods for measurements were used to evaluate medication adherence. In addition, each participant received individualised counselling aimed at improving adherence. Only those who were actively receiving treatment and provided informed consent were included in the study.

The study was conducted at government-supported healthcare facilities operating under the NTEP. All eligible patients with DR-TB who attended these centres during the study period were screened for inclusion. A consecutive sampling strategy was adopted to recruit participants, ensuring that every accessible and eligible patient within the defined timeframe was included.

Inclusion and Exclusion criteria: Patients with DR-TB who were 18 years of age or older, of either sex and getting treatment at the designated centres met the eligibility requirements were included. The study excluded patients who were younger than 18 years and those who refused to participate. A total of 133 of the 136 individuals those underwent eligibility screening were eventually enrolled. The high enrollment rate indicates broad coverage of patients managed under the NTEP and suggests that the study sample is reasonably representative of the DR-TB population at the selected centres.

Study Procedure

The study utilised a self-developed questionnaire to evaluate medication adherence among patients with DR-TB. The questionnaire consisted of 21 items categorised into five domains: Patient-Related Factors (Q1-Q5), Healthcare System-Related Factors (Q6-Q9), Social and Economic Factors (Q10-Q13), Medical Condition-Related Factors (Q14-Q17) and Therapy-Related Factors (Q18-Q21). Each questionnaire item was scored on a five-point Likert scale ranging from one to five, where lower scores reflected greater adherence-related barriers or challenges, whereas higher scores indicated better medication adherence and more favourable adherence-related behaviours. The questionnaire was reviewed and validated by healthcare professionals and necessary modifications were incorporated based on their expert recommendations. Collected responses were coded systematically and analysed using descriptive statistical methods to evaluate medication adherence patterns among the study participants.

The present study followed a single-group pre-post interventional design without inclusion of a control arm. All patients who met the eligibility criteria were provided with pharmacist-mediated counselling along with PIL as part of the pharmaceutical care services. The intervention aimed to enhance patients' knowledge regarding disease and treatment, thereby promoting better medication adherence throughout therapy. In addition to the intervention, participants continued to receive routine care under the NTEP. Medication adherence outcomes were assessed by comparing findings obtained before and after the counselling intervention.

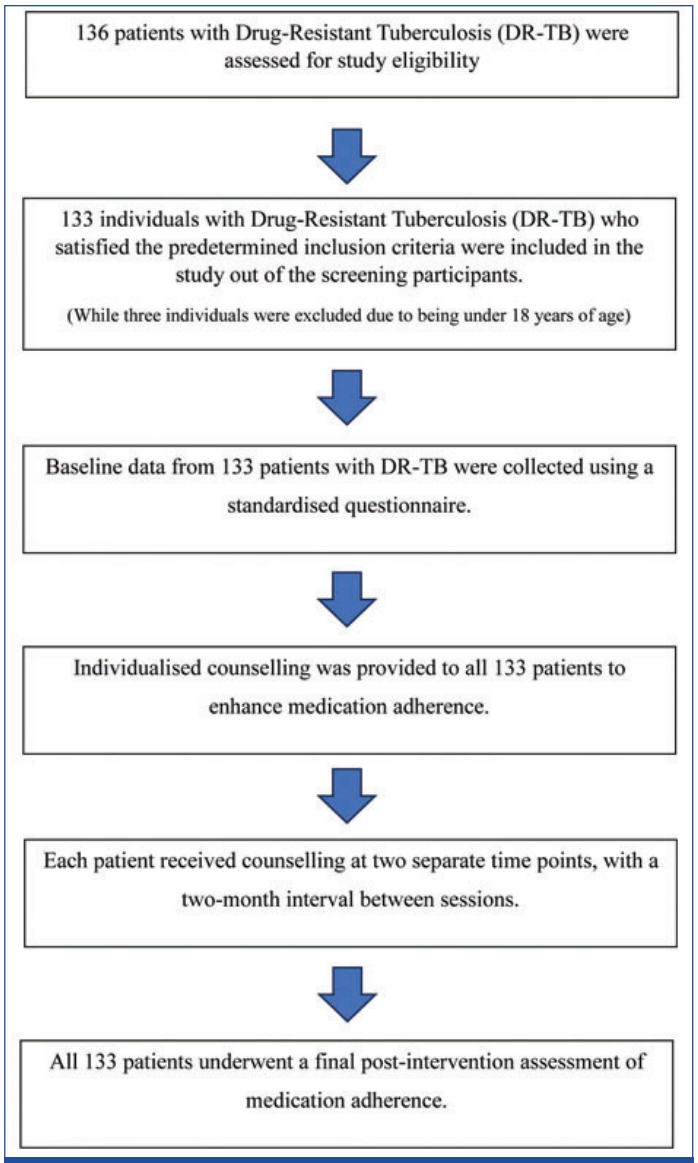
Questionnaire development and validation: The questionnaire was initially reviewed and validated by a panel of 20 experts, including pulmonologists (5), nursing professionals (5), clinical pharmacists (5) and academicians (5), to assess the relevance, clarity and comprehensiveness of the items. Following content validation, the questionnaire was translated into Kannada, Hindi and Marathi. The translated versions were subsequently evaluated by language experts (2) to ensure linguistic accuracy, cultural appropriateness and conceptual equivalence with the original instrument. The content validity assessment yielded I-CVI values ranging from 0.80 to 1.00 and an S-CVI/Ave of 0.95, indicating excellent content validity. The questionnaire was further pilot tested among 20 participants and reliability analysis demonstrated good internal consistency (Cronbach's α=0.801). These findings support the validity and reliability of the instrument for assessing medication adherence among patients with DR-TB.

