Patient Preference and Adherence

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Knowledge, Attitude, and Practice Toward Antitubercular Agents Among Pulmonary Tuberculosis Patients in Southwestern China: A Cross-Sectional Study

Yinhuan Pi[1,2,*], Junyi Tan[3,*], Pei Yang[1], Jing Pan[2], Xianghui Yang[2], Mingque Xiang[2], Tianju Li[2]

[1]Business Affairs Section, Chongqing Blood Center, Chongqing, People's Republic of China; [2]Department of Infectious Diseases, The Ninth People's Hospital of Chongqing, Chongqing, People's Republic of China; [3]Department of Gastroenterology, Chongqing University Three Gorges Hospital, Chongqing, People's Republic of China

*These authors contributed equally to this work

Correspondence: Tianju Li, Department of Infectious Diseases, The Ninth People's Hospital of Chongqing, Chongqing, People's Republic of China, 400700, Email tianjulee@126.com

Objective: To investigate the knowledge, attitudes, and practice (KAP) toward first-line antitubercular agents among patients with pulmonary tuberculosis (TB) in southwestern China, and to examine sociodemographic disparities in KAP.

Methods: A simple sampling survey was conducted among TB patients clinically diagnosed with active pulmonary TB at the Ninth People's Hospital of Chongqing. The questionnaire was used to collect demographic, knowledge, attitude, and practice data on first-line TB drugs.

Results: A total of 188 respondents were included in the analysis, of whom 129 were males and 59 were females, 44.7% scored below the median knowledge score 7 (4,8). Lower knowledge was seen in those aged ≥60 (P=0.001), earning <1000 yuan/month (P=0.049), with ≤secondary education (P<0.001), farmers (P=0.015), and single-drug users (P<0.001). Attitude scores were lower in older (P=0.001), less-educated (P<0.001), and farming populations (P=0.004). Non-adherent behaviors (18.1%) and missed dose compensation (47.3%) were more common in males (P=0.005), older adults (P=0.026), low-income (P=0.022), less-educated (P<0.001), farmers (P<0.001), and single-drug users (P=0.014).

Conclusion: This study reveals significant differences and deficiencies in knowledge, attitude, and practice of first-line antitubercular drugs among patients with active pulmonary TB, with the most pronounced gaps observed among older adults, lower educational attainment, and farmers.

What Did We Study?: We wanted to know how well patients with active tuberculosis (TB) in southwest China understand their medications, their attitudes toward treatment, and how they actually take their drugs. TB is a serious infection, and taking medicines correctly is crucial to cure it and prevent drug resistance.

How Did We Study It?: We surveyed 188 TB patients at a hospital in Chongqing. They answered questions about their knowledge of their medications (like doses and side effects), their beliefs about treatment, and their daily habits in taking the drugs. We compared answers across groups—like older vs younger patients, farmers vs other jobs, and those with different income or education levels.

What Did We Find?: TB treatment works best when patients take their drugs correctly. Our study shows that older, low-income farmers in rural areas face the biggest challenges. They need extra support—like easy-to-understand education, community health workers, and better access to all-in-one pills (FDCs). Hospitals and policymakers should focus on these groups to prevent TB from spreading and becoming drug-resistant.

Takeaway Message: Fighting TB isn`t just about medicines—it`s about making sure everyone, especially vulnerable groups, has the knowledge and support to stick to their treatment. Simple fixes, like better patient education and easier-to-use drug packs, could save lives.

Keywords: KAP study, antitubercular drugs, FDC, compliance

Received: 19 February 2025
Accepted: 19 May 2025
Published: 30 May 2025

Introduction

Tuberculosis (TB) is the leading cause of death from a single infectious disease agent worldwide. A global total of 10.8 million people were reported as newly diagnosed with TB in 2023, with China accounting for 74,000 new cases, ranking third globally.[1] Despite the World Health Organization's (WHO) emphasis on directly observed treatment, short-course (DOTS) strategy and fixed-dose combination (FDC) to improve adherence,[2] patient-level barriers persist, particularly in low-resource settings. Knowledge, Attitudes, and Practices (KAP) research methodology is commonly used in public health and health behavior areas, WHO recommends KAP surveys to identify knowledge gaps, cultural beliefs, and behavioral barriers in tuberculosis (TB) control, enabling targeted interventions and effective communication strategies.[3] However, most existing KAP studies focus on general tuberculosis (TB) awareness rather than knowledge of first-line antitubercular agents.[4–6] Evidence from Chongqing, China—a region with high TB incidence (51.73/100,000, ranking 8th in mainland China) and mortality (0.36/100,000, ranking 4th in mainland China) rates,[7] coupled with significant socioeconomic disparities—remains limited.[8] This study aimed to evaluate KAP toward first-line antitubercular drugs among active pulmonary TB patients in Chongqing, China and identify modifiable sociodemographic factors driving KAP disparities. Findings will guide the development of context-specific strategies to optimize TB care in similar settings.

