BMJ Open

Tuberculosis treatment management in primary healthcare sectors: a mixed-methods study investigating delivery status and barriers from organizational and patient perspectives

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-053797
Article Type:	Original research
Date Submitted by the Author:	07-Jun-2021
Complete List of Authors:	Zhou, Jiani; Army Medical University, Department of Social Medicine and Health Service Management Pu, Jie; Army Medical University, Department of Social Medicine and Health Service Management Wang, Qingya; Chongqing institute of Tuberculosis prevention and Treatment, Department of districts and counties Zhang, Rui; Army Medical University, Department of Social Medicine and Health Service Management Liu, Shili; Army Medical University, Department of Social Medicine and Health Service Management Wang, Geng; Army Medical University, Department of Social Medicine and Health Service Management Zhang, Ting; Chongqing Institute of Tuberculosis Prevention and Treatment, Department of districts and counties Chen, Yong; Army Medical University, Department of Social Medicine and Health Service Management Xing, Wei; Army Medical University, Department of Social Medicine and Health Service Management Liu, Jiaqing; Army Medical University, Department of Social Medicine and Health Service Management Hu, Daiyu; Chongqing Institute of Tuberculosis Prevention and Treatment, Department of districts and counties Li, Ying; Army Medical University, Department of Social Medicine and Health Service Management
Keywords:	Tuberculosis < INFECTIOUS DISEASES, PRIMARY CARE, HEALTH SERVICES ADMINISTRATION & MANAGEMENT

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Tuberculosis treatment management in primary health care sectors: a mixed-methods study investigating delivery status and barriers from organizational and patient perspectives

Jiani Zhou[1], Jie Pu[1], Qingya Wang[2], Rui Zhang[1], Shili Liu[1], Geng Wang[1], Ting Zhang[2], Yong Chen[1], Wei Xing[1], Jiaqing Liu[1], Daiyu Hu[2§], YingLi[1§]

[1] Department of Social Medicine and Health Service Management, Army Medical University (Third Military Medical University), Chongqing, China.

[2] Department of districts and counties, Chongqing Institute of TB Prevention and Treatment, Jiulongpo District, Chongqing, China.

§ Correspondence: Daiyu Hu, Chongqing Institute of TB Prevention and Treatment, Jiulongpo District, Chongqing, China (E-mail:hukaixiu@126.com); Ying Li, Department of Social Medicine and Health Service Management, Army Medical University (Third Military Medical University), China (E-mail:lilyliying2012@163.com).

Abstract

Objective Tuberculosis (TB) treatment management service (TTMS) is crucial to improve patient adherence to treatment. Under the TB integrated control model in China, healthcare workers (HCWs) in primary healthcare (PHC) sectors are responsible for TTMS delivering. This mixed method study aims to explore the status of and barriers to TTMS delivery faced by HCWs in PHC sectors from the health organizational and patient perspectives.

Design We completed 459 questionnaire survey with HCWs and 261 with TB patients in PHC sectors, and we also conducted 16 semi-structured interviews with health organizational leaders, HCWs and patients. SPSS 22.0 and the framework approach were used for data analysis.

Setting Primary healthcare sectors in West China

Results Our results showed that TTMS delivery rate by HCWs in PHC sectors was <90% (88.4%) on average, and the delivery rates of intensive and continuation phase DOT were only 54.7% and 53.0% respectively. HCWs with high working satisfaction and junior title were more likely to deliver first-time home visit and DOT services. Our results suggested that barriers to TTMS delivery in organizational level included limited patient-centered approaches, poor cross-sectional coordination, inadequate resources and incentives, and strict performance assessment. In patient level, barriers include low socioeconomic characteristics, poor health literacy, and TB-related social stigma.

Conclusion: TTMS in West China still need further improvement, and this study highlighted specific barriers to TTMS delivery in PHC sectors. Comprehensive measures are urgent

needed to address those barriers in organizational and patient levels to promote TB control in West China.

Key words: tuberculosis, treatment management, healthcare worker, primary healthcare

Strengths and limitations of this study

- This is a mixed method study on accessing the status of and barriers to tuberculosis treatment management services (TTMS) delivery by healthcare workers (HCWs) in primary healthcare sectors (PHC) in West China.
- This study collected both perspectives from organizations and patients followed by using the PRISM model to evaluate specific barriers to TTMS delivery.
- We collected a total of 720 questionnaires with HCWs and patients, and conducted 16 interviews with leaders, HCWs and patients in totally 71 PHC sectors.
- Further studies are required to provide more evidence for producing more effective TB control strategies since well-evidenced implementation strategies that able to address current barriers in TTMS delivery were not able to be provided in this study.

Introduction

Tuberculosis (TB) is a major infectious disease that seriously endangers the health of the public. World Health Organization's Global Tuberculosis Report 2020 indicates that TB, one of the top 10 causes of death, is the leading cause of a death from a single infectious agent (Mycobacterium tuberculosis), ranking above HIV/AIDS [1]. Globally, around 10 million people fell ill with TB each year [1]. In recent years, China has implemented various prevention and control measures to address TB epidemic in China, cases notification has decreased from 70.6/100,000 population in 2012 to 59.3/100,000 population in 2018 with a treatment success rate above 90% [1]. However, the situation of TB epidemic in China is still urgent, ranked the third and accounted for 8.4% of the global TB burden [1]. The problem of drug-resistant TB (DR-TB) is prominent, the medical burden of patients is heavy, and the task of TB prevention and control is difficult [2].

The goal of China's latest Action Plan to Stop TB (2019-2022) is to reduce the incidence of TB nationwide to less than 55/100,000 population by 2022 and maintain a low mortality rate below 3/100,000 population [2]. To accomplish this goal, TB prevention and control program has been further improved with enhanced services capacity, strengthened the prevention and control measures for key populations and key areas, advanced the standardized diagnosis and treatment coverage, and increased the public awareness level of tuberculosis prevention and control [2]. Patients' adherence to anti-TB treatment plays an important role to cure and avoid DR-TB, hence treatment management is essentially necessary for TB patients to ensure treatment adherence, monitor adverse side-effects from treatment, and avoid development of

DR-TB [3]. Since Chinese National 12th Five-Year TB Control Plan (2011-2015) came out in 2011, TB control model in China started using the integrated TB control model in most regions [4]. Under the integrated TB control model, the Centers of Disease Control (CDCs) are responsible for TB program governance, surveillance, training and health promotion; the TB designated hospitals are responsible for diagnosis and treatment; and the Primary Healthcare (PHC) sectors are responsible for referrals, tracing, health education and TB treatment management services (TTMS) [4]. Later, China's National 13th Five-Year TB Control Plan (2016-2020) combined with the Action Plan to Stop TB (2019-2022) requested to further strengthen TB prevention and control which emphasized TTMS and strengthened the implementation of various measures to reduce TB epidemic in China [2, 5]. In addition, the new Chinese National Basic Public Health Service (BPHS) Guideline issued in 2017 specificates that TTMS provided by healthcare workers (HCWs) in PHC sectors into 7 themes, including: the first-time home visit, health education, supervising drug intake, follow-up supervision, case closing evaluation, other services and services among patient's family members [6]. TTMS is one of the key BPHS programs for all residents in China (one of the priorities of the new health reform launched in 2009) which are delivered by HCWs in PHC sectors [5, 6]. The BPHS guideline sets a target to accomplish both standard TTMS rate and treatment success rate above 90% [5, 6]. TTMS for diagnosed TB patients are delivered by HCWs in PHC sector under the supervision of CDC with coordination from other departments, such as assistances from the TB designated hospital to deal with patients side-effects and supports from department of education to conduct health education to student

population [6]. In China, PHC sectors include the community health centers (CHCs) and stations in urban areas, township hospital centers (THCs) and village health clinics in rural areas [3]. The HCWs in PHC sectors who are in charge of TTMS delivery involve HCWs in CHCs, THCs and village health clinics.

Study in Jiangxi indicated that TTMS under the integrated TB control model did improve treatment outcomes [7]. Study in Wuhan pointed that TTMS was crucial important for monitoring treatment complications and reducing the development of DR-TB [8, 9]. Other studies showed that in more developed areas in China, TTMS coverage was highly improved and produced impressive effects [7, 8, 10-13]. Few studies reported the delivery status to TTMS delivery in resource-limited and mountain regions with high TB/DR-TB burden in China. One study found that only 37.1% of TB patients received TTMS by HCWs in West China [14] and study in Chongqing found that 34.3% of TB patients never received TTMS by HCWs [15]. However, very few studies focus on the perspective of HCWs to evaluate the current TTMS program under the integrated TB control model. Therefore, this study not only aim to assess the delivery status of TTMS program from the perspectives of both organizations and patients, but also to explore the specific barriers to TTMS delivery faced by HCWs in PHC sectors to provide evidence for promote TB control and treatment outcome.

Methods

Study design

Our study utilized mixed research methods to collect data from June 2018 to December 2018.

Questionnaire surveys and semi-structured in-depth interviews were conducted to evaluate the delivery of TTMS in PHC sectors from both health organizational (CHWs and leaders) and patient's perspectives.

Study Setting

The prevalence of TB in the western region was significantly higher than the central and eastern regions in China [16]. We purposively selected Chongqing municipality (region with relatively developed socioeconomic status with Gross Domestic Product (GDP) at 2.04 trillion RMB and per capita GDP at 66.2 thousand RMB) and Guizhou province (region with relatively less developed socioeconomic status with GDP at 1.48 trillion RMB and per capita GDP at 41.4 thousand RMB) as the study regions [17]. Chongqing's reported TB incidence rate has dropped from 85.57/100,000 in 2012 to 73.37/100,000 in 2018, and the treatment success rate has remained above 90%. However, the current epidemic situation of TB in Chongqing is still severe, with an average of about 23,000 new cases reported each year, and the reported incidence of TB in 2018 ranked 8th in the country [2]. The TB epidemic status in Guizhou was more severe which TB incidence ranked 3rd in China [18]. According to the fifth national TB epidemiological survey, the active and smear positive TB prevalence in Guizhou were 1226/100,000 and 231/100,000 [19]

A stratified random sampling method was used to select study sites based on socioeconomic developing status. All counties/districts in Chongqing municipality and Guizhou province were grouped into three levels according to the per capita GDP [17]. A total of twelve districts/counties were included in this study. All of the PHC sectors (included both CHCs

and THCs) in the 12 selected counties/districts, totally 71 PHC sectors were included in this study.