Patient counselling sessions: Patient counselling was conducted to identify and address the factors contributing to medication non adherence among DR-TB patients. Individual counselling sessions were provided by the investigator to both patients and their caregivers, focusing on improving understanding of the disease, treatment regimen, importance of adherence and overall disease management. PILs were also used as supportive educational tools during the counselling sessions. In addition to face-to-face interactions, telephonic counselling was provided to patients who were unable to attend the healthcare facility in person, ensuring continuity of counselling and follow-up support. The counselling procedure was implemented in a step-wise manner. Eligible patients were first enrolled in the study, followed by a baseline (preintervention) assessment of medication adherence. Subsequently, adherence-focused counselling was delivered to each participant for 10-15 minutes. The patient counselling was individualised according to each patient's clinical condition, treatment status and adherence-related concerns. No predefined checklist was used; instead, the counselling content was individualised to address patient-specific issues and improve treatment adherence. The counselling intervention was delivered by the principal investigator and included education on the importance of each prescribed medication, its therapeutic benefits and the potential consequences of medication non adherence, including poor treatment outcomes, disease progression and the development of additional drug resistance. Baseline assessment was conducted at study enrollment, followed by the first counselling session after two months and a second counselling session after a further two-month interval. The final post-intervention assessment was performed at the end of six months from baseline to evaluate changes in medication adherence. This six-month follow-up period provided sufficient time for patients to adopt and sustain adherence-related behavioural changes.

Counselling was primarily delivered through face-to-face interactions, which was considered the preferred approach in the present study to ensure better communication, patient engagement and individualised support. However, in cases where patients were unable to attend follow-up visits, counselling was provided through telecommunication methods (such as phone calls) to maintain continuity of care. Despite this, the majority of participants received counselling in person.

Patients received follow-up care and medication refills either from the DR-TB Centre or nearby PHCs under NTEP based on accessibility and convenience. Owing to the overlapping pattern of patient follow-up between centres, site-wise patient distribution and comparative analysis were not feasible.

Data collection procedure: The study followed a structured approach in which 136 patients DR-TB were initially screened by considering predefined eligibility criteria. Of these, 133 patients were included, while three were excluded due to age below 18 years. Baseline data, including medication adherence, were collected from all enrolled participants. Individualised counselling focused on improving medication adherence was provided to all participants. This was followed by a follow-up assessment using a standardised questionnaire to evaluate changes in adherence after the intervention. All responses before and after counselling were systematically recorded. The collected data were analysed using appropriate descriptive and inferential statistical methods to assess the effectiveness of the counselling intervention [Table/Fig-1].



[Table/Fig-1]: Study procedure flowchart.

STATISTICAL ANALYSIS

The collected data were coded, entered and analysed using the Statistical Package for the Social Sciences (SPSS) software version 26.0. Descriptive statistics, including frequencies, percentages, means and standard deviations, were used to summarise participant characteristics and study variables. Paired t-tests and Wilcoxon's signed-rank tests were performed to compare pre- and post-intervention adherence scores, as appropriate. Correlation analysis was conducted to evaluate associations between adherence-related domains, while multiple linear regression analysis was used to identify factors associated with post-intervention adherence outcomes. The results were presented as frequencies, percentages, mean±standard deviation, correlation coefficients (r), regression coefficients (β), odds ratios where applicable and p-values. A p-value of less than 0.05 was considered statistically significant. Pre- and post-intervention domain scores were compared using paired-sample statistical tests. The magnitude of change was quantified using Cohen's dz, an effect size measure appropriate for paired-sample comparisons. Cohen's dz values of 0.2, 0.5 and ≥0.8 were interpreted as small, moderate and large effects, respectively.