Materials and Methods

Patients

A simple sampling survey was conducted among 190 patients with active pulmonary TB who visited the TB clinic of Chongqing Ninth People's Hospital from June 1, 2021 to December 31, 2021. Each patient was limited to one answer. Inclusion criteria: 1) patients aged 15–75 years old; 2) those diagnosed with active secondary TB; 3) HRZE/HR anti-TB treatment <6 months for treatment-naive patients; 4) informed consent was obtained and case information was complete. Exclusion criteria: 1) patients who could not take the medicine independently due to their age and physical dysfunction; 2) those who could not complete the questionnaire due to mental and psychological abnormalities, difficulties in expression and understanding, etc.

Questionnaire Design

The questionnaire was designed through discussion among physicians and researchers with extensive experience in the diagnosis and treatment of pulmonary TB. A pre-survey was conducted to validate the rationality and readability of the questionnaire. Researchers underwent unified training before participating in the research. The questionnaire includes four parts: demographics (6 questions), knowledge (5 questions, scored 0–9), attitude (4 questions, scored 4–20), and practice (4 questions). Demographics included age, gender, education, occupation, income, and drug dosage form. For the knowledge section, researchers verified patients' actual medication regimens. For the medication plan (drug name, dosage, frequency), 0 points indicated that all drugs were wrong, 1 point indicated that some were right, and 2 points indicated that all were right. For the medication time, 0 points indicated that the time was wrong and 1 point indicated that the time was right. For adverse drug reactions (ADRs), 0 points were used for 0 correct answers, 1 point for 1–2 correct answers, and 2 points for ≥3 correct answers. The attitudes section included attitudes about voluntarily stopping taking drugs or missing drugs, the relationship between drug resistance and taking drugs, and the impact of taking drugs on life, which were scored using the 5-point Likert scale, where 1 = "strongly disagree", 2 = "disagree", 3 = "neutral", 4 = "agree", and 5 = "strongly agree". The practice section included the use of anti-TB drugs, managing ADRs, post-treatment after a missed dose, and whether to actively acquire drug knowledge. To ensure accuracy, practice data were cross-validated through patient self-reports and researchers' reviews of prescriptions and clinical visit records in the medical system. This study was approved by the Ethics Committee of Chongqing Ninth People's Hospital (No. 2021–011).

Sample Size Calculation

The sample size was calculated using the following formula:[9]

$$n = \frac{\frac{p\times(1-p)\times Z^2}{\varepsilon^2}}{1+\frac{p\times(1-p)\times Z^2}{N\times\varepsilon^2}}$$

where z is the *z* score; ε is the margin of error; N is the population size; and p is the population portion. According to the 2015–2020 Chongqing Ninth People's Hospital data, an estimated 300 new cases of TB were reported each year. With a population proportion of 50%, a margin of error of 5%, and a confidence interval of 95%, the sample size was set at 169, conservatively estimating the invalid rate of the questionnaires being 10%.

Data Analysis

Data were analyzed using SPSS 25.0. Statistical tests indicated that all continuous variables in this study were non-normally distributed. Therefore, continuous data were expressed as the median and interquartile range [M (P25,P75)]. Categorical variables were expressed as frequency and percentage. Data were compared using the rank sum test. The $\chi 2$ test or Fisher's test was used to compare categorical variables. Subgroup analyses included gender (male, female), age (< 60 years, ≥ 60 years), income level (<1000 yuan, ≥ 1000 yuan), educational level (secondary school or below, junior college or above), occupation type (farmer, other), and pharmaceutical dosage forms taken (only compound preparations, including single preparations). $P < 0.05$ was considered statistically significant.

Results

Demographic Characteristics

Among 190 respondents, 188 were included in the final analysis (98.9% response rate), excluding 2 cases with incomplete basic information. Of the 188 eligible patients, 129 were males (68.6%) and 59 were females (31.4%). The average age was 49.2 ± 17.8 years old, ranging from 16 to 75 years. Low educational attainment (secondary school or below: 76.6%) and low-income status (<1000 yuan/month: 44.1%) were prevalent. Occupations were predominantly farmers (28.7%) and workers (25.0%). Most patients (70.7%) received single-drug formulations. Full demographic details are provided in Table 1.