Study participants and data Collection

Quantitative study

All adult pulmonary TB patients who met the following criteria were targeted for recruitment from the 71 PHC sectors in the 12 selected counties/districts: (1) registered at TB dispensaries and were diagnosed as drug-sensitive pulmonary TB patients according to national TB diagnosis standards, (2) completed standard anti-TB drug treatment for at least 4 months which indicated that received TTMS for both intensive (first 2 months) and continuation phases (following 4 months), (3) aged 15 years and older. Patients who: (1) with extra-pulmonary TB, (2) could not express themselves clearly (had disturbance of consciousness or difficulties with speech or hearing), (3) unwilling to participated in the study were excluded. Patient recruitment was facilitated by TB dispensaries in the study counties/districts. First, research group members provided a detailed explanation about the study objectives to all potential participants. Then, those who were willing to participate in the study were asked to read and sign the informed consent form to assure of confidentiality.

All HCWs who were working at the selected 71 PHC sectors and met the following criteria were targeted for recruitment: (1) responsible for the TB prevention and control program, (2) in charge of TTMS delivery to TB patients. HCWs who: (1) didn't work at the PHC sectors in selected county/district, (2) didn't responsible for the TB prevention and control program, (3) didn't provide TTMS for TB patients were excluded in this study.

Structured questionnaires were conducted to collect data among the participated TB patients and HCWs. Among TB patients, structured survey involved demographic information (such as gender, age, and residence), and TTMS received from HCWs during treatment (such as intensive phase DOT and continuation phase DOT). Among HCWs, the questionnaire included demographic and working-related information (such as gender, age, professional title, and working years), working satisfaction, and delivery situation of TTMS (such as the first-time home visit). Questionnaires were designed by our research team based on the existing literature reports, and then consulted related experts. All questionnaires were executed by trained investigators from our research group in a meeting room or clinic room at each PHC sector. HCWs, who were willing to voluntary participated in the study, were asked to read the informed consent form and then sign the informed consent form. Each completed questionnaire was checked and examined by trained investigators for quality control.

Qualitative study

In-depth interviews were utilized to explore the current status and identify barriers to the TTMS delivery from HCWs to TB patients. Purposive sampling method was used to selected participants for in-depth interview and the sample size was decided by the point of data 'saturation'. In-depth interviews were conducted with nine purposely selected local CDC and Health Commission leaders, five HCWs and two TB patients.

Semi-structured topic guides with open-ended questions were used for interviews. The guiding framework for the topic design was the Practical Robust Implementation and Sustainability Model (PRISM) [20]. This model considered how the intervention design,

recipients, external environment, and implementation and sustainability infrastructure influence health program implementation and success, which widely used as theoretical framework in implementation research [20-22]. With the guide of the PRISM, this study collected data on barriers on TTMS delivery in the following aspects: (1) intervention design; (2) recipients; (3) external environment; and (4) implementation and sustainability infrastructure. The adaptation of PRISM for this study is illustrated in Figure1. All interviews were conducted in Mandarin or local language at the meeting rooms in PHC sectors. Each interview lasted about 40-60 minutes and was audio-recorded with consent of the participants.

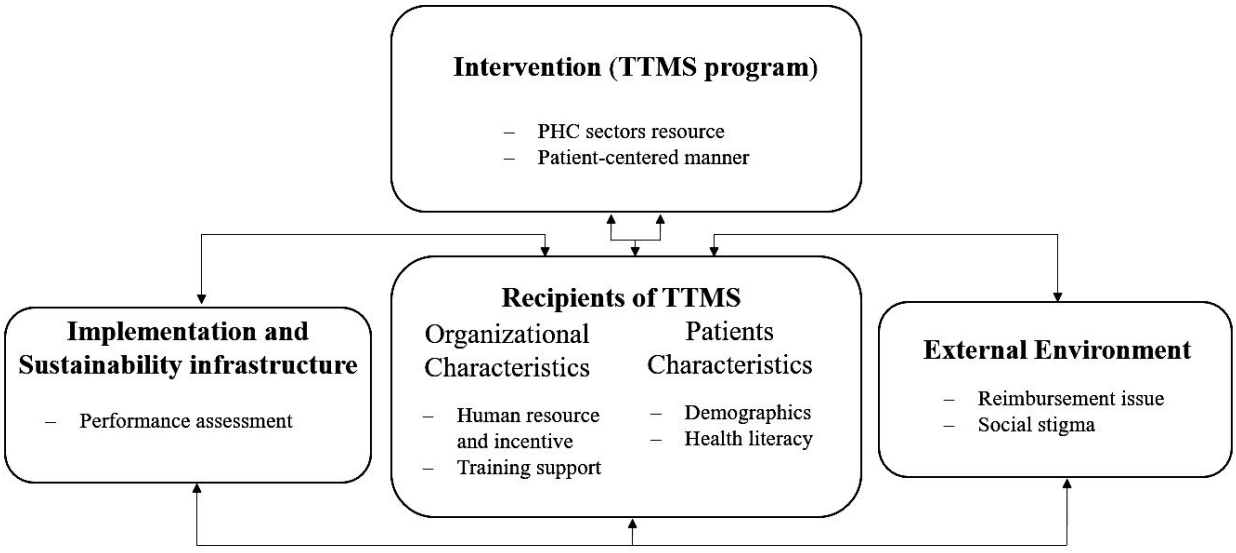

Figure 1 Adapted PRISM for barriers on TTMS delivery in PHC sectors. This figure presents the four core domains of the Practical Robust Implementation and Sustainability Model (PRISM) for barriers on TTMS delivery in PHC sectors, including: 1) TTMS program design; 2) the recipients, 3) the external environment, and 4) the implementation and sustainability infrastructure. Activated elements for each domains were presented in boxes. Notes: *TTMS* refers to tuberculosis treatment management service; *PHC* refers to primary healthcare; *HCW* refers to healthcare worker).

Data analysis

Quantitative analysis

Data were entered using Epi Data 3.1 and then analyzed using the Statistical Package for the Social Sciences (SPSS 22.0 (IBM Corporation, Armonk, NY, USA)). Missing data were excluded during analyze. A two-tailed probability level of $p<0.05$ was chosen as the level of statistical significance. Missing data were excluded from analysis. Descriptive statistics were used to describe study participants' demographic characteristics and TTMS delivery rates. According to the 13th Five-Year TB Prevention and Control Plan, the targeted TTMS delivery rate from HCWs to TB patients is >90% [5]. Therefore, delivery rate below 90% is described as lower delivery rate in this manuscript. Factors associated with lower delivery rate (<90%) screened by the Chi-square test ($p<0.05$) (Appendix A) were entered into multivariate logistic regression models (delivery rate <90% = 1, delivery rate >90% = 0), which were used to examine the effects of those factors on TTMS delivery.

Qualitative analysis

The framework approach was used to analyze all qualitative data following a five steps process: (1) familiarization, (2) creating theoretical framework, (3) indexing, (4) summarizing and (5) data synthesis and interpretation [23-24]. Following that, all interviews were carefully transcribed into Word Documents, reviewed for accuracy, and then being coded and classified by our research team members. We identified themes on TTMS delivery barriers for four domains of the PRISM, including: (1) intervention design (PHC sectors resource and patient-centered manner); (2) the recipients (human resource and incentives, training support, socio-economy and health literacy); (3) external environment (health

insurance, cross-sectional coordination, and social stigma); and (4) implementation and sustainability infrastructure (performance assessment). All the names of participants were removed in quotations of the results to keep anonymity.

Patient and public involvement

There were no patients or public involvement in the design, conduct, reporting and in the dissemination plans of this research.

Results

Characteristics of participants

Participants for the quantitative study

Total of 261 HCWs and 459 TB patients completed the questionnaire survey (Table 1). Among the HCWs, 66.4% (172) were female, 71.5% (178) were aged 20-40 years old, 70% (189) worked at THCs, 50.0% and 35.8% had junior and non-professional titles respectively. Near 60% of the HCWs had junior college education and over 80% had medical school education background (32.4% majored in clinical medicine and 30.5% majored in nursing). More than half (56.4%) of the HCWs undertook 2-3 BPHS programs in PHC sector, and only 7.6% were dedicatedly in charge of TB program. The majority (67.5%) had a monthly income of 2500-4500 CNY, and notably, 40.5% reported low working satisfaction.

Among the TB patients, the majority of the patients were male (70%), married (69.7%), Han ethnicity (78.2%), and 41.6% were aged ⩾60. 82.4% of the patients were rural residences and 95.2% were permanent residences. Almost 70% of the patients were farmer/migrant workers, and 56.0% had only primary/below education.

Participants for the qualitative study

9 leaders, 5 HCWs, and 2 patients were interviewed. Most leaders were male (7/9) with deputy senior titles (5/9) and worked for 7.6 years on average. The majority of HCWs were technical secondary school educated (4/5) and majored in clinical medicine (4/5), 4/5 came from CHCs with had none or junior professional titles. Besides, among the 2 interviewed patients, aged mid-20s and late-50s respectively, both of them completed anti-TB therapy.

Table 1 Demographic characteristics of the participants for quantitative study

Demographic characteristic	Number	Percentage
HCWs in questionnaire survey		
Gender（n=259）		
female	172	66.4
male	87	33.6
Age（n=249）		
20-29	94	37.8
30-39	84	33.7
40-50	52	20.9
>50	19	7.6
Education（n=259）		
Technical secondary school or below	60	23.2
Junior college	155	59.8
Undergraduate college or above	44	17.0
Medical school education (n=247)		
Yes	202	81.8
No	45	18.2
Major (n=256)		
Clinical Medicine	83	32.4
Nursing	78	30.5
Public Health	33	12.9
Chinese Medicine	27	10.5
Other	17	6.6
Region (n=261)		
Relatively developed	93	35.6
Medium developed	89	34.1
Less developed	79	30.3
Working place (n=261)		

Township health center	189	72.4
Community health center	72	27.6
Professional Title (n=240)		
Non	86	35.8
Junior	120	50.0
Intermediate	31	12.9
Deputy senior	3	1.3
Number of BPHS programs undertook (n=225)		
TB program only	17	7.6
2-3	127	56.4
⩾4	80	36.0
Monthly Income (n=242)		
<2500	52	21.5
2500-3500	89	36.8
3500-4500	74	30.6
>4500	27	11.2
Working satisfaction（n=259）		
High satisfaction	58	22.4
Middle satisfaction	96	37.1
Low satisfaction	105	40.5
TB patients in questionnaire survey		
Gender (n=459)		
Male	324	70.6
Female	135	29.4
Age (n=459)		
<40	94	20.5
40-49	96	20.9
50-59	78	17
⩾60	191	41.6
Ethnicity (n=459)		
Han	359	78.2
Ethnic minority	100	21.8
Marital status (n=459)		
Single	69	15.0
Married	320	69.7
Divorced/Widowed	70	15.3
Residence (n=459)		
Urban	81	17.6
Rural	378	82.4
Registered information (n=459)		
Permanent resident	437	95.2
Migrant	22	4.8

Education (n=459)		
Primary and below	257	56.0
Junior middle school	125	27.2
High school and above	77	16.8
Occupation (n=459)		
Staff/Cadre/Retiree	50	10.9
Self-employed	10	2.2
Farmer/Migrant worker	315	68.6
Student	20	4.4
Others	64	13.9

Note: *TB* refers to tuberculosis, *HCW* refers to health care worker, *BPHS* refers to basic public health services.