RESULTS

The study included 133 patients who had been diagnosed with drug-resistant TB. The largest proportion of participants belonged to the 25-44 years age group (45.9%), followed by those aged 45-60 years (29.3%), indicating that the disease was more common among individuals in their productive years. Younger patients aged 18-24 years constituted 15%, while those above 60 years accounted for 9.8%. There was a clear predominance of male participants (61.7%) compared to females (38.3%). In terms of behavioural risk factors, 24.1% of patients reported alcohol use, 17.3% were smokers and a notable 46.6% used chewing tobacco, reflecting a substantial presence of substance-related habits within the cohort. Most of the participants were married (77.4%), suggesting that a significant proportion of patients were part of family units.

Among the 133 DR-TB patients included in the study, the majority of patients were receiving the longer M/XDR-TB treatment regimen, accounting for 84 patients (63.15%). Regimens prescribed for H-mono/poly-resistant tuberculosis were observed in 65 patients (48.87%). The newer Bedaquiline+Pretomanid+Linezolid+Moxifloxacin (BPaLM)/Bedaquiline+Pretomanid+Linezolid (without moxifloxacin) (BPaL) regimen, recommended for selected MDR/RR-TB patients under updated NTEP guidelines, was used in 20 patients (15.03%). A smaller proportion of patients, 5 (3.75%), were receiving the shorter MDR/RR-TB regimen. Regimen categories were not mutually exclusive. Some patients were included in more than one treatment category due to regimen modifications, overlapping resistance classifications, or transition to newer MDR/RR-TB regimens such as BPaLM/BPaL during the study period under NTEP guidelines [Tables/Fig-2] [7].

Particulars	n (%)
Age (in years)	
18-24	20 (15)
25-44	61 (45.9)
45-60	39 (29.3)
>60	13 (9.8)
Gender	
Male	82 (61.7)
Female	51 (38.3)
Alcohol consumption	
Yes	32 (24.1)
No	101 (75.9)
Smoking	
Yes	23 (17.3)
No	110 (82.7)
Chewing tobacco	
Yes	62 (46.6)
No	71 (53.4)
Marital status	
Married	103 (77.4)
Unmarried	30 (22.6)
DR-TB drug regimens	
BPaLM/BPaL regimen	20 (15.03)
Longer M/XDR-TB regimen	84 (63.15)
Regimen for H-Mono/poly	65 (48.87)
Shorter MDR/RR-TB regimen	5 (3.75)

[Table/Fig-2]: Demographic details [7].

The analysis of pre- and post-intervention scores revealed significant improvement in all medication adherence domains among DR-TB patients after the counselling intervention. The mean score for patient-related factors increased from 22.15±1.35 before intervention to 23.38±1.03 after intervention (t=-11.62, p<0.001). Healthcare system-related factor scores also improved significantly from 16.50±0.97 to 17.76±0.93 (t=-12.35, p<0.001).

Similarly, social and economic factor scores increased from 15.72±1.02 during the preintervention phase to 16.92±0.91 following the intervention (t=-12.65, p<0.001). A notable rise was observed in medical condition-related factor scores, which improved from 8.66±1.30 to 11.68±1.26, demonstrating the greatest change among all domains (t=-27.70, p<0.001). Therapy-related factor scores also showed significant enhancement after intervention.

The effect size analysis demonstrated large intervention effects across all domains, with Cohen's dz values ranging from 1.01 to 2.40. The highest effect size was observed for medical condition-related factors (d=2.40), followed by therapy-related factors (d=1.37), indicating a substantial positive impact of pharmacist-led counselling and PIL-based education on medication adherence among DR-TB patients [Table/Fig-3].

Domain	Preintervention Mean±SD	Post-intervention Mean±SD	Mean difference	t value	p-value	Cohen's dz
Patient-related factors	22.15±1.35	23.38±1.03	-1.23	-11.62	<0.001*	1.01
Healthcare system-related Factors	16.50±0.97	17.76±0.93	-1.26	-12.35	<0.001*	1.07
Social and economic factors	15.72±1.02	16.92±0.91	-1.20	-12.65	<0.001*	1.10
Medical condition-related factors	8.66±1.30	11.68±1.26	-3.02	-27.70	<0.001*	2.40
Therapy-related factors	14.25±0.86	16.17±1.19	-1.92	-15.81	<0.001*	1.37

[Table/Fig-3]: Comparison of pre- and post-intervention scores across medication adherence domains among DR-TB patients.
Interpretation of Cohen's dz:Effect sizes were calculated using Cohen's dz for paired pre-post comparisons. Cohen's d values of 0.2, 0.5 and ≥0.8 indicate small, moderate and large effects, respectively
(Note: Mean difference was calculated as preintervention score minus post-intervention score)

Across all domains, the majority of items demonstrated a higher proportion of positive ranks compared to negative ranks, indicating overall improvement following the intervention.

