Psychosocial and health system factors associated with tuberculosis treatment adherence in Kota Kinabalu, Sabah

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ABSTRACT

Introduction: Treatment adherence remains a major challenge in tuberculosis (TB) control and may be influenced by psychosocial and health system factors that remain underexplored in many settings. This study aimed to examine the association between psychosocial and health system factors and treatment adherence among TB patients in Kota Kinabalu, Sabah.

Materials and Methods: A cross-sectional study was conducted among 351 TB patients registered in the National TB Registry between 2023 and 2024. Data were collected using structured, validated, and translated questionnaires, including the TB Stigma Scale and the Patient Health Questionnaire-9 (PHQ-9). Variables included sociodemographic characteristics, TB knowledge, treatment-related factors, and healthcare system factors. Simple and multivariable logistic regression analyses were performed to identify factors of treatment adherence.

Results: Stigma was negatively associated with treatment adherence (AOR=0.90; 95% CI: 0.86–0.95; p<0.001), whereas higher TB knowledge was associated with higher treatment adherence (AOR=1.20; 95% CI: 1.06–1.35; p=0.004). Compared with video directly observed therapy (VDOT), healthcare worker (HCW)-supervised direct observed treatment short-course (DOTS) was associated with lower treatment adherence (AOR=0.23; 95% CI: 0.06–0.90; p=0.030). Longer clinic waiting time was associated with higher treatment adherence (AOR=1.09; 95% CI: 1.05–1.13; p<0.001). Depression was negatively associated with adherence in univariate analysis but was not statistically significant in the multivariable model (AOR=0.58; 95% CI: 0.21–1.58; p=0.285).

Conclusion: Stigma, TB knowledge, DOTS modality, and clinic waiting time were independently associated with TB treatment adherence in this setting. These findings highlight the importance of integrated, patient-centered TB care that addresses stigma, strengthens patient education, and incorporates digital approaches such as VDOT. Strengthening multifaceted interventions targeting both psychosocial and health system factors may improve TB treatment outcomes in Malaysia and similar high-burden settings.

KEYWORDS:
Tuberculosis; stigma; depression; DOTS, knowledge; adherence

INTRODUCTION

Tuberculosis (TB) remains a major global public health challenge, particularly in developing countries. Although substantial progress has been made in diagnosis and treatment, TB continues to cause significant morbidity and mortality worldwide. Ensuring consistent treatment adherence remains a critical challenge in achieving effective TB control.

The Global Tuberculosis Report estimated that approximately 10.7 million people developed TB worldwide in 2024. In Malaysia, the incidence of TB in 2022 was 113 cases per 100,000 population, with a treatment success rate of 79% for the 2021 cohort. Effective TB control depends largely on sustained adherence to treatment regimens, which typically extend for six months or longer, as recommended by the Ministry of Health Malaysia (MOH) Clinical Practice Guidelines. Maintaining adherence throughout the treatment is essential for successful therapy completion, preventing relapses, reducing the emergence of drug resistance, limiting disease transmission, and lowering TB-related mortality.

Numerous studies have identified a range of factors associated with medication adherence among TB patients, including sociodemographic characteristics, patient-related factors, treatment-related factors, health system influences, and social support systems.[1-2] However, psychosocial determinants such as stigma and depression remain insufficiently addressed despite growing evidence of their influence on treatment adherence. Evidence suggests that between 42% and 82% of TB patients experience some form of stigma. TB-related stigma may lead to social isolation, fear of disclosure, and reduced motivation to continue treatment.[3] It can affect patients' self-esteem and quality of life. Depression is also common among TB patients and may further compromise adherence by worsening health-seeking behaviour and treatment engagement.[4-5] Previous studies have reported depression prevalence ranging from 40% to 70% among TB patients in high-burden settings.[6] Depression can impair cognitive function, reduce motivation, and limit patients' ability to consistently follow treatment

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recommendations, thereby increasing the risk of treatment non-adherence.[7]

Despite increasing global attention, evidence on the psychosocial determinants of TB treatment adherence remains limited in Malaysia, particularly in Sabah. Therefore, this study aimed to examine the association between psychosocial and health system factors and treatment adherence among TB patients in Kota Kinabalu, Sabah. Addressing these determinants through integrated, patient-centered care approaches is essential to ensure that patients receive adequate psychological and social support to complete treatment. The findings may inform the development of more effective and context-specific TB control strategies aligned with the WHO End TB Strategy 2035, ultimately contributing to improved treatment outcomes in Sabah and other high-burden settings.