Quantitative results about TTMS delivery status

TB patient's survey showed that 76.0% (349) of the patients ever received TTMS from HCWs in CHCs during the whole course of treatment (it was 83.7% and 76.7% during their intensive and continuation phase respectively). Just around 40.0% ever received TTMS from HCWs in THCs/village clinics during their whole course of treatment (it was 45.1% and 42.3% during intensive and continuation phase respectively). Only 17.0% received standard TTMS from HCWs during the whole course of treatment (it was 18.1% and 55.8% for intensive and continuation phase respectively). 2.8% were never received TTMS from HCWs (it was 3.9 % and 7.2% during intensive and continuation phase respectively). (Table 2)

Table 2 TTMS TB patient received from HCWs during treatment (n=459)

Variable	Number	Percentage
Ever received TTMS from HCWs in CHCs		
Intensive phase	384	83.7
Continuation phase	352	76.7
Whole course of treatment	349	76.0
Ever received TTMS from HCWs in THCs/village clinics		
Intensive phase	207	45.1
Continuation phase	194	42.3
Whole course of treatment	189	41.2

Received standard TTMS from HCWs		
Intensive phase	83	18.1
Continuation phase	256	55.8
Whole course of treatment	78	17.0
Never received TTMS from HCWs		
Intensive phase	18	3.9
Continuation phase	33	7.2
Whole course of treatment	13	2.8

Note: *TB* refers to tuberculosis, *TTMS* refers to tuberculosis treatment management services, *CHC* refers to community health center, *THC* refers to township health center, *HCW* refers to health care worker.

HCWs' survey showed that the average delivery rate of TTMS (involved totally 60 service items) in PHC sectors was 88.4 %, and 13 TTMS items reported a lower delivery rate (<90%). Notably, the delivery rates of DOT in intensive phase and continuation phase were low, with only 54.7% and 53.0% respectively. Besides, less than half (44.9%) of HCWs in PHC sectors provided service of collecting patients' sputum samples during the follow-up supervision. Less than half of the HCWs provided food or transport assistances for poor TB patient (45.2%), provided subsistence allowance or psychological support for migrant patient (49.6%), and provided injection treatment for MDR-TB patient (41.0%). Moreover, less than 60% provided supervision for newly released prison patient (58.9%) and established platform for TB patient communication (57.8%). (Table 3)

Table 3 TTMS with lower delivery rate provided by HCWs in PHC sectors (n=239)

Services	Delivery rate N (%)
First time home visit	
Patients' peer supervision establish (n=235）	185 (78.7)
DOT	
Intensive phase DOT (n=236）	129 (54.7)
Continuation phase DOT (n=236）	125 (53.0)
Regular medicine delivery (n=234）	160 (68.4)
Follow-up supervision	
Sputum sample collection (n=236）	106 (44.9)

Others	
Providing food or transport assistances for poor TB patient (n=230）	104 (45.2)
Providing subsistence allowance or psychological support for migrant patient (n=236）	117 (49.6)
Providing DOT for migrant TB patient at their convenient time (n=235）	203 (86.4)
Providing injection treatment for MDR-TB patient (n=234）	96 (41.0)
Providing supervision for newly released prison patient (n=236）	139 (58.9)
Training cured TB patients to provide peer education (n=237）	208 (87.8)
Establishing platform for TB patients communication (n=237）	137 (57.8)
Referring TB patient with mental/psychological problems or alcohol/drug addiction to receive professional therapy (n=235）	182 (77.4)

Note: *Lower delivery rate* refers to a rate below 90%, *TB* refers to tuberculosis, *TTMS* refers to tuberculosis treatment management service, *DOT* refers to directly observed therapy, *MDR-TB* refers to multidrug-resistant tuberculosis

Factors associated with TTMS with lower delivery rate

Multivariate logistic regression analysis showed that HCWs with high working satisfaction were less likely to have a lower delivery rate to establish patients peer supervision as needed (OR=0.182, 95%CI: 0.059-0.562). Among both intensive and continuation phase DOT, HCWs with junior title (OR=0.424, 95%CI: 0.215-0.835) and high working satisfaction (OR=0.326, 95%CI: 0.140-0.766) were less likely to have lower delivery rate. Similarly, HCWs with junior title (OR=0.458, 95%CI: 0.242-0.865) and high working satisfaction (OR=0.395, 95%CI: 0.160-0.826) were more likely to deliver sputum sample collection service (Table 4).

292 **Table 4** Logistic regression analysis of factors associated with lower delivery rate of TTMS by HCWs

Variable	Patients' peer supervision establish (n=235) OR (95%*CI*)	Intensive phase DOT (n=236) OR (95%*CI*)	Continuation phase DOT (n=236) OR (95%*CI*)	Regular medicine delivery (n=234) OR (95%*CI*)	Sputum sample collection (n=236) OR (95%*CI*)	Injection treatment for MDR-TB patient (n=234) OR (95%*CI*)	Providing supervision for newly released prison patient (n=236) OR (95%*CI*)
Gender							
Female	Reference			Reference			
Male	0.577（0.258-1.270）			0.605(0.320-1.147)			
Age							
>50		Reference					
40-50		2.053(0.985-4.279)					
30-39		2.230(0.947-5.248)					
<30		Default					
Professional Title							
Non		Reference	Reference		Reference	Reference	Reference
Junior		0.424(0.215-0.835)*	0.419(0.228-0.771) *		0.458(0.242-0.865) *	0.307(0.159-0.594)	0.681(0.364-1.273)
Intermediate		0.625(0.233-1.787)	0.860(0.355-2.804)		1.137(0.432-2.993)	0.686(0.258-1.827)	2.107(0.829-5.353)
Deputy senior		0.276(0.021-3.605)	0.415(0.024-5.020)		1.644(0.131-20.584)	0.809(0.054-12.031)	2.534(0.179-35.887)
Training frequency							
0/6 months					Reference	Reference	Reference
1/6 months					2.474(0.566-10.821)	3.533(0.767-16.277)	4.752(0.858-26.335)
2/6 months					2.890(0.729-11.460)	2.217(0.534-9.199)	2.568(0.500-13.182)
3/6 months					0.776(0.165-3.660)	0.607(0.126-2.923)	0.990(0.162-6.048)
>3/6 months					2.307(0.432-12.327)	2.841(0.503-16.-54)	3.346(0.508-22.044)
Working satisfaction							
Low satisfaction	Reference	Reference	Reference	Reference	Reference		
Middle satisfaction	0.354(0.168-0.745) *	0.449(0.219-0.903) *	0.584 (0.312-1.095)	0.582(0.309-1.094)	0.661(0.304-1.532)		
High satisfaction	0.182(0.059-0.562) *	0.326(0.140-0.766) *	0.347(0.163-0.741) *	0.375(0.165-0.853)	0.395(0.160-0.826) *		

Note: *Lower delivery rate* refers to rate below 90%, *TTMS* refers to tuberculosis treatment management service, *DOT* refers to directly observed therapy, *MDR-TB* refers to multidrug-resistance tuberculosis, *CI* refers to confidence interval,* refers to p<0.05.

Qualitative results about barriers to TTMS delivery

The in-depth interviews disclosed numerous barriers to TTMS delivery from the four core PRISM domains as follows (Table 5):

Table 5 Barriers of TTMS delivery by HCWs in PHC sectors

Core PRISM domains	Results	Quotations
Intervention: TTMS program	**Patient-centered manner:** Patient expressed antipathy to DOT. Some HCWs also stated that TB patients don't like the current approach to deliver TTMS, maybe new e-health approach should be taken into account.	*Got telephone calls during the first 2 months, very few afterwards...I didn't like (DOT). (Mid-20s patient)* *There is one MDR-TB patient...say it is annoying to call him every day (by us to deliver TTMS program). (HCW)* *I think that we can remind patients to take medicine via digital technologies. Although, the elders may not use phone adroitly, we find that they missed drug taking less frequently than the young patients. So we can remind young patients through APP in mobile phone. (HCW)*
Recipients	**Resources and incentive in PHC sectors:** Majority HCWs and leaders stated that PHC sectors, particularly THCs faced insufficient human resource HCWs to deliver TTMS program. HCWs often undertook >2 BPHS programs which led to hardship to deliver standard TTMS to TB patients. And inadequate professional capability, particularly village doctors, led to patients' distrusts and therefore hindered TTMS delivery. Many HCWs claimed that PHC sectors lacked of transportation tools to facilitate home-visits especially for remote rural patients Moreover, majority HCWs and leaders reported that lack of incentive for HCWs in TTMS program, and almost all HCWs unsatisfied with low subsidy, allowance, and salary regarding their heavy workload and infection risk. Out-of-pocket expenditure for transportations and telephone charges for TTMS delivery was also reported by HCWs.	*Too many works, it is hard to communicated well with patients...I have 2-3 days a week to give phone calls to TB patients, too tired...we often take two works by one person, the workloads is huge. (HCW)* *Insufficient and unstable HCWs ...one HCW leave, then we need to train a new one…(CDC leader)* *HCWs, especially at TCHs, low quality, patients don't trust them. (CDC leader)* *Lacking of transportation tools for home-visit, some (patients) live in rural area, far away...need to take a long distance to visit one patient. (HCW)* *We face high risks of infection. There is no subsidies for us to provide manage. Funding for* TTMS *delivery is not separated from* subsidies *for the whole BPHS program. Actually those subsidies from BPHS is not even enough for my telephone and transportation costs. (HCW)* *Without subsidies, the HCWs motivation and working satisfaction is low...they just to complete tasks, and will not really care about the quality of TTMS. (CDC leader)*