Within patient-related factors (Q1-Q5), positive ranks ranged from 12.8% to 40.6%, while negative ranks were minimal (0.8%-3.8%), with a large proportion of ties (58.6%-85.7%). All items showed statistically significant differences (p≤0.001), reflecting meaningful changes. For healthcare system-related factors (Q6-Q9), positive ranks varied between 17.3% and 48.9%, with negative ranks ranging from 2.3% to 8.3%. A notable observation was Q8, where positive ranks (48.9%) were equal to ties (48.9%), indicating moderate improvement. All items were statistically significant (p≤0.001). In the social and economic domain (Q10-Q13), Q10 showed no change (100% ties, p=1.000), indicating no effect of the intervention. However, the remaining items (Q11-Q13) demonstrated positive ranks between 33.8% and 40.6%, with low negative ranks (1.5%-7.5%) and were statistically significant (p≤0.001).

The medical condition-related factors (Q14-Q17) exhibited the most pronounced improvement, with positive ranks ranging from 57.1% to 77.4% and minimal negative ranks (0%-3%). All items in this domain showed strong statistical significance (p≤0.001), highlighting substantial impact. Similarly, in the therapy-related domain (Q18-Q21), positive ranks ranged from 42.1% to 63.2%, with negative ranks between 0% and 15.8%. All items were statistically significant (p≤0.001), indicating consistent improvement. Analysis of effect sizes

further supported the observed improvements across domains. The largest effects were observed within the medical condition-related domain, particularly for Q17 (r=0.833), Q14 (r=0.695), Q15 (r=0.692) and Q16 (r=0.665), indicating a substantial impact of the intervention on medication adherence behaviours associated with disease-related concerns. Similarly, large effect sizes were observed for therapy-related items Q21 (r=0.754), Q19 (r=0.613) and Q20 (r=0.560), suggesting meaningful improvements in treatment-related adherence. Moderate to large effects were also evident for several patient-related and healthcare system-related items, including Q1 (r=0.592), Q6 (r=0.515) and Q8 (r=0.626). In contrast, Q10 demonstrated no measurable effect (r=0.000), consistent with the absence of change observed across all participants. Overall, the effect size estimates indicate that the intervention produced clinically meaningful improvements, particularly in medical condition-related and therapy-related aspects of medication adherence. Overall, the findings suggest that the intervention led to significant improvements across most domains, particularly in medical condition-related and therapy-related factors, while minimal or no change was observed in select social factors. In summary, the findings demonstrate a significant overall improvement, particularly in the medical condition-related and therapy-related domains, whereas patient-related and healthcare system-related factors showed comparatively moderate gains. However, no change was observed for Q10 within the social domain. This lack of variation warrants careful interpretation. The item assessed delays in medication refilling due to financial constraints, which may not be a contextually sensitive indicator in this setting. Under the National Tuberculosis Elimination Programme in India, DR-TB treatment is provided free of cost, thereby substantially reducing direct financial barriers to medication access. As a result, the baseline responses for this item were already uniform (100% ties), leaving minimal scope for change following the intervention [Table/Fig-4].