MATERIALS AND METHODS

Study Design and Study Setting

This cross-sectional study was conducted in Kota Kinabalu, the capital and largest district of Sabah, Malaysia, with an estimated population of 500,421 according to the Department of Statistics of Malaysia (DOSM 2020). The district has a high TB burden, with approximately 1,400 cases reported in 2023, according to the National Tuberculosis Registry (NTBR). In Kota Kinabalu, TB treatment services are provided through four government primary care facilities, namely Luyang, Manggatal, Inanam, and Telipok, all operated under the supervision of the Kota Kinabalu District Health Office. These four health centers were chosen as study sites for data collection. The data collection period lasted three months, from May 2024 to July 2024, spanning twelve weeks.

National Tuberculosis Registry (NTBR)

In Malaysia, TB is a legally notifiable disease. All newly diagnosed TB cases, including those identified in both public and private healthcare facilities, are mandatorily notified to the district health office and recorded in the NTBR system. The Ministry of Health Malaysia coordinates the NTBR and functions as the national surveillance and monitoring system for TB.

Study Population and Sampling Criteria

All adult TB patients registered at the selected TB treatment center in Kota Kinabalu were considered the study population. Patients aged 18 years or older, registered in the NTBR during the 2023–2024 cohort year, and who had completed at least 1 month of TB treatment were included. TB patients with pre-existing (documented) mental health conditions, pregnant or postpartum TB patients within six weeks of delivery, and those who declined to give written informed consent were all excluded.

Sample Size Calculation

The sample size was calculated using G*Power with a 95% confidence level to estimate the prevalence of stigma and depression among adult TB patients in Kota Kinabalu. Based on a reported depression[8] prevalence of 45% and using the single population proportion formula with a 5% margin of error, the required sample size was determined to be 381. For stigma, a prevalence of 57% was used[9], yielding a sample size of 377. The larger estimate of 381 was adopted as the final target sample size. Participants were consecutively recruited from the NTBR 2023–2024 cohort, based on the most recent notification dates, and all met the study's inclusion and exclusion criteria.

Operational Definition and Study Variables

The primary outcome variable in this study was TB treatment adherence. According to the World Health Organization, medication adherence refers to the extent to which a patient's behaviour aligns with the prescribed treatment recommendations provided by healthcare professionals.[10] In this study, non-adherence was defined as missing 10% or more of the total prescribed doses during either the intensive or continuation phase of TB treatment.[11] Key independent variables included stigma (measured by the TB Stigma Scale), depression (measured by Patient Health Questionnaire-9), and TB knowledge (measured by the TB Knowledge Questionnaire). Potential confounders included sociodemographic characteristics (age, sex, nationality, education level, employment status, and income), treatment-related factors (side effects, Directly Observed Treatment Short course abbreviated as DOTS, treatment duration), and healthcare access variables (distance to clinic and waiting time).

Healthcare worker (HCW)-supervised DOTS refers to direct observation of medication intake by healthcare personnel at health facilities. Family-supervised DOTS involves treatment observation by a designated household member following counselling by HCWs. Video directly observed therapy (VDOT) allows patients to record or submit videos of medication intake via a mobile application, which are reviewed subsequently by HCWs. Treatment-related side effects were identified based on patient self-report during routine clinic visits and documented in medical records by attending healthcare providers. Distance to the clinic was assessed using the patient's residential location and the estimated travel distance to the treatment facility. Clinic waiting time was defined as the duration from registration to medical consultation and was assessed based on patient self-report during the interview.

Data Collection Tools

Data were collected using a structured, self-administered questionnaire comprising five sections: sociodemographic information, stigma, depression, TB knowledge, and treatment adherence. The first section comprises semi-structured items on sociodemographic characteristics, TB treatment-related factors, and health system-related factors.

Stigma was assessed using the 12-item TB Stigma Scale (TSS) developed by Zakaria et al.[5], rated on a 4-point Likert scale. Total scores ranged from 0 to 36, with higher scores indicating greater perceived stigma. The scale demonstrated acceptable internal consistency (Cronbach's alpha = 0.78).