Table 1 Respondent Demographics Information

Parameters	n (%)
Gender:	
Male	129 (68.6)
Female	59 (31.4)
Age:	
<60 years	119 (63.3)
≥60 years	69 (36.7)
Education level:	
Illiterate	13 (6.9)
Primary school	46 (24.5)
Secondary school	85 (45.2)
Junior college or above	44 (23.4)
Occupation:	
Farmer	54 (28.7)
Worker	47 (25.0)
Student	17 (9.0)
Civil servants and teachers	4 (2.1)
Unemployed and non-working individuals	14 (7.4)
Self-employed individuals	33 (17.6)
Retirees	19 (10.1)

(*Continued*)

Table 1 (Continued).

Parameters	n (%)
Income level:	
<1000 yuan / month	83 (44.1)
1000–5000 yuan / month	89 (47.3)
5000–10000 yuan / month	14 (7.4)
≥10000 yuan / month	2 (1.1)
Drug dosage forms taken:	
Fixed-dose combinations (FDC)	33 (17.6)
FDC+ single-drug formulations	22 (11.7)
Single-drug formulations	133 (70.7)

Notes: n (%): Absolute count (n) and percentage (%) of participants in a subgroup.

Knowledge

The median knowledge score was 7 (4, 8), with 44.7% of participants scoring below the median. 64.9% correctly identified their prescribed drugs, and 61.2% knew the correct administration time, but only 50.3% accurately reported dosage, frequency, or adverse drug reactions (ADRs) (Table S1).

Subgroup analyses revealed significant disparities. Age: Patients aged ≥60 years scored lower than those <60 years ($P = 0.001$). Education: Junior college-educated participants outperformed those with ≤secondary education ($P < 0.001$). Income: Participants earning <1000 yuan/month had lower scores than higher-income groups ($P = 0.049$). Occupation: Farmers scored lower than non-farmers ($P = 0.015$). Treatment: Fixed-dose combination (FDC) users scored higher than single-drug users ($P < 0.001$). No gender-based differences were observed ($P = 0.261$). Full statistical results are presented in Table 2 and Figure 1A.

Table 2 Knowledge Score in Subgroups

Parameters	*M* (P_{25}, P_{75})	*U*	*P*
Gender:		3422.0	0.261
Male	7 (4,7)		
Female	7 (5,8)		
Age:		2972.5	0.001
<60 years	7 (5,8)		
≥60 years	6 (4,7)		
Income level:		3640.5	0.049
<1000 yuan	6 (4,8)		
≥1000 yuan	7 (4,8)		
Education level:		1944.5	<0.001
Secondary and below	6 (4,8)		
Junior college or above	8 (7,8)		
Occupation type:		2805.5	0.015
Farmer	6 (2,8)		
Non-farmer	7 (5,8)		
Pharmaceutical dosage forms:		1357.5	<0.001
FDC only	8 (7,8)		
Including single formulations	6 (4,8)		

Notes: M: Median (the middle value of the dataset). P25 = 25th percentile. P75 = 75th percentile. U: Mann–Whitney U statistic, a non-parametric test used to compare differences between two independent groups when data are non-normally distributed. A smaller U value indicates greater divergence between groups. P: P-value, $P < 0.05$ was considered statistically significant.