	Training support to HCWs in PHC sectors: Some HCWs stated that TB trainings lack of communication and professional knowledge for TTMS delivery. Both HCWs and leaders mentioned lack of TB-specific training for HCWs.	*2-3 TB trainings each year, from CDC...combined with other (BPHS) trainings...and I think this training is not effective.(HCW)*
	Patient's socio-economy: Most HCWs and leaders consistently agreed that most TB patients were old age and living with low socioeconomic status, have high risk to reject TTMS. Some HCWs also stated the hardship to deliver TTMS among migrant patients since hard to reach them.	*During treatment in later period, I didn't (take sputum examination), no money, no money for transportation. (Late-50s patient)* *Because TB itself is a "disease of the poor", most TB patients have financial difficulties with bad lifestyles and poor literacy. (HC leader)* *Migrant patients are hard to reach...some have no stable work and often change their phone numbers...don't like TTMS. (HCW)* *I told him/her the dangerousness and seriousness of MDR-TB, he/she still didn't keep treatment, only told me: 'no money'. (HCW)*
	Patient's health literacy: Vast majorities of HCWs stated that some patients and their families refused to receive TTMS to manage their nonadherence behaviors due to poor health literacy and weak TB-related awareness.	*Some (patients) don't prioritize their health, and dislike our TTMS...they are aged and less educated...Some have very poor adherence to TB treatment. (HCW)*
External environment	**Health insurance:** Most HCWs and leaders stated that the health insurance cannot cover all medicines and tests related to side-effect which added financial burden among poor TB patients and led to hardship for TTMS delivery.	*The reimbursement from health insurance for TB is very strict, anti-TB drugs are free, and other liver protection medicines and tests are not.(HC leader)*
	Cross-sectional coordination: Majority HCWs and leaders reported the difficulties to conduct cross-sectional coordination for TTMS delivery, especially coordination from TB designated hospitals. One leaders also stated a poor cross-sectional coordination between PHC sectors with the departments of education, public security, civil affair, and finance for TTMS delivery.	*It is hard to connect with TB designated hospitals' doctors, they are very busy. One patients stopped treatment and said it is doctors' advice...but I cannot confirm. (HCW)* *The department of finance, education, civil affairs, public security, and others， ... they are not highly motivated (to give us support in TTMS program). (CDC leader)*
	Social stigma: TB-related social stigma was mentioned by many HCWs. Urban patients with more concerns of privacy issue were more likely to refuse home-visit from HCWs.	*There is one patient, it's impossible to go to his/her home... due to privacy, he/she doesn't like people around know they have TB. (HCW)* *Some TB patients don't like us to go to their home for home-visit... (They are)*

		worried about how people around would think of them. (HCW)
Implementation and Sustainability infrastructure	**Performance assessment:** All HCWs and some of the leaders stated that the performance assessment for TTMS may exist irrationality considering heavy workload. And leaders pointed out that this could lead to substandard TTMS and also hinder HCW's working enthusiastic.	*(Performance) assessment is unreasonable, more works you do, more mistakes you make, and this is unfair. There is no rewards when you perform well...while, any negative feedbacks (such as patients' dissatisfactions with treatment costs) would affect our performance assessment. (HCW)* *The indexes are quiet high (considering HCW's workload). Sometimes, the purpose becomes to complete indexes but not to really care about patients. (CDC leader)*

Note: *TB* refers to tuberculosis, *MDR-TB* refers to multidrug-resistant tuberculosis, *TTMS* refers to tuberculosis treatment management services, *DOT* refers to directly observed theory, *HCWs* refers to health care workers, *CDC* refers to Center of Disease Control, *HC* refers to Health Commission, *BPHS* refers to basic public healthcare services, *THCs* refers to township health centers.

1) Interventions

Current TTMS program was mainly delivered via telephone calls and lacked of sufficient patient-centered manner which led to patient's antipathy to DOT. HCW suggested that e-health approach, including APP would be good choice to deliver TTMS.

2）Recipients:

Most PHC sectors faced insufficient health human resource to deliver TTMS program. Every HCW often undertook more than 2 BPHS programs. HCWs with this heavy work load of BPHS had difficulty to deliver standard TTMS delivery. On the other hand, PHC sectors lacked of transportation tools to facilitate home-visits especially for remote rural TB patients. HCWs in PHC sectors also faced inadequate professional capability, especially village doctors, which led to patients' distrusts and therefore hindered TTMS delivery by those HCWs. On the other hand, PHC sectors lack of sufficient incentive for HCWs in TTMS program, and almost all HCWs unsatisfied with low salary, and subsidy regarding their heavy

workload and infection risk of TB. In addition, out-of-pocket expenditure for transportation and telephone charge for TTMS delivery could further influence HCW's working motivation, performance, and attrition. Moreover, inadequate qualified training (the content lack of communicational and professional knowledge for TTMS delivery, and the training approach of TB trainings mixed with other BPHS programs and lacking of high quality TB-specific training for HCWs) supports for TB HCWs were also reported by interviewers. So current training could not provide much support in HCWs' capabilities and performance.

In terms of patient characteristics, the majority of interviewers claimed that TB is a disease of the poor and most TB patients were disadvantaged group (aging, low education, migrant and financial difficulty), who had poor TB-related health literacy and had high risk to reject TTMS. HCWs also mentioned the hardship to deliver TTMS among migrant patients due to hard to reach them.

3）External environment:

On the one hand, inadequate health insurance coverage for medicines and tests related to side-effects accentuated financial burden among poor TB patients and reduced willingness to receive TTMS. On the other hand, difficulties in cross-sectional coordination to assist TTMS delivery were reported, especially supports from TB designated hospitals and also other departments like departments of public security and education. Furthermore, TB-related social stigma was reported as one of the main barriers to conduct home-visits among urban patients who care much privacy and were more likely to refuse to accept home-visits from HCWs.

4）Implementation and sustainability infrastructure:

The performance assessment for TB HCWs might exist irrationality considering their heavy workload. One leader pointed out that to the purpose of TTMS delivery could become to complete the targeted indicators, and therefore, lead to substandard TTMS to patients. Moreover, inappropriate performance assessment also hinder working motivation and increased working attrition among HCWs to deliver TTMS.

Discussion

In China, HCWs in PHC sectors are considered as an important part of the TB integrated model and taking responsibility for TTMS delivery. This study assessed the delivery of TTMS program by HCWs in PHC sectors in West China. Though we found that the TTMS delivery rates in intensive phase and continuation phase were higher than previous study in West China [14], the standard TTMS (at least 24 times TTMS during their treatment course) delivery rate is far below the required rate of >90% according to the National TB Control Plan [5]. Besides, our study showed that TB patients received DOT from HCW in CHCs (in urban regions) was higher than that from HCW in THCs (in rural regions). This difference might be explained by our qualitative results as interviewed HCWs reported the challenges to delivery TTMS to remote rural patients due to patients' poor health literacy which is also reported in other studies [16, 25], and our study also pointed the far away distance with insufficient transportation tools for HCWs blocked TTMS delivery. In addition, our study revealed that less than half of HCWs provided services of collecting patients' sputum samples during follow-up supervision, which is much lower than the result reports in the

study in Guizhou (96.56%) [25]. Furthermore, we found a low level of working satisfaction (22.4%) among TB HCWs, while, it is higher than previous study (12.2%) [26]. Our study results indicated that HCWs with low working satisfaction were more likely to have a low delivery rate of first-time home visit, DOT, and sputum sample collection services. Efforts should be made to maintain and promote HCWs' working satisfaction to enhance TTMS delivery.

Our study disclosed that the current TTMS delivery was confronted with various barriers, despite that TB HCWs in PHC sectors carried out TTMS program had made many achievements in West China. In the organizational level, we found that the TTMS programs itself existed several barriers for HCWs to delivery services. On the one hand, the national TB action plans and nationwide TB survey in China [2, 8, 27] mentioned the cross-sectional coordination for TTMS delivery, however, we found that HCWs in PHC sectors still lack of well coordination with other departments, such as coordination from department of education to support students treatment management, help from department of public security to trace migrant patients' information. Particularly, HCWs from some PHC sectors faced barriers to access timely connections with TB HCWs from TB designated hospital in addressing TB patients' side effects and treatment adherence. It is difficult to realize the participation of the whole society in TB control in China so far [28]. As the call by the Action Plan to Stop TB (2019 to 2022) in China [2], it is an emergent need to build a multi-sectorial collaboration mechanism led by the National Health Commission (NHC) in order to coordinate cross-sectional efforts to support TB prevention and control program [29].

The second barrier emerged at health organizational level is the approaches to delivery TTMS. We found TTMS were mainly delivered by telephone call, which consistent with previous studies in West China [14, 28], and the insufficient patient-centered manners could resulted in patients' rejects to DOT and TTMS by HCWs. Although researches showed that home-visits and DOT did led to positive treatment outcome [29, 30], our study pointed out the need to provide TTMS with e-health approach, which was consistent with previous studies, and previous studies demonstrated the effectiveness of e-health technology for promoting patients' treatment adherence [31-36]. It is deserved to explore internet-based case management model, such as digital supported self-management, and with the help of HCWs in PHC sectors to deliver TTMS to TB patients who live in remote mountain area or against face-to-face DOT.

The third barrier in organizational level is the health human resource for TTMS in PHC sectors. Other studies reported that PHC sectors especial in rural areas had a limited number of HCWs to conduct BPHS programs which led to heavy workload and "shortage of hands" since HCWs often carried out multiple assigned services [37-39]. We consistently found that PHC sectors, particularly in THCs, faced human resource barriers in terms of insufficient number and inadequate professional capability to deliver TTMS program. On the one side, our study showed that heavy workload with multiple BPHS programs could led to hardship to deliver standard TTMS to TB patients. On the other side, we found that inadequate professional capability, especially village doctors, could led to patients' distrusts and hence impeded TTMS delivery. Simultaneously, our study disclosed that PHC sectors lack of

adequate TB training for HCWs, particularly training related to communicational and professional knowledge for TTMS delivery resulted in substandard TTMS. Other studies proved the on-the-job training is important to improve professional skills among HCWs [28, 38, 40, 41], especially trainings emphasized both knowledge and practice [42]. Furthermore, we found that the performance assessment for HCWs in TTMS program may exist irrationality regarding their heavy workload which led to hardship to deliver standard TTMS and hindered their working enthusiastic.