Depression was measured using the Patient Health Questionnaire-9 (PHQ-9), a 9-item screening tool rated on a 4-point Likert scale. Scores ranged from 0 to 27 and were categorized into normal, mild, moderate, and severe levels based on validated cut-off points. The tool showed strong

internal consistency (Cronbach's alpha = 0.89) in prior Malaysian validation studies by Sun et al.[12] TB knowledge was assessed using the 25-item TB Knowledge Questionnaire by Zakaria et al.[5], with a maximum score of 25. Higher scores indicated greater knowledge. The instrument showed moderate internal consistency (Cronbach's alpha = 0.62).

Treatment adherence was measured using the Malaysian Medication Adherence Assessment Tool (MyMAAT), developed by Hatah et al.[13] This 12-item scale, rated on a 5-point Likert scale, yields a total score ranging from 0 to 60. Respondents scoring ≥54 were classified as adherent, while those scoring <54 were considered non-adherent. The cut-off points were based on validated scoring systems to ensure interpretability and clinical relevance. The tool demonstrated high internal consistency (Cronbach's alpha=0.91). Self-reported adherence was verified through cross-checking with clinic DOTS records and confirmation by HCWs to enhance data accuracy and reduce reporting bias. All instruments were translated into the Malay language and previously validated for use in the Malaysian context.

Data Management and Analysis

Data were entered into Microsoft Excel and analysed using SPSS version 29 and Jamovi version 2.6.26. The dataset was complete with no missing values. Descriptive statistics summarised participant characteristics, with categorical variables presented as frequencies and percentages, and continuous variables as medians with interquartile ranges (IQRs). Simple and multivariable logistic regression were used to examine associations between treatment adherence and independent variables, including sociodemographic characteristics, treatment-related factors, healthcare system factors, stigma, depression, and TB knowledge. Depression was initially categorized into four levels (normal, mild, moderate, and severe) based on established cut-offs. Due to small numbers in the moderate and severe groups, it was dichotomized into "normal" and "depression" to ensure adequate statistical power. Variables with $p<0.05$ and theoretically relevant predictors with $p<0.25$ in the univariable analysis were included in the multivariable model to control potential confounders.[14-15] Adjusted odds ratios (AORs) with 95% confidence intervals were reported. A p-value ≤0.05 was considered statistically significant. Model assumptions, including multicollinearity and model fit, were assessed.

Ethical Consideration

This study received ethical approval from the Medical Research Ethics Committee (MREC) of Malaysia (NMRR ID: 24-00556-TXG), the Research Committee of University Malaysia Sabah [JKEtika 1/24 (13)], and the Sabah State Health Department (UMS/FPSK6.9/600-2/1/33). All participants provided written informed consent after being informed of the study objectives and procedures. Confidentiality was maintained, and participants were informed of their right to withdraw at any time without consequences. The study was conducted in accordance with the Declaration of Helsinki and reported in line with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines to ensure transparency and completeness.

RESULTS

Sociodemographic Characteristics of Respondents

The study included 351 respondents, a response rate of 92.0%. The sociodemographic characteristics of the respondents are summarised in Table I. Among the respondents, 59 (16.8%) were 18–24 years old, 236 (67.2%) were 25–59 years old, and 56 (16.0%) were over 60 years old. Age >60 had the highest adherence at 89.3%. A majority of responders were male (n=213, 60.7%), while 39.3% were female (n=138). Adherence was higher among women (85.5%) than men (83.1%). Malaysians (n=199, 56.7%) outnumbered non-Malaysians (n=152, 43.3%). Non-Malaysians (81.6%) had lower adherence than Malaysians (85.9%). The unemployed were the majority (n=194, 55.3%), while employed respondents were 44.7% (n=157). The unemployed had a greater adherence rate (85.1%) than the employed (82.8%). Among the respondents, 27.4% had no formal education, 32.8% had primary education, 29.6% had secondary education, and 9.4% had tertiary education. The highest adherence rate was observed among those with secondary education (87.9%), while the lowest was among those with no formal education (79.2%). In terms of income, 24.5% earned less than RM 1000, 32.8% earned RM 1000–1999, 39.9% earned RM 2000–3999, and 2.9% earned more than RM 4000. Adherence rates increased with income, with the highest adherence in the > RM 4000 group (90.0%) and the lowest in the < RM 1000 group (74.4%).