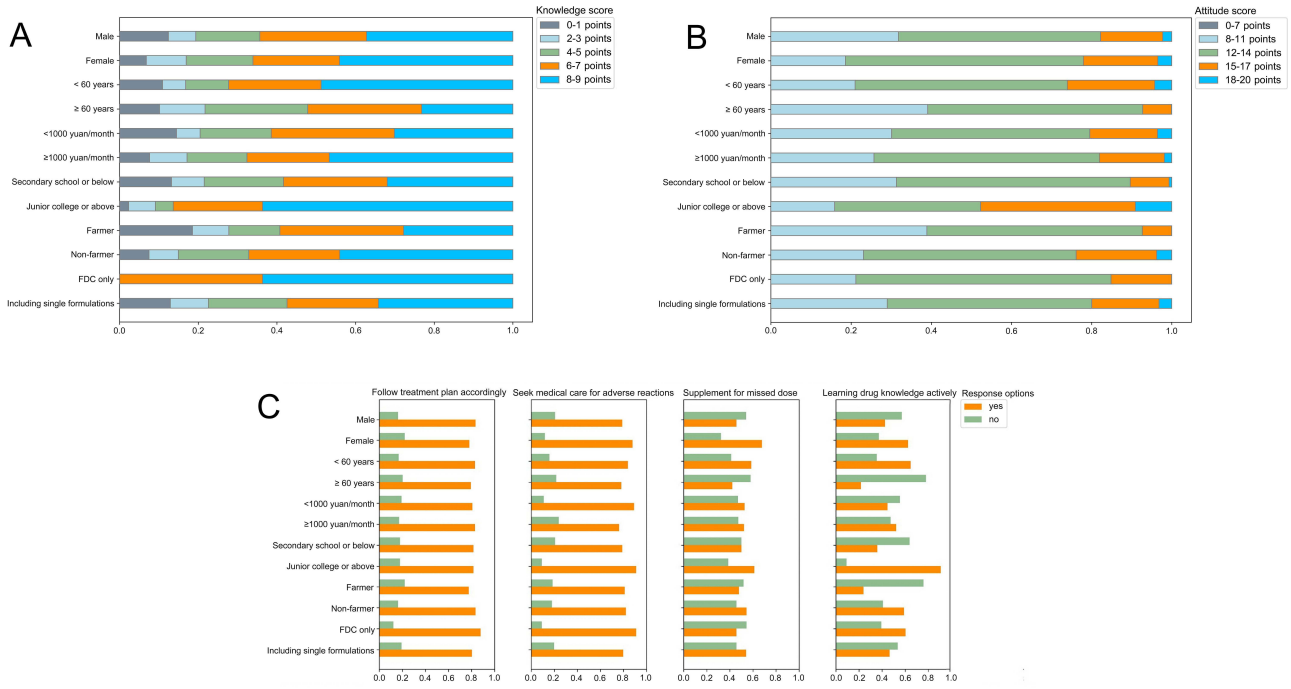

Figure 1 Knowledge, Attitude, and Practice (KAP) Toward First-Line Antitubercular Drugs Among Pulmonary Tuberculosis Patients (**A**) Knowledge Scores: Distribution of medication literacy scores (0–9 points) across demographic subgroups. Higher scores indicate better understanding of drug names, dosages, frequencies, and adverse reactions. (**B**) Attitude Scores: Attitudes toward antitubercular drugs were assessed using a 5-point Likert scale (total score range: 4–20), with higher scores indicating better medication-related perceptions. (**C**) Practice Behaviors: Patients who responded 'yes' to medication-related behavioral choices were considered to demonstrate correct practice behaviors.

Attitude

The attitude questionnaire yielded a median score of 13 (11,14). 14.4% believed self-discontinuing medication was acceptable when symptoms improved, 47.9% perceived no treatment impact from missed doses, and 20.2% denied links between medication adherence and drug resistance (Table S2).

Subgroup disparities were significant. Age: Participants aged <60 years scored higher than those ≥60 years (P = 0.001). Education: Junior college-educated individuals scored higher than those with ≤secondary education (P < 0.001). Occupation: Farmers scored lower than non-farmers (P = 0.004). No associations were observed with gender, income, or drug formulation (P > 0.05). Complete statistical outcomes are detailed in Table 3 and Figure 1B.

Table 3 Attitude Score in Subgroups

Parameters	*M* (P_{25}, P_{75})	*U*	*P*-value
Gender:		3271.0	0.119
Male	13 (11,14)		
Female	13 (12,14)		
Age:		2889.0	0.001
<60 years	13 (12,15)		
≥60 years	12 (10,13)		
Income level:		4282.5	0.838
<1000 yuan / month	13 (11,14)		
≥1000 yuan / month	13 (11,14)		

(*Continued*)

https://doi.org/10.2147/PPA.S520100

Table 3 (Continued).

Parameters	*M* (P_{25}, P_{75})	*U*	*P*-value
Education level:		1806.5	<0.001
Secondary or below	12 (11,14)		
Junior college or above	14 (13,16)		
Occupation type:		2653.0	0.004
Farmer	12 (11,13)		
Non-farmer	13 (12,14)		
Pharmaceutical dosage forms:		2390.0	0.551
FDC only	12 (12,14)		
Including single formulations	13 (11,14)		

Notes: M = Median. P25 = 25th percentile. P75 = 75th percentile. U = Mann–Whitney U statistic. P = P-value.

Practice

Through patient self-reports and clinical record verification, most (81.9%, 154/188) respondents continued to take medicine according to the anti-TB treatment plan given by the doctor, while 18.1% deviated. For adverse drug reactions (ADRs), 81.9% respondents sought medical treatment immediately after drug-related ADRs, but 18.1% self-monitored or self-adjusted doses. Only 52.7% compensated for missed doses, and 48.9% actively sought drug-related knowledge (Table S3).