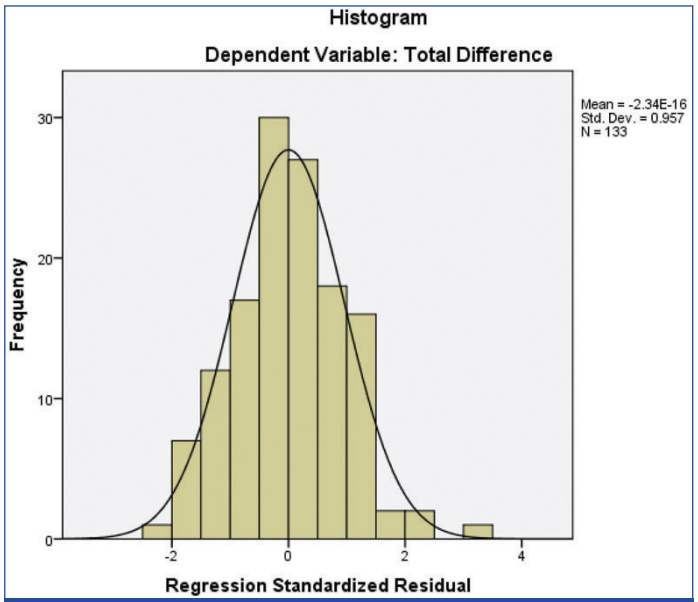
Domain	Item	Negative ranks n (%)	Positive ranks n (%)	Ties n (%)	Z value	Effect size (r)	p-value
Patient-related factors	Q1	1 (0.8)	54 (40.6)	78 (58.6)	-6.824	0.592	<0.001
	Q2	5 (3.8)	35 (26.3)	93 (69.9)	-4.743	0.411	<0.001
	Q3	3 (2.3)	41 (30.8)	89 (66.9)	-5.729	0.497	<0.001
	Q4	2 (1.5)	22 (16.5)	109 (82.0)	-4.082	0.354	<0.001
	Q5	2 (1.5)	17 (12.8)	114 (85.7)	-3.441	0.298	0.001
Healthcare system-related factors	Q6	7 (5.3)	53 (39.8)	73 (54.9)	-5.939	0.515	<0.001
	Q7	5 (3.8)	23 (17.3)	105 (78.9)	-3.402	0.295	0.001
	Q8	3 (2.3)	65 (48.9)	65 (48.9)	-7.221	0.626	<0.001
	Q9	11 (8.3)	43 (32.3)	79 (59.4)	-4.355	0.378	<0.001
Social and economic factors	Q10	0	0	133 (100.0)	0.000	0.000	1.000
	Q11	2 (1.5)	54 (40.6)	77 (57.9)	-6.642	0.576	<0.001
	Q12	10 (7.5)	45 (33.8)	78 (58.6)	-4.719	0.409	<0.001
	Q13	3 (2.3)	53 (39.8)	77 (57.9)	-6.338	0.550	<0.001
Medical condition-related factors	Q14	4 (3.0)	80 (60.2)	49 (36.8)	-8.018	0.695	<0.001
	Q15	4 (3.0)	84 (63.2)	45 (33.8)	-7.978	0.692	<0.001
	Q16	4 (3.0)	76 (57.1)	53 (39.8)	-7.666	0.665	<0.001
	Q17	0	103 (77.4)	30 (22.6)	-9.610	0.833	<0.001
Therapy-related factors	Q18	21 (15.8)	56 (42.1)	56 (42.1)	-3.824	0.332	<0.001
	Q19	4 (3.0)	61 (45.9)	68 (51.1)	-7.070	0.613	<0.001
	Q20	7 (5.3)	61 (45.9)	65 (48.9)	-6.461	0.560	<0.001
	Q21	0	84 (63.2)	49 (36.8)	-8.695	0.754	<0.001

[Table/Fig-4]: Comparison of pre- and post-intervention responses to medication adherence questionnaire items using the Wilcoxon's Signed-rank test (N=133).

Multiple linear regression analysis was conducted to identify demographic and clinical factors associated with changes in medication adherence following the counselling intervention. The overall model was not statistically significant ($F(11,121)=0.918$, $p=0.525$) and accounted for 7.7% of the variance in adherence improvement ($R^2=0.077$).

Although none of the predictors achieved conventional statistical significance ($p<0.05$), smoking status emerged as the strongest predictor of adherence improvement ($\beta=0.197$, $B=1.485$, $p=0.081$). Smokers demonstrated a greater increase in medication adherence scores compared with non smokers, suggesting that this subgroup may have derived relatively greater benefit from the counselling intervention. While this association did not reach statistical significance, the observed trend may warrant further investigation in studies with larger sample sizes.

The remaining variables, including age, gender, alcohol consumption, chewing tobacco use, marital status and treatment regimen, showed weak associations with adherence improvement and were not significant predictors. The confidence intervals for all regression coefficients crossed zero, indicating uncertainty regarding the direction and magnitude of these effects. The histogram of standardised residuals demonstrated an approximately normal distribution, with residuals cantered around zero and closely following the expected bell-shaped curve. This finding supports the assumption of residual normality and suggests that the regression model was statistically appropriate despite the absence of significant predictors [Table/Fig-5].



[Table/Fig-5]: Distribution of regression standardised residuals for the medication adherence change model.

Overall, the results suggest that demographic and treatment-related characteristics had limited influence on improvements in medication adherence following counselling. However, the observed trend among smokers indicates a potentially meaningful relationship that deserves further exploration in future studies [Table/Fig-6].

The correlation analysis revealed different patterns of association among the medication adherence domains following the counselling intervention among DR-TB patients. Healthcare system-related differences demonstrated a weak positive correlation with therapy-related factor differences ($r=0.197$, $p=0.023$), indicating that improvements in healthcare-related support were modestly associated with better therapy-related adherence outcomes.

Social and economic factor differences showed a weak negative association with therapy-related factors ($r=-0.248$, $p=0.004$), suggesting that persistent social and economic difficulties may negatively affect treatment-related adherence behaviours.