Prevalence of Depression and Medication Adherence

Of the 351 TB patients, 295 (84.0%; 95% CI: 80.2–87.9) were adherent to their medication regimen, while 56 (16.0%; 95% CI: 12.1-19.8) were non-adherent. Depression was reported in 10.9% of respondents, with most cases classified as mild (9.4%; 95% CI: 6.4–12.5), followed by moderate (0.9%; 95% CI: 0.0–1.8) and severe depression (0.6%; 95% CI: 0.0–1.4). Details are represented in Table II.

Factors associated with medication adherence

Simple logistic regression identified stigma, depression, TB knowledge, monthly income, clinic waiting time, and distance to the clinic as significant predictors of treatment adherence (Table III). Higher stigma (OR=0.89; 95% CI: 0.85–0.93; $p<0.05$) and depression scores (OR=0.23; 95% CI: 0.11–0.48; $p<0.05$) were associated with lower treatment adherence, whereas higher TB knowledge scores (OR=1.17; 95% CI: 1.09–1.26; $p<0.05$) were associated with better treatment adherence. Patients with higher monthly income (RM 2,000–3,999) also demonstrated better treatment adherence (OR=2.87; 95% CI: 1.39–5.90; $p<0.05$). In addition, longer clinic waiting time (OR=1.10; 95% CI: 1.06–1.13; $p<0.001$) and greater distance to the clinic (OR=1.10; 95% CI: 1.01–1.20; $p<0.05$) were associated with higher treatment adherence.

In the final multivariable logistic regression model (Table IV), stigma, TB knowledge, clinic waiting time, and DOTS modality remained significant predictors of treatment adherence. Stigma was inversely associated with treatment adherence (AOR=0.90; 95% CI: 0.86–0.95; $p<0.001$), while higher TB knowledge (AOR=1.20; 95% CI: 1.06–1.35; $p<0.05$) and longer clinic waiting time (AOR=1.09; 95% CI: 1.05–1.13; $p<0.001$) were associated with higher treatment adherence.

Table I: Sociodemographic Characteristics of the Participants (n=351)

Variables	Characteristics	Total	Adherent (n=295)		Non-adherent (n=56)	
			n	%	n	%
Age (years)	18 - 24	59	49	83.1	10	16.9
	25 - 59	236	196	83.1	40	16.9
	> 60	56	50	89.3	6	10.7
Gender	Male	213	177	83.1	36	16.9
	Female	138	118	85.5	20	14.5
Nationality	Malaysian	199	171	85.9	28	14.1
	Non-Malaysian	152	124	81.6	28	18.4
Employment status	Employed	157	130	82.8	27	17.2
	Unemployed	194	165	85.1	29	14.9
Education level	Tertiary	33	28	84.8	5	15.2
	Secondary	107	94	87.9	13	12.1
	Primary	115	97	84.3	18	15.7
	No formal education	96	76	79.2	20	20.8
Income (RM)	< 1000	86	64	74.4	22	25.6
	1000-1999	115	97	84.3	18	15.7
	2000-3999	140	125	89.3	15	10.7
	>4000	10	9	90.0	1	10.0
Depression	Normal	313	272	86.9	41	13.1
	Mild	33	20	60.6	13	39.4
	Moderate	3	1	33.3	2	66.7
	Severe	2	2	100.0	0	0.0
DOTS modality	HCW-supervised	212	185	87.3	27	12.7
	Family-supervised	104	82	78.8	22	21.2
	VDOT	35	28	80.0	7	20.0
Duration of treatment (days)	<180	288	242	84.0	46	16.0
	>180	63	53	84.1	10	15.9
Side effects	Present	58	47	81.0	11	19.0
	Absent	293	248	84.6	45	15.4
Clinic waiting time (min)	0-30	285	229	80.4	56	19.6
	>30	66	66	100.0	0	0.0
Distance to clinic (km)	0-10	307	257	83.7	50	16.3
	>10	44	38	86.4	6	13.6
Stigma	Median (IQR)		0.0(12.0)		12.0(6.0)	
Knowledge	Median (IQR)		22.0(1.0)		22.0(2.0)	

Table II: Prevalence of Depression and Medication Adherence among the Respondents (n=351)