In addition, our results showed that PHC sectors lack of sufficient funding for TTMS program, and most HCWs unsatisfied with low salary, allowance or subsidy which was consistent with other study [25]. Many research also indicated that the diverse issues of financial incentives combined with heavy workload could influence HCW's motivation and performance [38, 43-46]. The appropriate use of incentives for HCWs is a means of promoting health outcomes with a direct impact on the effectiveness and sustainability of a health program, and also able to improve services delivery through enhancing motivation and reducing attrition [42]. Notably, we found that HCWs faced out-of-pocket expenditure for transportations and telephone charges for TTMS delivery which could further impact their work enthusiastic.

Our results also identified barriers in patient level to TTMS delivery included their susceptible socioeconomic characteristics（aging, low education, migrant, and poor financial status） and lower literacy related to TB control. Previous nationwide TB epidemiology survey in China revealed that near half (48.8%) of the TB patients were aged ≥60, less

educated, and over 80% of TB patients had household incomes below local levels [16]. Our results indicated that poor socioeconomic characteristics and low TB-related health literacy together highly impeded TTMS delivery. As patients with low socioeconomic features were often found with lower education background, poor health literacy, and more likely to be have nonadherence, hence, they more likely to refuse to HCWs' supervision, which is consistent with other studies [16, 47]. In addition, we found that TTMS delivery among migrant patients was challenging for HCWs due to hard to reach. Other studies also reported that migrant patients with frequently movement and low socioeconomic status had relatively poorer TB-related awareness [48-50] which could future hindered TB case management. Previous studies revealed that West China had a higher proportion of rural mountain areas as well as domestic migrants compared with other regions in China, and TB-related awareness among rural, less educated, and migrants was particularly serious [16, 48, 50-52].

Our study also discovered that the health insurance cannot cover all medicines and tests related to side-effects which accentuated financial burden among poor TB patients and led to hardship for TTMS delivery. In order to relief barriers from TB patients, on the one hand, addressing financial burden due to TB treatment among poor patients is crucial. Notwithstanding, previous national TB epidemiology survey in China reported that over 90% of TB patients had medical insurance combined with the policy of free TB diagnosis and treatment, the proportion of out-of-pocket among patients was still around 75.0%-84.2% [16]. Studies and reports mentioned the necessary to increase reimbursement ratio and amount for TB treatment, to expand the scope of current free TB treatment policy, and to strengthen care

and assistance for TB patients [2, 5, 31]. Particularly need to target DR-TB and impoverished patients with transportation, accommodation and nutrition allowance during TTMS delivery to promote TB control outcomes.

On the other hand, promoting TB-related health literacy among patients and enhancing TB-related awareness among the public are urgently necessary. As our study revealed that not only poor TB heath literacy is a barrier from patients, TB-related social stigma also impeded TTMS delivery especially in urban areas. Previous studies suggested to provide easily understandable TB health education to particular target population (the aged, less educated, close contacts, etc.) with certain modes of health education [16, 51]. Other study indicated that a combination of mass media approaches and interpersonal communications between patients and HCWs could lead to more effective TB control [52]. Similarly, Chinese Action Plan to Stop TB called for various publicity activities to raise awareness of TB which includes traditional media such as television broadcasting and newspaper, and also the use of new media such as WeChat to promote dissemination of scientific TB knowledge and eliminate social discrimination [2].

Strengthens and limitations

Our study used a mixed research method combining quantitative research (questionnaire survey) with qualitative research (semi-structured, open-ended in-depth interviews) to assess TTMS program delivery by HCWs in PHC sectors. Perspectives from organizations and patients were both included by using the PRISM model to evaluate specific barriers to TTMS delivery. Three levels of the local health organization were all involved in our study, which

contained the HCWs as the frontline staffs, the CDC leaders as the managers, and the Health Commission leaders as the policy makers. However, there are a number of limitations in the current study. First, the sample size of both questionnaire survey and in-depth interviews could be further expanded to enhance the representativeness of study. Second, as we only explore the status of and barriers to TTMS delivery by HCWs in PHC sectors, well-evidenced implementation strategies that able to solve current problems successfully were not able to be provided in this study. Further studies are required to provide more evidence for producing more comprehensive and effective TB control strategies.

Conclusion

All the engagements of HCWs in TTMS program suggests that the government realized the importance of HCWs in PHC sectors in promoting TB patients treatment adherence and outcomes and underscored their integration into the TB control model. We identified barriers operating in organizational level (cross-sectional coordination, patient-centered approach, resources and incentives, training support, reimbursement issue, and performance assessment) and patient level (socioeconomic characteristics, health literacy and social stigma) to TTMS delivery by HCWs in PHC sectors. There is an urgent need to identify comprehensive measures to effectively overcome barriers to TTMS delivery and further promote TB control in West China.

Acknowledgements We would like to thank the participants who responded our questionnaires. We also thank all leaders and healthcare workers in the PHCs in study places who supported this study by facilitating implementation of the field questionnaire survey and participated in our interviews.

Contributions JZ, JP and YL have designed this survey, JZ, JP, GW, WX, TZ, SL and QW have collected data, JZ, JP, RZ, YC and JL have managed and analyzed data, YL and DH have controlled the quality of data collection and analysis, JZ has drafted the manuscript. YL has edited the manuscript. All authors have interpreted the results, revised the report and completed the final version. The author(s) read and approved the final manuscript.

Funding The study was funded by the National Natural Science Foundation of China (No.81773489), the Chongqing outstanding youth project (No.cstc2020jcyj-jq0035), Social Science and Technology Innovation Subject in Chongqing (No.cstc2015shmszx120070).

Disclaimer The funders had no role in study design, data collection and analysis, interpretation of the data, writing the paper and the decision to submit the paper for publication.

Competing interests Not declared

Patient consent Obtained.

Ethics approval Ethics approval was obtained from the Institutional Review Board of Army Medical University (Third Military Medical University), Chongqing, China (No.AF/SC-08/1.0) before starting the study. This study was conducted in accordance with the Declaration of Helsinki. A full explanation of the purpose and procedure of the study was provided to participants prior to obtain their written informed consent. All demographic data and quotes used in this study were deidentified to maintain the anonymity of participants.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

References:

[1].World Health Organization. Global tuberculosis report 2020. Geneva: World Health Organization. 2020.

[2].National Health Commission. Stop TB Action Plan (2019-2022). 2019. http://www.nhc.gov.cn/jkj/s3589/201906/b30ae2842c5e4c9ea2f9d5557ad4b95f.shtml

[3].World Health Organization: Treatment of tuberculosis: Guidelines for national programmes (4thedition), 2010. https://www.ncbi.nlm.nih.gov/books/NBK138748/pdf/Bookshelf_NBK138748.pdf.

[4].Ministry of Health of the People's Republic of China. National tuberculosis control programme (2011-2015). 2011. National Health Commission. Stop TB Action Plan (2019-2022). 2019. http://www.gov.cn/gongbao/content/2011/content_2020914.htm.

[5].General Office of the State Council of the People's Republic of China. The 13th five year plan for the prevention and control of tuberculosis. 2017. http://www.gov.cn/zhengce/content/2017-02/16/content_5168491.htm

[6].National Health Commission of the People's Republic of China. National basic public health service standard (3rd edition). 2017. http://www.nhc.gov.cn/jws/s3578/201703/d20c37e23e1f4c7db7b8e25f34473e1b.shtml

[7].Yufei Chen. Discussion on the effect of the integrated tuberculosis prevention and control model in Dongxiang County. Foreign Medical science section of medgeograpgy, 2014; 35 (3).

[8].Xiaojie Chen, Zhanchun Feng. Analysis of the implementation effect of the integrated tuberculosis prevention and control model in Wuhan. Medicine and society. 2014;27(2):62–4.

[9].Xiaodan Wu. The impact of community supervisors' supervision and management visits on the rate and curative effect of non-hospital pulmonary tuberculosis patients. World Latest Medicine Information. 2018;18(90):210.

[10]. Zhang SN, Yuan ZA, Mei J, Shen M, Shen X. The effectiveness of the new TB control network in Shanghai. Chin J Antituberc. 2007;29(1):74–7.

[11]. Wang XY. Evaluation on effectiveness of the new trinity TB control network in Wujin District

of Changzhou. Jiangsu J Prev Med. 2013;24(5):18–20.

[12]. Jing GQ, Qian QW, Ding TD. The effects of tuberculosis prevention and control using the integrated mode in Bengbu. Anhui J Prev Med. 2012;18(6): 425–6.

[13]. Xie MF, Lai SF, Lian ST. Analysis on the effect of integrated tuberculosis control mode, Wuping county. Prev Med Trib. 2018;24(1):76–8

[14]. Pu J, Chen W, Jiang WX, Xing W, Liang SX, Wang G, et al. Is tuberculosis patients management improved in the integrated TB control model in West China? A survey in Guizhou Province, China. Infect Dis Poverty. 2019 Jul 2;8(1):55.

[15]. Li Y, Ehiri J, Oren E, Hu D, Luo X, Liu Y, et al. Are we doing enough to stem the tide of acquired MDR-TB in countries with high TB burden? Results of a mixed method study in Chongqing, China. PLoS One. 2014 Feb 5; 9 (2):e88330.

[16]. Yu Wang. The fifth national tuberculosis epidemiological sampling survey. Beijing: Military Medical Science Press. 2011.10

[17]. National Bureau of Statistics. China Statistical Year book: China Statistics Press. 2018. http://www.stats.gov.cn/tjsj/ndsj/2018/indexch.htm.

[18]. Q Wang, T Li, X Du, N Yan, YL Zhao, H Zhang. Analysis in the incidence of national tuberculosis reports from 2015-2019. Chinese Journal of Antituberculosis. 2021; 43(02):107-112.

[19]. Xin J. Tuberculosis DOT counterparts to DOT understanding, manner and demand. Chinese Center for Diseases Control and Prevention. 2008.