Variables	B (SE)	β	t-value	p-value	95% CI for B
Constant	9.018 (1.162)	-	7.762	<0.001	6.718 to 11.318
18-24 years	0.900 (0.835)	0.113	1.078	0.283	-0.753 to 2.553
25-44 years	-0.434 (0.605)	-0.076	-0.717	0.475	-1.631 to 0.763
>60 years	0.335 (0.939)	0.035	0.357	0.722	-1.524 to 2.194
Gender	-0.212 (0.580)	-0.036	-0.365	0.716	-1.361 to 0.937
Alcohol consumption	0.106 (0.780)	0.016	0.136	0.892	-1.437 to 1.649
Smoking	1.485 (0.845)	0.197	1.757	0.081	-0.188 to 3.157
Chewing tobacco	-0.158 (0.615)	-0.028	-0.257	0.798	-1.376 to 1.060
Marital status	-0.505 (0.608)	-0.074	-0.831	0.407	-1.708 to 0.698
BPaLM/BPaL regimen	-0.552 (1.162)	-0.043	-0.475	0.636	-2.852 to 1.749
H mono/poly regimen	0.711 (1.213)	0.056	0.586	0.559	-1.690 to 3.111
Shorter MDR/ RR-TB regimen	0.155 (0.576)	0.026	0.269	0.789	-0.985 to 1.295

[Table/Fig-6]: Multiple linear regression analysis of factors associated with change in medication adherence among patients with Drug-Resistant Tuberculosis (DR-TB).
Model statistics:
$R=0.278$; $R^2=0.077$; Adjusted $R^2=-0.007$; $F(11,121)=0.918$; $p=0.525$

No statistically significant correlations were observed between healthcare-related and medical condition-related factors (r=-0.038, p=0.660), healthcare-related and patient-related factors (r=0.027, p=0.758), or medical condition-related and therapy-related factors (r=0.027, p=0.761). Similarly, patient-related differences did not show significant associations with social and economic factors (r=0.035, p=0.689), medical condition-related factors (r=0.087, p=0.319), or therapy-related factors (r=0.078, p=0.373).

Overall, these findings suggest that medication adherence among DR-TB patients is influenced by multiple interacting domains, with healthcare support and therapy-related factors demonstrating modest positive relationships, whereas social and economic barriers may adversely impact adherence outcomes [Table/Fig-7].

Variables	Healthcare related difference	Social and economic factors difference	Medical condition-related factors difference	Therapy-related factors difference	Patient-related difference
Healthcare related difference	1.000	-0.099	-0.038	0.197*	0.027
Sig. (2-tailed)	-	0.256	0.660	0.023	0.758
N	133	133	133	133	133
Social and economic factors difference	-0.099	1.000	0.109	-0.248**	0.035
Sig. (2-tailed)	0.256	-	0.214	0.004	0.689
N	133	133	133	133	133
Medical condition-related factors difference	-0.038	0.109	1.000	0.027	0.087
Sig. (2-tailed)	0.660	0.214	-	0.761	0.319
N	133	133	133	133	133
Therapy-related factors difference	0.197*	-0.248**	0.027	1.000	0.078
Sig. (2-tailed)	0.023	0.004	0.761	-	0.373
N	133	133	133	133	133
Patient-related difference	0.027	0.035	0.087	0.078	1.000
Sig. (2-tailed)	0.758	0.689	0.319	0.373	-
N	133	133	133	133	133

[Table/Fig-7]: Association between changes in medication adherence domains among DR-TB patients.
*Correlation is significant at the 0.01 level (2-tailed); **Correlation is significant at the 0.05 level (2-tailed)

DISCUSSION

The present study identified meaningful improvements across several domains following the intervention, including patient-related, healthcare system-related, social and economic, medical condition-related and therapy-related aspects. Most participants were in the 25-44-year age group (45.9%), with a higher proportion of males (61.7%) and the majority were non smokers (82.7%) and non alcohol consumers (75.9%). Despite these variations in demographic and treatment characteristics, multiple linear regression analysis using post-intervention medication adherence scores as the outcome variable did not identify any demographic or clinical characteristic as a significant predictor of medication adherence following the counselling intervention. In contrast, Jomidava T et al., MDR-TB adherence study demonstrated improved treatment outcomes with optimised adherence support, primarily focusing on clinical indicators such as treatment success. While that study emphasises clinical endpoints, the current findings provide additional insight by capturing improvements across multiple patient-centred domains, reflecting a broader impact of adherence-focused strategies. The relatively weak associations between domains further suggest that these improvements occurred across distinct areas rather than as a uniform change [8]. Baseline scores played a key role in determining post-intervention outcomes.

The demographic characteristics of the present study show some differences when compared with Lin K and Xiang L MDR-TB adherence study. In this study, most participants belonged to the 25-44-year age group (45.9%), whereas the comparative study had a larger proportion of individuals aged 35-64 years. Both studies reported a predominance of male participants, although the proportion was higher in the comparative study. A majority of participants were married in both settings, reflecting a similar pattern across populations. While the present study primarily described behavioural factors such as smoking and alcohol use, the comparative study included broader socioeconomic variables such as employment status, insurance coverage and healthcare-related expenditures. In addition, the comparative study reported a higher level of non adherence among migrants compared to local residents, indicating the impact of socioeconomic and access-related factors on treatment adherence. In contrast, the current study did not find demographic or behavioural characteristics to be significantly associated with outcomes, suggesting that the intervention produced consistent effects across different patient groups [9].