Variable	Characteristics	Frequency, n	Percentage, %	CI (95%)
Depression	Normal	313	89.2	85.92- 92.42
	Mild	33	9.4	6.35- 12.45
	Moderate	3	0.9	0.0- 1.82
	Severe	2	0.6	0.0- 1.36
Medication adherence	Adherent	295	84.0	80.21- 87.88
	Non-adherent	56	16.0	12.12- 19.79

*CI: confidence interval

Compared with VDOT, HCW-supervised DOTS was associated with lower treatment adherence (AOR=0.23; 95% CI: 0.06–0.90; p<0.05). In the unadjusted analysis, HCW-supervised DOTS showed higher odds of adherence compared with VDOT (p=0.25). However, after adjustment for potential confounders, HCW-supervised DOTS was associated with lower adherence, indicating that the crude association was influenced by underlying differences between patient groups. Depression was not statistically significant in the adjusted model (AOR=0.58; 95% CI: 0.21–1.58; p=0.285). The final model explained 34.2% of the variance in treatment adherence (Nagelkerke R^2=0.342). Multicollinearity was not observed, with variance inflation factor (VIF) values ranging from 1.08 to 1.31. The inclusion of depression slightly reduced the model fit (Hosmer–Lemeshow p=0.03); however, this variable was retained due to its theoretical relevance in adherence behaviour.

DISCUSSION

This study identified stigma, knowledge, DOTS modality, and clinic waiting time as key factors of treatment adherence among TB patients in Kota Kinabalu. The median stigma score was lower among adherent patients compared with non-adherent patients, indicating a negative relationship between stigma and treatment adherence. This finding is

Table III: Simple Logistic Regression Model for Factors Associated with TB Treatment Adherence

Variables	Characteristics	Total	OR	CI (95%)	p-value
Age (years)	Median (IQR)	1.01	0.99-1.03	0.241	
Gender	Male	213	0.83	0.46 -1.51	0.548
	Female	138	Ref	-	-
Nationality	Malaysian	199	1.38	0.78-2.45	0.271
	Non-Malaysian	152	Ref	-	-
Employment status	Employed	157	Ref	-	-
	Unemployed	194	1.18	0.67-2.09	0.568
Education level	Tertiary	33	Ref	-	-
	Secondary	107	1.29	0.42-3.94	0.653
	Primary	115	0.96	0.33-2.82	0.944
	No formal education	76	0.68	0.23-1.98	0.478
Income (RM)	< 1000	86	Ref	-	-
	1000-1999	115	1.85	0.92-3.72	0.084
	2000-3999	140	2.87	1.39-5.90	0.004**
	>4000	10	3.09	0.37-25.83	0.297
Depression	Normal	313	Ref	-	-
	Depression	38	0.23	0.11-0.48	<0.001**
DOTS modality	HCW-supervised	212	1.71	0.68-4.30	0.252
	Family-supervised	104	0.93	0.36-2.42	0.884
	VDOT	35	Ref	-	-
Side effects	Present	58	Ref	-	-
	Absent	293	1.29	0.62-2.68	0.494
Duration of treatment (days)	Median (IQR)		1.00	1.00-1.01	0.539
Clinic waiting time (min)			1.10	1.06-1.13	<0.001**
Distance to clinic (km)			1.10	1.01-1.20	0.034*
Stigma			0.89	0.85-0.93	<0.001**
Knowledge			1.17	1.09-1.26	<0.001**

OR: Unadjusted Odds Ratio; CI: Confidence Interval; Ref: Reference
*p<0.05; **p<0.01

Table IV: Multivariable Logistic Regression Model for Factors Associated with TB Treatment Adherence

Variable	AOR	CI (95%)	p-value
Stigma	0.90	0.86-0.95	<0.001**
Knowledge	1.20	1.06-1.35	0.004**
Depression	0.58	0.21-1.58	0.285
Normal	Ref	-	-
Clinic waiting time (min)	1.09	1.05-1.13	<0.001**
DOTS modality			
HCW-supervised	0.23	0.06-0.90	0.030*
Family supervised	0.35	0.09-1.30	0.115
VDOT	Ref	-	-