[20]. Feldstein, A.C, R.E. Glasgow. A practical, robust implementation and sustainability model (PRISM) for integrating research findings into practice. Jt Comm J Qual Patient Saf. 2008; 34(4): p. 228-43.

[21]. Liles, E.G, et al. Implementation challenges and successes of a population-based colorectal cancer screening program: a qualitative study of stakeholder perspectives. Implementation Science. 2015; 10(1).

[22]. Schneider, J.L, et al Stakeholder perspectives on implementing a universal Lynch syndrome screening program: a qualitative study of early barriers and facilitators. Genetics in Medicine. 2016; 18(2): p. 152-161.

[23]. Smith J, Firth J. Qualitative data analysis: the framework approach. Nurse Researcher. 2011; 18(2): 52–62.

[24]. Ward DJ, Furber C, Tierney S, Swallow V. Using Framework Analysis in nursing research: A worked example. J Adv Nurs. 2013; 69(11): 2423–31.

[25]. YY He, JL Li, W Chen, L Luo, Y Shang, JH Xu. Analysis on the implementation of basic public health tuberculosis service items in Guizhou Province. Studies of Trace Elements and Health. 2020; 37(02):54-57.

[26]. Gaspar LMDS, Braga C, Albuquerque GDM, Silva MPN, Maruza M, Montarroyos UR, et al.

Knowledge, attitudes and practices of community health agents regarding pulmonary tuberculosis in a capital city in northeastern Brazil. Cien Saude Colet. 2019; 26;24(10):3815-3824.

[27]. Hui Z, Xiaoqiu L, Caihong X, Dongmei H, Xue L, Tao L, et al. Guiding Tuberculosis Control Through the Healthy China Initiative 2019−2030. China CDC Weekly. 2020, 2(49): 948-950..

[28]. Liu GH, Deng J, Chen W. Investigation on the status of needs on community doctors for tuberculosis management in Guizhou Province. China Health Industry. 2019;16(21):11-13.

[29]. Xu L, Gai R, Wang X, Liu Z, Cheng J, Zhou C, Liu J, Zhang H, Li H, Tang W. Socio-economic factors affecting the success of tuberculosis treatment in six counties of Shandong Province China. The International Journal of Tuberculosis and Lung Disease. 2010;14(4):440–6.

[30]. Lertkanokkun S, Okanurak K, Kaewkungwal J, Meksawasdichai N. Healthcare providers' knowledge, attitudes & practices regarding tuberculosis care. JItMM2012 PrOcEEDInGs. 2013;2:1–10.

[31]. Chongqing tuberculosis dispensary. Implementation plan of the Chongqing Stop Tuberculosis Action (2019-2022). 2020. http://www.cqtb.org/html/zcfg/20/01/1121.html

[32]. Zhang H, Liu JJ. The overview and prospect of tuberculosis control in China since the founding of the Peoples Republic of China. Chin J Antituberc. 2019; 41(9):913 − 6.

[33]. Liu X, Lewis JJ, Zhang H, Lu W, Zhang S, Zheng G, et al. Effectiveness of Electronic Reminders to Improve Medication Adherence in Tuberculosis Patients: A Cluster-Randomised Trial. PLoS Med. 2015 Sep 15; 12 (9):e1001876.

[34]. Alipanah N, Jarlsberg L, Miller C, Linh NN, Falzon D, Jaramillo E, et al. Adherence interventions and outcomes of tuberculosis treatment: A systematic review and meta-analysis of trials and observational studies. PLoS Med. 2018 Jul 3;15 (7):e1002595.

[35]. Nhavoto JA, Grönlund Å, Klein GO. Mobile health treatment support intervention for HIV and tuberculosis in Mozambique: Perspectives of patients and healthcare workers. PLoS One. 2017 Apr 18;12(4):e0176051.

[36]. Wang N, Zhang H, Zhou Y, Jiang H, Dai B, Sun M, et al. Using electronic medication monitoring to guide differential management of tuberculosis patients at the community level in China. BMC Infect Dis. 2019 Oct 15;19(1):844.

[37]. Huang et al. Global Health Research and Policy. 2018. (3):18. https://doi.org/10.1186/s41256-018-0072-0

[38]. Tao T, Zhao Q, Jiang S, Ma L, Wan L, Ma Y, et al. Motivating health workers for the provision of directly observed treatment to TB patients in rural China: does cash incentive work? A qualitative study. Int J Health Plann Manag. 2013;28(4):e310–24.

[39]. Liang S, Deng H, Liu S, Wang G, Li L, Wang M, et al. Competency building for lay health workers is an intangible force driving basic public health services in Southwest China. BMC Health Serv Res. 2019 Aug 23;19(1):596.

[40]. Edwards NC, Roelofs SM. Sustainability: The elusive dimension of international health projects. Can J Public Health. 2006;97:45–9. http://www.jstor.org/stable/41994677.

[41]. Li N, Yan LL, Niu W, Yao C, Feng X, Zhang J, et al. The effects of a community-based sodium reduction program in rural China–a clusterrandomized trial. PLoS One. 2016;11(12):e0166620..

[42]. World Health Organization. WHO guideline on health policy and system support to optimize healyhcare worker programmes. Geneva: World Health Organization. 2018.

[43]. Campbell C, Scott K. Retreat from Alma Ata? The WHOs report on task shifting to healyhcare workers for AIDS care in poor countries. Glob Public Health. 2011;6 (2):125–38.

[44]. Jaskiewicz W, Tulenko K. Increasing healyhcare worker productivity and effectiveness: a review of the influence of the work environment. Hum Resour Health. 2012; 10 (1):1.

[45]. Hemminki E, Long Q, Zhang W-H, Wu Z, Raven J, Tao F, et al. Impact of financial and educational interventions on maternity care: results of cluster randomized trials in rural China, CHIMACA. Matern Child Health J. 2013; 17 (2):208–21.

[46]. Meng Q, Li R, Cheng G, Blas E. Provision and financial burden of TB services in a financially decentralized system: a case study from Shandong, China. Int J Health Plann Manag. 2004;19(S1):S45–62.

[47]. Hutchison C, Khan MS, Yoong J, Lin X, Coker RJ. Financial barriers and coping strategies: a qualitative study of accessing multidrug-resistant tuberculosis and tuberculosis care in Yunnan, China. BMC Public Health. 2017 Feb 22;17(1):221.

[48]. Wang SN, Deng YH, Shi YY, Shan LY, Liu Y. Investigation on knowledge of tuberculosis prevention and treatment among floating population tuberculosis patients in Putuo District, Shanghai. Health Education and Promotion.2020,15(06):636-638.

[49]. Ma Y, Liu YH, Du J, Tan SY, Fu YY, Ma LP, et al. Survey on awareness of core information of tuberculosis prevention and control knowledge in pulmonary tuberculosis patients. Chinese Anti-tuberculosis Journal. 2015 (10).

[50]. Zou X, Zhou L, Wu H, Chen L, Zhou F, Gong C, Ye J, Ling L. The role of tuberculosis control institutes in delivering tuberculosis information to domestic migrants in China: A multi-level analysis of a nationwide cross-sectional survey. Int J Infect Dis. 2019; 86:94-101.

[51]. Chen W, Li Y, Yang H, Ehiri J, Chen Z, Liu Y, Wang M, Liu S, Tang H, Li Y. Is tuberculosis health education reaching the public in China? A cross-sectional survey in Guizhou Province. BMJ Open. 2016; 6(9):e013534.

[52]. Arulchelvan S, Elangovan R. Effective communication approaches in tuberculosis control: Health workers' perceptions and experiences. Indian J Tuberc. 2017;64(4):318-322.

Appendix 1: Chi-square test results

Factors associated with TTMS with lower delivery rate

Variable	Patients' peer supervision establish (n=235)		Train patient to use smart tools to assist TTMS (n=236)		Intensive phase DOT (n=236)		Continuation phase DOT (n=236)		Regular medicine delivery (n=234)		Sputum sample collection (n=236)	
	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)
Gender		0.025*		0.429		0.370		0.867		0.033*		0.760
Female	115(74.7)		88(57.1)		81(52.6)		81(52.6)		97(63.8)		68(44.2)	
Male	69(87.3)		50(62.5)		47(58.8)		43(53.8)		62(77.5)		37(46.3)	
Age		0.23		0.496		0.023*		0.478		0.261		0.950
20-29	73(83.9)		47(53.4)		55(61.8)		51(57.3)		63(70.8)		40(44.9)	
30-39	60(78.9)		46(60.5)		37(49.3)		36(48.0)		46(61.3)		31(41.9)	
40-50	33(68.8)		28(58.3)		19(43.2)		24(50.0)		35(74.5)		22(44.9)	
>50	9(75.0)		9(75.0)		13(81.3)		8(66.7)		10(83.3)		6(50.0)	
Education		0.927		0.607		0.123		0.247		0.815		0.139
Technical secondary school and below	40(76.9)		33(64.7)		27(51.9)		25(48.1)		36(70.6)		25(49.0)	
College	112(79.4)		81(57.0)		84(59.2)		81(57.0)		94(66.7)		67(47.2)	
University and above	32(78.0)		24(57.1)		17(41.5)		18(43.9)		29(70.7)		13(31.0)	
Regions		0.468		0.323		0.367		0.399		0.360		0.820
Relatively developed	54(77.1)		47(66.2)		37(53.6)		38(55.1)		46(67.6)		32(45.1)	
Medium developed	66(75.9)		48(55.2)		53(60.2)		50(56.8)		64(73.6)		41(47.1)	
Less developed	65(83.3)		44(65.4)		39(49.4)		37(46.8)		50(63.3)		33(42.3)	
Primary Health Sector Type		0.044*		0.529		0.574		0.586		0.386		0.607
Township health center	141(82.0)		104(60.1)		97(55.7)		94(54.0)		121(69.9)		79(45.9)	
Community health center	44(69.8)		35(55.6)		32(51.6)		31(50.0)		39(63.9)		27(42.2)	
Professional Title		0.317		0.591		0.010*		0.036*		0.801		0.019*
Non	67(82.7)		46(56.8)		37(45.7)		36(44.4)		52(64.2)		30(37.0)	
Junior	82(78.8)		65(62.5)		70(66.7)		67(63.8)		73(70.2)		58(55.8)	
Intermediate	19(67.9)		15(53.6)		12(42.9)		13(46.4)		17(63.0)		9(32.1)	
Deputy senior	2(66.7)		1(33.3)		2(66.7)		2(66.7)		2(66.7)		1(33.3)	
Times of training received in the past six month		0.299		0.007*		0.147		0.214		0.963		0.022*
0	11(91.7)		10(83.3)		8(66.7)		8(66.7)		8(72.7)		7(58.3)	
1	37(78.7)		28(57.1)		22(44.9)		21(42.9)		34(69.4)		20(41.7)	
2	93(76.2)		68(56.2)		63(51.6)		62(50.8)		82(67.8)		46(37.4)	
3	31(88.6)		27(77.1)		23(67.6)		22(64.7)		22(64.7)		23(67.6)	
>3	13(68.4)		6(31.6)		13(68.4)		12(63.2)		14(73.7)		10(52.6)	
Working satisfaction		0.000*		0.042*		0.016*		0.012*		0.008*		0.027*
Dissatisfied	32(68.1)		27(56.3)		20(43.5)		20(43.5)		30(66.7)		19（40.4）	
General	26(60.5)		20(45.5)		19(43.2)		17(38.6)		22(50.0)		14（31.8）	
Satisfied	76(85.4)		51(57.3)		52(57.8)		51(56.7)		64(71.9)		39（43.8）	