Similarly, the present study demonstrated significant improvement in medication adherence following pharmacist-led counselling interventions among DR-TB patients. Post-intervention scores showed statistically significant enhancement across patient-related, healthcare-related, social and economic, medical condition-related and therapy-related domains (p<0.001). Although significant improvements were observed across most medication adherence domains, several questionnaire items demonstrated a high proportion of tied responses, including Q4 (82.0%), Q5 (85.7%), Q7 (78.9%) and Q10 (100%). The large number of unchanged responses may indicate a ceiling effect, whereby participants had already reported favourable adherence-related behaviours or perceptions at baseline, limiting the potential for further measurable improvement. This was particularly evident for Q10, which assessed delays in medication refilling due to financial constraints. Since anti-tuberculosis medications are provided free of cost under the National Tuberculosis Elimination Programme (NTEP) in India, financial barriers to medication access were minimal, resulting in no observable change following the counselling intervention. Therefore,

the high proportion of tied responses likely reflects favourable baseline conditions rather than a lack of intervention effectiveness. Large effect sizes were also observed across all domains, with Cohen's dz values ranging from 1.02 to 2.35, indicating a substantial positive impact of counselling and PIL-based education on adherence-related outcomes. While the Handayani RS et al., study primarily established the association between poor adherence and the development of DR-TB and also study had two groups, but the present study was single group study, the present study further extends these findings by demonstrating that structured pharmaceutical counselling interventions can significantly improve adherence-related behaviours among DR-TB patients. Together, both studies emphasise the importance of medication adherence in TB management and support the role of patient-centred counselling strategies in improving treatment outcomes [3].

The findings of the present study are comparable with previous studies conducted among TB patients attending DOTS centres, where 69% of patients were adherent to therapy, while 31% reported missing medication doses. Barriers such as inconvenient treatment timings (38.9%) and inaccessible treatment locations (22.2%) were identified as major contributors to non adherence. Similarly, the present study demonstrated significant improvement in medication adherence-related outcomes among DR-TB patients following pharmacist-led counselling and PIL-based education, with statistically significant improvements observed across all adherence domains ($p<0.001$). These findings highlight the importance of continuous counselling, patient support and healthcare accessibility in improving adherence behaviours among DR-TB patients [10].

The observations of the present study are consistent with earlier findings Byakod VR et al., that inadequate patient awareness and poor adherence to anti-tubercular therapy are important contributors to unfavourable MDR-TB outcomes. Previous studies reported that 29% of patients had a family history of MDR-TB, indicating insufficient understanding of disease transmission, treatment importance and adherence practices among patients and their caregivers. In a similar manner, the current study identified several patient-related, social and therapy-related barriers affecting medication adherence among DR-TB patients. The significant improvement observed after pharmacist-led counselling and PIL-based education highlights the importance of structured counselling and continuous educational support in promoting better treatment adherence and minimising the likelihood of treatment failure [11].

The observations of the present study are in line with earlier review studies conducted by Rai S et al., states that under the NTEP, which reported that medication adherence among DR-TB patients is influenced by multiple socioeconomic, clinical and psychosocial factors. Previous reports identified financial difficulties, stigma, adverse drug reactions, prolonged treatment duration and inadequate social support as important barriers affecting treatment adherence. Likewise, the current study found that patient-related, social and economic and therapy-related factors significantly affected adherence outcomes, while pharmacist-led counselling along with PIL-based education contributed to improved medication adherence behaviours among DR-TB patients [12].

In the context of limited evidence addressing multidimensional adherence outcomes in DR-TB, the present study contributes meaningful insight into the broader effects of adherence-focused interventions. Rather than concentrating solely on clinical endpoints or isolated determinants, this study evaluates multiple domains concurrently, offering a more integrated perspective on how interventions influence treatment-related, behavioural and social dimensions of care. The findings indicate that well-structured, patient-centred strategies can bring about measurable improvements across these domains, even when demographic factors show minimal influence. Notably, pharmacist-led counselling appears to play a pivotal role in strengthening patient engagement, improving understanding of therapy and supporting sustained adherence, which collectively enhance overall health outcomes. Such interventions facilitate more effective management of DR-TB by addressing practical and behavioural barriers to treatment. From a wider public health perspective, integrating pharmacist-driven and multidisciplinary approaches into routine care may contribute substantially to improving treatment success and advancing efforts toward long-term tuberculosis control and eventual elimination. Future studies could benefit from including control groups and recruiting larger, more diverse populations to strengthen the generalisability of the findings. Incorporating longer follow-up periods would help in understanding the durability of the intervention effects. Exploring additional clinical and behavioural factors may also provide deeper insight into the determinants of patient outcomes.