AOR: Adjusted Odds Ratio; CI: Confidence Interval; Ref: Reference
*p <0.05; **p<0.01

consistent with studies from Malaysia, China, India, and several African countries, which have demonstrated that both external and internalised stigma can hinder care-seeking behaviours and treatment completion.[1,16-21] A substantial proportion of participants in this study had lower educational attainment, which may contribute to higher levels of stigma and, in turn, adversely affect treatment adherence. In addition, the lack of routine psychological screening for TB patients may intensify the psychological burden associated with stigma. External stigma, including social exclusion and discrimination by peers, family members, or HCWs, may contribute to patient isolation, while internalised stigma can diminish self-worth and foster feelings of hopelessness, further discouraging treatment adherence.[17,22-23] A study from Tanzania reported that 52.6% of HCWs exhibited high levels of TB-related stigma, including negative attitudes, stereotyping, and stigmatising behaviours toward patients.[18] Such stigma may undermine patient trust and compromise the quality of TB services. Collectively, these findings highlight the need for stigma-reduction strategies at both community and healthcare levels. Public health initiatives should prioritise community education to challenge negative perceptions of TB. In parallel, HCWs should be trained to deliver compassionate and non-judgmental care. Integrating routine mental health screening into TB services may further support the identification and management of stigma-related psychosocial challenges, ultimately improving treatment adherence and outcomes.

Consistent with our hypothesis, this study found that higher TB knowledge was significantly associated with better treatment adherence. This is consistent with findings from Nigeria, Eritrea, and China, in which patients with a good understanding of TB aetiology, transmission, and treatment were more likely to adhere to their medication regimens.[24-27] A lack of knowledge may lead to misconceptions, underestimation of disease severity, and treatment discontinuation. However, knowledge alone may not ensure adherence. Beliefs, attitudes, and lived experiences play a critical role in shaping health behaviour. Patients who perceive themselves as cured before completing treatment or who view TB as non-threatening may discontinue medication prematurely. Similarly, perceived barriers such as side effects, long treatment duration, and logistical challenges may discourage adherence when they outweigh perceived benefits.[28] Cultural beliefs and traditional healing practices also influence adherence.[29] A study in Ethiopia reported that belief in traditional remedies led some patients to abandon conventional TB treatment.[28] These findings highlight the importance of integrating culturally sensitive health education that resonates with patients' values and worldviews to drive behaviour change. Patients are more likely to adhere when the information provided is accurate, relevant, and respectful of their culture. Therefore, TB education strategies should be community-based, culturally appropriate, and focused on both increasing awareness and addressing misconceptions to promote sustained adherence.

A notable finding of this study was higher treatment adherence observed among patients monitored via VDOT compared with those supervised by HCWs, challenging the long-standing assumption that HCW-supervised DOTS is the optimal approach. These findings are consistent with studies from Tibet, the United Kingdom, and the United States, which have highlighted the practical challenges of traditional DOTS and the benefits of remote monitoring options, including VDOT, medication reminders, and TB mobile apps.[29-32] VDOT enables patients to complete treatment in the privacy of their homes, thereby reducing social discomfort and stigma associated with daily clinic visits.[2,33] This is particularly relevant in Sabah, where logistical and financial barriers may hinder adherence. Emerging evidence also suggests that VDOT and gamified digital platforms may enhance adherence and patient motivation.[31] However, the observed association between VDOT and higher treatment adherence should be interpreted within the context of routine clinical practice. In this setting, VDOT was primarily offered to patients who faced logistical barriers to daily clinic attendance as part of efforts to strengthen telehealth services. Participation required access to a smartphone, either owned by the patient or available through a family member, which may reflect differences in digital access or social support. These factors suggest that patients enrolled in VDOT may have differed from those under HCW-supervised DOTS in ways not fully captured by measured variables. Although multivariable adjustment was performed, residual confounding related to digital access, family support, or patient engagement may have contributed to the observed association. Nevertheless, these findings highlight the potential of VDOT as a flexible and patient-centered supervision strategy within routine TB care. Integrating digital approaches may strengthen treatment adherence and improve outcomes, particularly when tailored to address logistical, financial, and psychosocial barriers in Malaysia and other high-burden settings.