Very satisfied	50(92.6)	39(73.6)	38(70.4)	37(68.5)	44(81.5)	33(61.1）

Note: *p<0.05, TTMS refers to tuberculosis treatment management service, DOT refers to directly observed therapy, MDR-TB refers to multi-drug resistance tuberculosis, Lower delivery rate refers to a rate below 90%, DOT refers to directly observed therapy

Factors associated with TTMS with lower delivery rate (Continue)

Variable	Providing food or transport assistances for poor TB patient (n=230)		Providing DOT for migrant TB patient at their convenient time (n=235)		Providing subsistence allowance or psychological support for migrant patient (n=236)		Providing injection treatment for MDR-TB patient (n=234)		Providing supervision for newly released prison patient (n=236)		Referring TB patient with mental/psychological problems or alcohol/drug addiction (n=235)		Training cured TB patients to provide peer education (n=237)		Establishing platform for TB patients communication (n=237)	
	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)
Gender		0.215		0.153		0.313		0.274		0.669		0.431		0.957		0.845
Female	40(51.3)		72(91.1)		36(45.0)		37(46.3)		46(57.5)		59(74.7)		70(87.5)		47(58.8)	
Male	64(42.7)		130(84.4)		80(51.9)		59(38.8)		93(60.4)		122(79.2)		136(87.7)		89(57.4)	
Age		0.174		0.573		0.243		0.561		0.408		0.242		0.016*		0.783
<30	43(49.4)		74(83.1)		50(56.8)		37(42.5)		57(64.0)		71(79.8)		84(94.4)		55(61.8)	
30-39	26(35.1)		65(86.7)		32(42.1)		26(34.2)		40(52.6)		56(73.7)		61(80.3)		42(55.3)	
40-50	25(53.2)		44(91.7)		22(45.8)		21(43.8)		26(54.2)		39(83.0)		44(91.7)		28(58.3)	
>50	6(50.0)		10(83.3)		7(58.3)		6(50.0)		8(66.7)		7(58.3)		9(75.0)		6(50.0)	
Education		0.847		0.526		0.352		0.198		0.073		0.189		0.136		0.194
Technical secondary school and below	22(44.0)		45(88.2)		23(44.2)		23(45.1)		35(68.6)		43(84.3)		47(90.4)		32(61.5)	
College	64(46.4)		123(87.2)		75(53.2)		60(42.9)		84(59.2)		110(77.5)		127(89.4)		85(59.9)	
University and above	17(41.5)		34(81.0)		18(42.9)		12(28.6)		19(45.2)		28(68.3)		33(78.6)		19(45.2)	
Regions		0.277		0.327		0.104		0.613		0.299		0.343		0.048		0.737
Relatively developed	28(40.6)		63(90.0)		36(50.7)		31(44.3)		44(62.9)		56(80.0)		57(80.3)		39(54.9)	
Medium developed	36(42.4)		77(87.5)		49(57.0)		36(42.4)		54(62.1)		70(80.5)		81(93.1)		53(60.9)	
Less developed	40(52.6)		63(81.8)		32(40.5)		29(36.7)		41(51.9)		56(71.8)		70(88.6)		45(57.0)	

Primary Health Sector Type		0.885		0.498		0.613		0.394		0.127		0.528		0.157		0.768
Township health center	76(45.5)		147(85.5)		87(50.6)		73(42.7)		107(61.8)		135(78.5)		115(89.6)		101(58.4)	
Community health center	28(44.4)		56(88.9)		30(46.9)		23(36.5)		32(50.8)		47(74.6)		53(82.8)		36(56.3)	
Professional Title		0.438		0.327		0.038*		0.004*		0.043*		0.870		0.683		0.789
Non	35(43.8)		67(82.7)		44(62.0)		23(28.4)		47(58.0)		61(76.3)		71(87.7)		43(53.1)	
Junior	50(50.0)		92(89.3)		26(47.3)		55(53.4)		68(64.8)		80(76.2)		94(88.7)		64(60.4)	
Intermediate	9(33.3)		22(78.6)		16(53.3)		9(33.3)		10(37.0)		22(81.5)		22(81.5)		16(59.3)	
Deputy senior	1(33.3)		3(100.0)		31(38.8)		1(33.3)		1(33.3)		2(66.7)		3(100.0)		2(66.7)	
Times of training received in the past six month		0.256		0.579		0.497		0.001*		0.022*		0.140		0.788		0.099
0	6(54.5)		9(81.8)		7(58.3)		6(54.5)		8(72.7)		11(100.0)		10(83.3)		6(50.0)	
1	21(43.8)		41(83.7)		23(46.9)		15(3.5)		22(44.9)		36(73.5)		42(85.7)		30(61.2)	
2	46(39.3)		103(85.1)		55(45.5)		42(35.0)		70(57.4)		90(74.4)		106(86.9)		63(51.6)	
3	20(57.1)		33(94.3)		21(60.0)		25(71.4)		28(80.0)		31(88.6)		32(91.4)		27(77.1)	
>3	11(57.9)		17(89.5)		11(57.9)		8(42.1)		11(57.9)		14(73.7)		18(94.7)		11(57.9)	
Working satisfaction		0.094		0.027*		0.115		0.263		0.452		0.021*		0.114		0.054
Dissatisfied	19(40.4)		38(80.9)		18(37.5)		16(34.0)		24(51.1)		34（72.3）		40(83.3)		24(50.0)	
General	15(35.7)		33(76.7)		23(52.3)		16(36.4)		25(56.8)		28（63.6）		36(81.8)		21(47.7)	
Satisfied	68(43.7)		78(87.6)		42(47.7)		35(40.2)		53(59.6)		70（79.5）		25(50.0)		52(58.4)	
Very satisfied	31(59.6)		52(96.3)		33(61.1)		28(51.9)		36(66.7)		48（88.9）		52(96.3)		39(72.2)	

Note: *p<0.05, TTMS refers to tuberculosis treatment management service, DOT refers to directly observed therapy, MDR-TB refers to multi-drug resistance tuberculosis, Lower delivery rate refers to a rate below 90%, DOT refers to directly observed therapy

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	8，9
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8，9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	10，11
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	10
		(*e*) Describe any sensitivity analyses	10
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11,12
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11,12
		(b) Indicate number of participants with missing data for each variable of interest	11,12
Outcome data	15*	Report numbers of outcome events or summary measures	12-15
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	16-20
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	21
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	21
Generalisability	21	Discuss the generalisability (external validity) of the study results	21
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	22

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Tuberculosis treatment management in primary healthcare sectors: a mixed-methods study investigating delivery status and barriers from organizational and patient perspectives

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-053797.R1
Article Type:	Original research
Date Submitted by the Author:	15-Feb-2022
Complete List of Authors:	Zhou, Jiani; Army Medical University, Department of Social Medicine and Health Service Management Pu, Jie; Army Medical University, Department of Social Medicine and Health Service Management Wang, Qingya; Chongqing institute of Tuberculosis prevention and Treatment, Department of districts and counties Zhang, Rui; Army Medical University, Department of Social Medicine and Health Service Management Liu, Shili; Army Medical University, Department of Social Medicine and Health Service Management Wang, Geng; Army Medical University, Department of Social Medicine and Health Service Management Zhang, Ting; Chongqing Institute of Tuberculosis Prevention and Treatment, Department of districts and counties Chen, Yong; Army Medical University, Department of Social Medicine and Health Service Management Xing, Wei; Army Medical University, Department of Social Medicine and Health Service Management Liu, Jiaqing; Army Medical University, Department of Social Medicine and Health Service Management Hu, Daiyu; Chongqing Institute of Tuberculosis Prevention and Treatment, Department of districts and counties Li, Ying; Army Medical University, Department of Social Medicine and Health Service Management
Primary Subject Heading:	Health services research
Secondary Subject Heading:	Health services research, Infectious diseases
Keywords:	Tuberculosis < INFECTIOUS DISEASES, PRIMARY CARE, HEALTH SERVICES ADMINISTRATION & MANAGEMENT

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Tuberculosis treatment management in primary health care sectors: a mixed-methods study investigating delivery status and barriers from organizational and patient perspectives

Jiani Zhou[1], Jie Pu[1], Qingya Wang[2], Rui Zhang[1], Shili Liu[1], Geng Wang[1], Ting Zhang[2], Yong Chen[1], Wei Xing[1], Jiaqing Liu[1], Daiyu Hu[2§], YingLi[1§]

[1] Department of Social Medicine and Health Service Management, Army Medical University (Third Military Medical University), Chongqing, China.

[2] Department of districts and counties, Chongqing Institute of TB Prevention and Treatment, Jiulongpo District, Chongqing, China.

§ Correspondence: Daiyu Hu, Chongqing Institute of TB Prevention and Treatment, Jiulongpo District, Chongqing, China (E-mail:hukaixiu@263.com); Ying Li, Department of Social Medicine and Health Service Management, Army Medical University (Third Military Medical University), China (E-mail:lilyliying2012@163.com).