Women were more likely than men to compensate for missed doses ($P = 0.005$) and seek drug knowledge ($P = 0.011$). Younger participants (<60 years) compensated for missed doses ($P = 0.026$) and sought drug knowledge ($P < 0.001$) more frequently than older adults (≥60 years). Low-income participants (<1000 yuan/month) sought medical care for ADRs more promptly ($P = 0.022$). Junior college-educated participants actively acquired drug knowledge compared to those with ≤secondary education ($P < 0.001$). Fixed-dose combination (FDC) users sought drug knowledge more than single-drug users ($P = 0.014$). Farmers lagged in knowledge-seeking ($P < 0.001$). No factors significantly predicted overall treatment adherence (ie, continued adherence to the treatment plan as scheduled) ($P > 0.05$). Full results are presented in Table 4 and Figure 1C.

Discussion

To the best of our knowledge, this is the first knowledge, attitude, and practice (KAP) study to explore first-line antitubercular drugs in patients with active pulmonary TB. Our finding demonstrate significant differences and deficiencies in the KAP toward antitubercular drugs among patients with active pulmonary TB in southwestern China, particularly among older, less educated, and low-income rural populations. These results are similar to previous studies in other low-resource settings.[4,10]

Although most single-drug formulations are given once on an empty stomach, pyrazinamide is often recommended three times a day due to its gastrointestinal side effects,[11–13] which may easily confuse patients. Our study found that patients with active TB had less than 70% correctly identified their drug name, dosage, frequency, time, or ADRs. This contrasts with higher awareness rates reported in urban Chinese cohorts,[10,14] underscoring the need for tailored education in rural areas.[15,16] Our research suggests that more efforts to be focused on educating the elderly, low-education, low-income, and peasant groups about antitubercular drugs.[17,18] Patients using FDC alone demonstrated better medication knowledge, potentially attributable to simplified dosing schedules and reduced pill burden.[19–21] These findings support WHO recommendations for FDCs to improve adherence,[2] though challenges remain in regions where single-drug formulations dominate. Therefore, doctors are recommended to prioritize FDC prescriptions, which may have a positive impact on improving patients' knowledge about drugs, compliance, and treatment outcomes.[19–21] New regimens, such as the WHO-recommended 4-month rifapentine regimen with moxifloxacin (2HPMZ/2HPM), may also reduce drug side effects and shorten treatment time.[2,17] Furthermore, the use of new media technologies, such as social media applications (APPs), for health education is becoming widely accepted by patients.[22–24]

Table 4 Practice in Subgroups

Parameters	Follow Treatment Plan Accordingly n (%)	χ^2	P	Seek Medical Care for Adverse reactions n (%)	χ^2	P	Supplement for Missed dose n (%)	χ^2	P	Learning drug Knowledge actively n (%)	χ^2	P
Gender:		0.905	0.341		2.246	0.134		7.903	0.005		6.530	0.011
Male	108 (83.7)			102 (79.1)			59 (45.7)			55 (42.6)		
Female	46 (78.0)			52 (88.1)			40 (67.8)			37 (62.7)		
Age:		0.358	0.550		0.982	0.322		4.942	0.026		32.267	<0.001
<60 years	99 (83.2)			100 (84.0)			70 (58.8)			77 (64.7)		
≥60 years	55 (79.7)			54 (78.3)			29 (42.0)			15 (21.7)		
Income level:		0.143	0.706		5.261	0.022		0.007	0.931		1.129	0.288
<1000 yuan / month	67 (80.7)			74 (89.2)			44 (53.0)			37 (44.6)		
≥1000 yuan / month	87 (82.9)			80 (76.2)			55 (52.4)			55 (52.4)		
Education level:		0.000	0.985		3.137	0.077		1.746	0.186		40.499	<0.001
Secondary or below	118 (81.9)			114 (79.2)			72 (50.0)			52 (36.1)		
Junior college or above	36 (81.8)			40 (90.9)			27 (61.4)			40 (90.9)		
Occupation type:		0.875	0.349		0.010	0.922		0.619	0.432		18.740	<0.001
Farmer	42 (77.8)			44 (81.5)			26 (48.1)			13 (24.1)		
Non-farmer	112 (83.6)			110 (82.1)			73 (54.5)			79 (59.0)		
Pharmaceutical dosage forms:		0.961	0.327		2.186	0.139		0.833	0.361		2.181	0.014
FDC only	29 (87.9)			30 (90.9)			15 (45.5)			20 (60.6)		
Including single formulations	125 (80.6)			124 (80.0)			84 (54.2)			72 (46.5)		