The association between longer clinic waiting time and higher treatment adherence was unexpected and contrasts with most published evidence, where prolonged waiting time is typically considered a barrier to care.[34-36] In Table I, the subgroup of patients reporting waiting times greater than 30 minutes demonstrated 100% adherence (n = 66). This finding should be interpreted in the context of the relatively small subgroup size, which may reflect a ceiling effect and limited variability rather than a true association. In this study, waiting time may reflect underlying clinic- or patient-level characteristics that were not directly measured. For example, clinics with higher patient volumes may experience longer queues while simultaneously implementing more systematic treatment management practices, such as scheduled follow-up, active tracing of missed appointments, and closer adherence monitoring. Similarly, individuals who are more motivated to complete treatment may be more willing to tolerate longer waiting times. In this context, waiting time may serve as a proxy for broader organisational or behavioural factors rather than a direct determinant of adherence. These findings highlight the complexity of service delivery dynamics in routine practice and warrant further investigation using objective workflow assessments and qualitative approaches to elucidate the underlying mechanisms better.

Numerous studies have reported a significant association between depression and poor TB treatment outcomes, including non-adherence, delayed recovery, and drug resistance.[37-39] In contrast, our study did not find a significant association between depression and treatment adherence. A possible explanation is the low prevalence and severity of depressive symptoms in our sample, where most participants reported only mild symptoms (9.4%), and fewer than 2% had moderate to severe depression. Similar findings have been reported in Sarawak, where depression was observed in only 7.7% of TB patients.[40] These findings suggest that mild psychological distress may not substantially influence adherence behaviour. The relatively low prevalence of depression in this population may reflect a supportive healthcare environment. TB treatment is provided free of charge in public facilities, reducing financial burden. Out-of-pocket transportation costs for DOTS visits may continue to pose challenges for some patients. However, additional support is provided through initiatives by non-governmental organisations (NGOs), such as SABATA in Sabah and MAPTB in Peninsular Malaysia. These NGOs provide transportation subsidies, nutritional support, and psychosocial counseling, which may help alleviate the physical, psychological, and social burdens associated with TB. These findings highlight the importance of integrated care models that incorporate mental health assessment and social support within TB services. While depression has been shown to adversely affect TB outcomes globally, the present findings suggest that its impact may be attenuated in settings with comprehensive, patient-centered support systems.

Strengths and Limitations of the Study

This study achieved a good response rate of 92%, with 351 TB patients completing guided questionnaires, ensuring consistency in data collection. Measurement validity was enhanced using validated instruments in the local language. However, several limitations must be acknowledged. Delays in ethical approval shortened the data collection period and may have limited the recruitment of patients with clinic appointments outside the study timeframe. The cross-sectional design allowed estimation of prevalence but precluded causal inferences. Depression was dichotomized for analysis due to the small number of participants with moderate to severe depressive symptoms. While this approach improved statistical stability, it may have reduced sensitivity to detect severity-specific effects. In addition, the relatively low prevalence and severity of depressive symptoms in the study sample may have limited statistical power to identify an independent association with treatment adherence. Future studies with larger samples across varying levels of depression severity may better elucidate potential dose–response relationships. Finally, self-reported adherence may be subject to recall and social desirability bias. Nevertheless, this was mitigated through triangulation with DOTS records and verification with HCWs.

Implications

This study's findings align with the End TB Strategy by identifying key areas to strengthen treatment adherence. The observed associations between stigma, knowledge, DOTS modality, and clinic waiting time with treatment adherence highlight the importance of addressing psychosocial and health system factors through patient education, counseling, and integrated support services. These approaches are consistent with Pillar 1: Integrated, patient-centered care and prevention, which emphasises comprehensive care that addresses both clinical and psychosocial needs. In line with Pillar 2: Bold policies and supportive systems, integrating mental health screening within TB services may facilitate early identification and management of stigma and depressive symptoms. In addition, health system improvements such as flexible clinic hours and transportation support may help reduce logistical barriers and enhance treatment adherence. Consistent with Pillar 3: Intensified research and innovation, future research should build upon existing evidence on the effectiveness of VDOT and evaluate the scalability, long-term impact, and cost-effectiveness of digital adherence technologies across diverse settings.

CONCLUSION

This study found that stigma, TB knowledge, DOTS modality, and clinic waiting time were significantly associated with treatment adherence among TB patients in Kota Kinabalu. Higher stigma and lower TB knowledge were associated with reduced adherence, highlighting the importance of psychosocial and educational support. The associations observed on DOTS modality and clinic waiting time likely reflect complex system- and patient-level dynamics within routine clinical practice. These findings highlight the need for multifaceted strategies that address stigma, strengthen patient education, and optimize context-appropriate service delivery to improve TB treatment outcomes in Malaysia and similar high-burden settings.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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