Limitation(s)

A few limitations should be considered while interpreting the findings. The absence of a control group limits the ability to attribute the observed changes solely to the intervention. The sample size was reduced due to time constraints, which could have affected the overall representation. Moreover, the model explained a moderate level of variation and the lack of extended follow-up makes it difficult to determine whether the observed improvements are sustained over time. Detailed categorisation of patients according to counselling modality was not systematically documented and therefore could not be analysed separately. As the counselling intervention and outcome assessments were conducted by the same investigator, the possibility of observer bias cannot be completely excluded, which may have influenced the study outcomes.

CONCLUSION(S)

The outcomes of the present study indicate that the intervention was associated with significant improvements across multiple domains, including patient-related, healthcare system-related, social and economic, medical condition-related and therapy-related factors. The pre-post comparisons demonstrated consistent positive changes in most of the assessed questionnaire items, suggesting a meaningful impact of the intervention on patient outcomes. Multiple linear regression analysis further revealed that demographic and lifestyle variables, including age, gender, smoking status, alcohol consumption, chewing tobacco use, marital status and treatment regimen, were not significantly associated with post-intervention medication adherence scores. These findings suggest that the benefits of the intervention were observed across diverse patient groups, regardless of their individual characteristics. Overall, individualised patient counselling was effective in improving medication adherence among patients with DR-TB and may serve as a valuable component of routine patient care to support treatment adherence and optimise therapeutic outcomes.

In addition, the correlation analysis revealed that improvements across different domains contributed to overall change, with relatively stronger contributions from medical condition related and therapy-related factors. At the same time, the limited strength of associations between certain domains suggests that these improvements did not occur uniformly, but rather across distinct dimensions of patient care.

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REFERENCES

[1] Mphothulo N, Hlangu S, Furin J, Moshabela M, Loveday M. Navigating DR-TB Treatment care: A qualitative exploration of barriers and facilitators to retention in care among people with history of early disengagement from drug-resistant tuberculosis treatment in Johannesburg, South Africa. BMC Health Serv Res. 2025;25(1):122.

[2] Mathew B, Kurian D, Mathew J, Senan A, Kumar TR, Sivakumar T. A study on reasons for medication non-adherence in tuberculosis patients and proposed clinical interventions. IJPCBS. 2015;5(4):986-94.

[3] Handayani RS, Hendarwan H, Ratri T. The influence of medication non-adherence on the occurrence of drug-resistant tuberculosis. Journal of Current Health Sciences. 2024;4(2):59-66.

[4] Wardani HK. Association between medication adherence and tuberculosis treatment outcomes: A retrospective cohort study at a primary health center in Kediri, Indonesia. In: Proceeding Strada International Conference on Health 2025 Oct 28 (pp. 118-125).

[5] Vasava KA, Parikh SS, Parikh VA, Sisodiya AH. Impact of counselling and health education on treatment adherence and outcomes in MDR-TB patients. GAIMS J Med Sci. 2026;6(2):01-08.

[6] O'Donnell MR, Daftary A, Frick M, Hirsch-Moverman Y, Amico KR, Senthilingam M, et al. Re-inventing adherence: Toward a patient-centered model of care for drug-resistant tuberculosis and HIV. Int J Tuberc Lung Dis. 2016;20(4):430-34.

[7] Directorate General of Health Services. National Tuberculosis Elimination Programme (NTEP) [Internet]. New Delhi: Ministry of Health and Family Welfare, Government of India; [cited 2026 Jun 4]. Available from: https://dghs.mohfw.gov.in/national-tuberculosis-elimination-programme.php.

[8] Jomidava T, Khogali M, Sereda Y, Avaliani Z, Davitashvili M, Madzgharashvili M, et al. Does optimized adherence support improve treatment outcomes in RR/MDR-TB patients on 18-20 months regimen in Tbilisi, Georgia? J Infect Dev Ctries. 2021;15(9.1):34S-42S.

[9] Lin K, Xiang L. Factors associated with non-adherence to treatment among migrants with MDR-TB in Wuhan, China: A cross-sectional study. Risk Manag Healthc Policy. 2024;17:727-37.

[10] Zaidi I, Sarma PS, Khayyam KU, Toufique Ahmad Q, Ramankutty V, Singh G. Factors associated with treatment adherence among pulmonary tuberculosis patients in New Delhi. Indian J Tuberc. 2024;71 Suppl 1:S52-S58.

[11] Byakod VR, Ganachari MS. Empowering care: Unleashing pharmaceutical care to confront MDR-TB transmission risks-A prospective interventional study. Indian J Tuberc. 2025;72(2):233-39.

[12] Rai S, Sen A, Shah H, Patel J. Barriers to effective management of drug-resistant tuberculosis in India, insights into patient & health system challenges: An exploratory review. Indian J Med Res. 2026;162(6):801-08.

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