Notes: χ^2: Chi-square statistic, testing associations between categorical variables. A higher value indicates stronger deviation from expected frequencies under the null hypothesis. P: P-value, $P < 0.05$ was considered statistically significant. n (%): Absolute count (n) and percentage (%) of participants in a subgroup.

https://doi.org/10.2147/PPA.S520100

Some studies on the causes of drug resistance in pulmonary TB show that irregular medication is the significant cause of drug resistance.[25–27] Nearly half (47.9%, 90/188) of the patients believed that missing doses did not affect the effect of antitubercular treatment, and 41.0% (77/188) of the respondents perceived TB drugs as disruptive to daily life—attitudes strongly associated with older age and lower education levels, this finding aligns with previous studies on treatment adherence.[15,18] This may reflect systemic issues such as limited access to healthcare resources in rural southwestern China,[28–31] compounded by stigma and financial constraints.[18,32,33] Targeted TB awareness programs for the public could alleviate societal prejudice against patients,[15,18] fostering better adherence to treatment.

In our study, 18.1% (34/188) of patients experiencing ADRs chose to self-monitoring, reduce the dose, or treatment discontinuation. Although studies have shown that most ADRs are mild and do not warrant treatment stoppage, there are also serious and even fatal reports.[13,34] Our study found that higher-income patients were not active in seeking medical attention after experiencing ADRs, inconsistent with the findings of some studies on the effect of income on compliance,[35,36] but consistent with reports of suboptimal health-seeking behavior in high-income people.[33,37] Therefore, education on ADRs should be strengthened for higher-income patients to avoid fluke-related adverse consequences. Our data further showed that a significant proportion of respondents neglected to compensate for missed doses (47.3%, 89/188) or proactively acquire drug-related knowledge (51.1%, 96/188), with these behaviors being more pronounced among elderly male patients. Therefore, doctors or community volunteers should pay more attention to elderly male patients when providing treatment support.[27,38] Conversely, patients with junior college education or above demonstrated greater initiative, aligning with global evidence on education's role in health literacy (15,16). Farmers, representing 28.7% (54/188) of our cohort, rarely sought drug-related knowledge and scored lowest in KAP domains. This mirrors China's high TB burden in underdeveloped regions.[28] To address this, combining material incentives with community health worker programs could improve outcomes.[39]

Conclusion

In summary, this study unravels significant differences and deficiencies in the knowledge, attitude, and practice toward first-line antitubercular drugs among patients with active pulmonary TB. Older, less educated and farmers demonstrated markedly lower knowledge and attitude scores, coupled with higher rates of non-adherent practices. Therefore, providing appropriate health education on antitubercular drugs is paramount to improving patients' cognitive levels, changing bad practice behaviors, and obtaining good treatment outcomes.

Data Sharing Statement

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and later versions.

Funding

Natural Science Foundation of Chongqing, China, Grant Number: cstc2021jcyj-msxmX1219.

Disclosure

Dr Tianju Li reports grants from Chongqing Municipal Science and Technology Commission, during the conduct of the study. The authors declare that they have no competing interests.

References

1. Global tuberculosis report 2024. World Health Organization. 2024. Available from: https://www.who.int/publications/i/item/9789240101531. Accessed May 22, 2025.
2. WHO Guidelines Approved by the Guidelines Review Committee. *WHO Consolidated Guidelines on Tuberculosis: Module 4: Treatment - Drug-Susceptible Tuberculosis Treatment*. World Health Organization© World Health Organization; 2022.

3. Partnership WHOST. Advocacy, communication and social mobilization for TB control: a guide to developing knowledge, attitude and practice surveys. World Health Organization. 2008. Available from: https://iris.who.int/handle/10665/43790. Accessed May 22, 2025.
4. Craciun OM, Torres MDR, Llanes AB, Romay-Barja M, Wang M. Tuberculosis knowledge, attitudes, and practice in middle- and low-income countries: a systematic review. *J Trop Med*. 2023;2023:1014666. doi:10.1155/2023/1014666
5. Essar MY, Rezayee KJ, Ahmad S, et al. Knowledge, attitude, and practices toward tuberculosis among hospital outpatients in Kabul, Afghanistan. *Front Public Health*. 2022;10:933005. doi:10.3389/fpubh.2022.933005
6. Hussein I, Sane J, Soini H, Vasankari T, Lyytikäinen O. Tuberculosis knowledge, attitudes and practices: a cross-sectional study in the Somali population living in Finland. *Eur J Public Health*. 2019;29(3):449–452. doi:10.1093/eurpub/cky220
7. Center SI. 2023 China health and wellness statistics yearbook. China Government Website, 2025. Available from: http://www.nhc.gov.cn/mohwsbwstjxxzx/tjtjnj/202501/b8d57baa95834269b5b3562bfec801a7.shtml. Accessed May 22, 2025.
8. Hu M, Feng Y, Li T, et al. Unbalanced risk of pulmonary tuberculosis in china at the subnational scale: spatiotemporal analysis. *JMIR Public Health Surveill*. 2022;8(7):e36242. doi:10.2196/36242
9. Calculator.net. Sample Size Calculator. 8-18. 2023.Available from: https://www.calculator.net/sample-size-calculator.html. Accessed May 22, 2025.
10. Ma N, Zhang L, Chen L, Yu J, Chen Y, Zhao Y. Demographic and socioeconomic disparity in knowledge, attitude, and practice towards tuberculosis in Northwest, China: evidence from multilevel model study. *BMC Health Serv Res*. 2024;24(1):948. doi:10.1186/s12913-024-11336-x
11. Requena-Méndez A, Davies G, Waterhouse D, et al. Intra-individual effects of food upon the pharmacokinetics of rifampicin and isoniazid. *J Antimicrob Chemother*. 2019;74(2):416–424. doi:10.1093/jac/dky444
12. Kumar AKH, Chandrasekaran V, Kumar AK, et al. Food significantly reduces plasma concentrations of first-line anti-tuberculosis drugs. *Indian J Med Res. Apr*. 2017;145(4):530–535. doi:10.4103/ijmr.IJMR_552_15
13. Prasad R, Singh A, Gupta N. Adverse drug reactions in tuberculosis and management. *Indian J Tuberc*. 2019;66(4):520–532. doi:10.1016/j.ijtb.2019.11.005
14. Zhang Y, Wu J, Hui X, Zhang P, Xue F. Knowledge, attitude, and practice toward tuberculosis prevention and management among household contacts in Suzhou Hospital, Jiangsu province, China. *Front Public Health*. 2024;12:1249971. doi:10.3389/fpubh.2024.1249971
15. Alipanah N, Jarlsberg L, Miller C, et al. Adherence interventions and outcomes of tuberculosis treatment: a systematic review and meta-analysis of trials and observational studies. *PLoS Med*. 2018;15(7):e1002595. doi:10.1371/journal.pmed.1002595
16. M'Imunya JM, Kredo T, Volmink J. Patient education and counselling for promoting adherence to treatment for tuberculosis. *Cochrane Database Syst Rev*. 2012;2012(5):Cd006591. doi:10.1002/14651858.CD006591.pub2
17. Byun JY, Kim HL, Lee EK, Kwon SH. A systematic review of economic evaluations of active tuberculosis treatments. *Front Pharmacol*. 2021;12:736986. doi:10.3389/fphar.2021.736986
18. Korhonen V, Lyytikäinen O, Ollgren J, Soini H, Vasankari T, Ruutu P. Risk factors affecting treatment outcomes for pulmonary tuberculosis in Finland 2007-2014: a national cohort study. *BMC Public Health*. 2020;20(1):1250. doi:10.1186/s12889-020-09360-7
19. Wei Q, Zhou J, Li H, et al. Medication adherence with fixed-dose versus free-equivalent combination therapies: systematic review and meta-analysis. *Front Pharmacol*. 2023;14:1156081. doi:10.3389/fphar.2023.1156081
20. Ki MS, Jeong D, Kang HY, Choi H, Sohn H, Kang YA. Real-world impact of the fixed-dose combination on improving treatment outcomes of drug-susceptible tuberculosis: a comparative study using multiyear national tuberculosis patient data. *BMJ Open Respir Res*. 2023;10(1). doi:10.1136/bmjresp-2023-001758
21. Gallardo CR, Rigau Comas D, Valderrama Rodríguez A, et al. Fixed-dose combinations of drugs versus single-drug formulations for treating pulmonary tuberculosis. *Cochrane Database Syst Rev*. 2016;2016(5):Cd009913. doi:10.1002/14651858.CD009913.pub2
22. Wu T, He H, Wei S, et al. How to optimize tuberculosis health education in college under the new situation? Based on a cross-sectional study among freshmen of a medical college in Guangxi, China. *Front Public Health*. 2022;10:845822. doi:10.3389/fpubh.2022.845822
23. Truong CB, Tanni KA, Qian J. Video-observed therapy versus directly observed therapy in patients with tuberculosis. *Am J Prev Med*. 2022;62(3):450–458. doi:10.1016/j.amepre.2021.10.013
24. Ravenscroft L, Kettle S, Persian R, et al. Video-observed therapy and medication adherence for tuberculosis patients: randomised controlled trial in Moldova. *Eur Respir J*. 2020;56(2). doi:10.1183/13993003.00493-2020
25. Chien JY, Lai CC, Tan CK, Chien ST, Yu CJ, Hsueh PR. Decline in rates of acquired multidrug-resistant tuberculosis after implementation of the directly observed therapy, short course (DOTS) and DOTS-Plus programmes in Taiwan. *J Antimicrob Chemother*. 2013;68(8):1910–1916. doi:10.1093/jac/dkt103
26. Elduma AH, Mansournia MA, Foroushani AR, et al. Assessment of the risk factors associated with multidrug-resistant tuberculosis in Sudan: a case-control study. *Epidemiol Health*. 2019;41(e2019014):e2019014. doi:10.4178/epih.e2019014
27. Pradipta IS, Forsman LD, Bruchfeld J, Hak E, Alffenaar JW. Risk factors of multidrug-resistant tuberculosis: a global systematic review and meta-analysis. *J Infect*. 2018;77(6):469–478. doi:10.1016/j.jinf.2018.10.004
28. Wang L, Zhang H, Ruan Y, et al. Tuberculosis prevalence in China, 1990-2010; a longitudinal analysis of national survey data. *Lancet*. 2014;383(9934):2057–2064. doi:10.1016/s0140-6736(13)62639-2
29. Zhang Q, Song W, Liu S, et al. An ecological study of tuberculosis incidence in China, from 2002 to 2018. *Front Public Health*. 2021;9:766362. doi:10.3389/fpubh.2021.766362
30. Yu H, Yang J, Yan Y, Zhang H, Chen Q, Sun L. Factors affecting the incidence of pulmonary tuberculosis based on the GTWR model in China, 2004-2021. *Epidemiol Infect*. 2024;152:e65. doi:10.1017/s0950268824000335
31. Wang Q, Guo L, Wang J, et al. Spatial distribution of tuberculosis and its socioeconomic influencing factors in mainland China 2013-2016. *Trop Med Int Health*. 2019;24(9):1104–1113. doi:10.1111/tmi.13289
32. Chen X, Du L, Wu R, et al. Tuberculosis-related stigma and its determinants in Dalian, Northeast China: a cross-sectional study. *BMC Public Health*. 2021;21(1):6. doi:10.1186/s12889-020-10055-2
33. Huang CY, Hung YT, Chang CM, Juang SY, Lee CC. The association between individual income and aggressive end-of-life treatment in older cancer decedents in Taiwan. *PLoS One*. 2015;10(1):e0116913. doi:10.1371/journal.pone.0116913
34. Choi H, Park HA, Hyun IG, et al. Incidence and outcomes of adverse drug reactions to first-line anti-tuberculosis drugs and their effects on the quality of life: a multicenter prospective cohort study. *Pharmacoepidemiol Drug Saf*. 2022;31(11):1153–1163. doi:10.1002/pds.5513

35. Woimo TT, Yimer WK, Bati T, Gesesew HA. The prevalence and factors associated for anti-tuberculosis treatment non-adherence among pulmonary tuberculosis patients in public health care facilities in South Ethiopia: a cross-sectional study. *BMC Public Health*. 2017;17(1):269. doi:10.1186/s12889-017-4188-9
36. Xu W, Lu W, Zhou Y, Zhu L, Shen H, Wang J. Adherence to anti-tuberculosis treatment among pulmonary tuberculosis patients: a qualitative and quantitative study. *BMC Health Serv Res*. 2009;9(1):169. doi:10.1186/1472-6963-9-169
37. Chanda-Kapata P, Kapata N, Masiye F, et al. Health seeking behaviour among individuals with presumptive tuberculosis in Zambia. *PLoS One*. 2016;11(10):e0163975. doi:10.1371/journal.pone.0163975
38. Pedersen OS, Butova T, Kapustnyk V, et al. Treatment outcomes and risk factors for an unsuccessful outcome among patients with highly drug-resistant tuberculosis in Ukraine. *Clin Microbiol Infect*. 2024;30(3):360–367. doi:10.1016/j.cmi.2023.12.001
39. Wingfield T, Tovar MA, Huff D, et al. The economic effects of supporting tuberculosis-affected households in Peru. *Eur Respir J*. 2016;48 (5):1396–1410. doi:10.1183/13993003.00066-2016