Abstract

Objective Tuberculosis (TB) treatment management service (TTMS) is crucial to improve patient adherence to treatment. Under the TB integrated control model in China, healthcare workers (HCWs) in primary healthcare (PHC) sectors are responsible for TTMS delivering. This mixed method study aims to explore the status of and barriers to TTMS delivery faced by HCWs in PHC sectors from the health organizational and patient perspectives.

Design We completed 261 questionnaire survey with TB HCWs and 459 with TB patients in PHC sectors, and we also conducted 20 semi-structured interviews with health organizational leaders, TB HCWs and TB patients. SPSS 22.0 and the framework approach were used for data analysis.

Setting Primary healthcare sectors in Southwest China

Results Our results showed that TTMS delivery rate by HCWs in PHC sectors was <90% (88.4%) on average, and the delivery rates of intensive and continuation phase DOT were only 54.7% and 53.0% respectively. HCWs with high working satisfaction and junior title were more likely to deliver first-time home visit and DOT services. Our results suggested that barriers to TTMS delivery at organizational level included limited patient-centered approaches, inadequate resources and incentives, insufficient trainings, poor cross-sectional coordination, and strict performance assessment. At patient level, barriers include low socioeconomic characteristics, poor health literacy, and TB-related social stigma.

Conclusion: TTMS in Southwest China still need further improvement, and this study highlighted specific barriers to TTMS delivery in PHC sectors. Comprehensive measures

are urgent needed to address those barriers in organizational and patient levels to promote TB control in Southwest China.

Key words: tuberculosis, treatment management, healthcare worker, primary healthcare

Strengths and limitations of this study

- This is a mixed method study on accessing the status of and barriers to tuberculosis treatment management services (TTMS) delivery by healthcare workers (HCWs) in primary healthcare sectors (PHC) in Southwest China.
- This study collected both perspectives from organizations and patients followed by using the PRISM model to evaluate specific barriers to TTMS delivery.
- We collected a total of 720 questionnaires with HCWs and patients, and conducted 20 interviews with leaders, HCWs and patients in totally 71 PHC sectors.
- Further studies are required to provide more evidence for producing more effective TB control strategies since well-evidenced implementation strategies that able to address current barriers in TTMS delivery were not able to be provided in this study.

Introduction

Tuberculosis (TB) is one of the leading causes of death worldwide [1]. According to the World Health Organization (WHO) global TB report 2021, there was a large global drop in the number of newly diagnosed TB (fall from 7.1 million in 2019 to 5.8 million in 2020) [1]. However, the most immediate consequence of the large drop is an increase in the number of deaths from TB in 2020 (raised from an estimated 1.2 million deaths among HIV-negative people in 2019 to an estimated 1.3 million in 2020) [1]. The Chinese government pays high attention to addressing the TB epidemic and sets the goal of reducing the incidence of TB to less than 55/100,000 population by 2022 and maintaining a low mortality rate below 3/100,000 population [2, 3]. Though TB cases notification in China has decreased from 70.6/100,000 population in 2012 to 58/100,000 population in 2019 with a treatment success rate above 90% [1, 2], China is listed as high-burden countries with TB, HIV-associated TB, and multidrug/rifampicin-resistant TB (MDR/RR-TB) for 2021-2025 in the WHO global TB report 2021 [1].

The goal of China's latest Action Plan to Stop TB (2019-2022) is to reduce the incidence of TB nationwide to less than 55/100,000 population by 2022 and maintain a low mortality rate below 3/100,000 population [2]. To accomplish this goal, TB prevention and control program has been further improved with enhanced services capacity, strengthened the prevention and control measures for key populations and key areas, advanced the standardized diagnosis and treatment coverage, and increased the public awareness level of tuberculosis prevention and control [2]. Patients' adherence to anti-TB treatment plays an

important role to cure and avoid DR-TB, hence treatment management is essentially necessary for TB patients to ensure treatment adherence, monitor adverse side-effects from treatment, and avoid development of DR-TB [4]. Since Chinese National 12th Five-Year TB Control Plan (2011-2015) came out in 2011, TB control model in China started using the integrated TB control model in most regions [5]. Under the integrated TB control model, the Centers of Disease Control (CDCs) are responsible for TB program governance, surveillance, training and health promotion; the TB designated hospitals are responsible for diagnosis and treatment; and the Primary Healthcare (PHC) sectors are responsible for referrals, tracing, health education and TB treatment management services (TTMS) [5]. Later, China's National 13th Five-Year TB Control Plan (2016-2020) combined with the Action Plan to Stop TB (2019-2022) requested to further strengthen TB prevention and control which emphasized TTMS and strengthened the implementation of various measures to reduce TB epidemic in China [2, 6]. TTMS is one of the key BPHS programs for all residents in China (one of the priorities of the new health reform launched in 2009) which are delivered by TB HCWs in PHC sectors [6, 7]. The BPHS guideline sets a target to accomplish both standard TTMS rate and treatment success rate above 90% [6, 7]. TTMS for diagnosed TB patients are delivered by HCWs in PHC sector under the supervision of CDC with coordination from other departments, such as assistances from the TB designated hospital to deal with patients side-effects and supports from department of education to conduct health education to student population [7].

Study in Jiangxi indicated that TTMS under the integrated TB control model did improve

treatment outcomes [8]. Study in Wuhan pointed that TTMS was crucial important for monitoring treatment complications and reducing the development of DR-TB [9, 10]. Other studies showed that in more developed areas in China, TTMS coverage was highly improved and produced impressive effects [8, 9, 11-14]. Few studies reported the delivery status to TTMS delivery in resource-limited and mountain regions with high TB/DR-TB burden in China. One study found that only 37.1% of TB patients received TTMS by HCWs in West China [15] and study in Chongqing found that 34.3% of TB patients never received TTMS by HCWs [16]. However, very few studies focus on the perspective of HCWs to evaluate the current TTMS program under the integrated TB control model. Therefore, this study not only aim to assess the delivery status of TTMS program from the perspectives of both organizations and patients, but also to explore the specific barriers to TTMS delivery faced by HCWs in PHC sectors to provide evidence for promote TB control and treatment outcome.

Methods

Study design

This cross-sectional study utilized mixed research methods [17] to collect data from June to December 2018. Questionnaire surveys and semi-structured in-depth interviews were conducted to evaluate the delivery of TTMS in PHC sectors from both health organizational (HCWs and leaders) and patient's perspectives.

Study Setting

The prevalence of TB in the western region was significantly higher than the central and

eastern regions in China [18]. Chongqing Municipality is located at the junction of Yangtze and Jialing rivers and has a population of 32.09 million [19]. This region is a relatively developed socioeconomic status, with a gross domestic product (GDP) at 2.5 trillion CNY and a per capita GDP at 55.6 thousand CNY in 2020 [19]. The growing population of Chongqing depends more on the secondary and tertiary industry as the main economic activity [19]. The urbanization rate and literacy rate are 69.5% and 98.4% respectively in 2021 [19]. The TB incidence of Chongqing Municipality (2019) is ranking the tenth (75/100,000) in China [20].

Guizhou Province is a mountainous province in West China and has a population of 38.6 [21]. 50.9% of its population depends on tertiary industry as a main source of income [21]. The employment rate and literacy rate are 49.0% and 93.3% respectively in 2020 [21]. The area maintains a relatively less developed socioeconomic status, with a GDP at 1.8 trillion CNY and a per capita GDP at 46.3 thousand CNY in 2020 [21]. The incidence of TB in Guizhou Province (2019) is ranking the third (133.5/100,000) following Xinjiang and Tibet [20].

A stratified random sampling method was used to select study sites in Chongqing Municipality and Guizhou Province as follows. irst, all counties/districts in Chongqing municipality and Guizhou province were grouped into three levels according to their socioeconomic status (GDP) in 2018 [22]: the relatively developed (GDP in the highest 30%), the medium developed (GDP in the middle 40%), and the relatively less developed (DGP in the lowest 30%). Then, from each group of counties/districts, 4 counties/districts

were randomly selected as study sites. A total of twelve districts/counties were finally included in this study. All of the PHC sectors (included both CHCs and THCs) in the 12 selected counties/districts, totally 71 PHC sectors were included in this study.

Study participants and data Collection

Quantitative study

All adult pulmonary TB patients who met the following criteria were targeted for recruitment from the 71 PHC sectors in the 12 selected counties/districts: (1) registered at TB dispensaries and were diagnosed as drug-sensitive pulmonary TB patients according to national TB diagnosis standards, (2) completed standard anti-TB drug treatment for at least 4 months which indicated that received TTMS for both intensive (first 2 months) and continuation phases (following 4 months), (3) aged 15 years and older. Patients who: (1) with extra-pulmonary TB, (2) could not express themselves clearly (had disturbance of consciousness or difficulties with speech or hearing), (3) unwilling to participated in the study were excluded. Patient recruitment was facilitated by local PHC sectors in the study counties/districts. First, research group members provided a detailed explanation about the study objectives to all potential participants. Then, those who were willing to participate in the study were asked to read and sign the informed consent form to assure of confidentiality.

The sample size was estimated using the Kish and Leslie formula as follows [23]:

$$n=Z_{\alpha}^{2}P\ (1-P)/d^{2}.$$

n is the minimum desired sample size. Z_{α} is the standard normal deviate, usually set as 1.96, corresponding to a 5% level of significance. P is the average rate of TB treatment

management, set at 37.1% based on estimates from the available literature [15]. *d* is the degree of accuracy (precision), set at 5% (0.05). Therefore, the calculated minimum sample size for patient-participants was 359. A total 481 TB patients were recruited to participate in the survey, and 16 declined. Six TB patients <15 years old were excluded, and finally 459 TB patients were included in the analysis (response rate were 95.4%).

All HCWs who were TB control medical staff in PHC sectors in the selected counties/districts and were willing to participate in the study were recruited as participants. TB HCWs who were unwilling to participate in the study were excluded. There were a total of 261 TB HCWs in the selected counties/distracts. Finally, all 261 TB HCWs were recruited and welling to participate in the survey, and zero declined (response rate was 100.0%). HCWs recruitment was facilitated by local CDCs in the study districts/counties.

Structured questionnaires were conducted to collect data among the participated TB patients and HCWs. Among TB patients, structured survey involved demographic information (e.g., gender, age, and residence), and TTMS received from HCWs during treatment (e.g., intensive phase DOT and continuation phase DOT). Among HCWs, the questionnaire included demographic and working-related information (e.g., gender, age, professional title, and working years), working satisfaction, and delivery situation of TTMS (e.g., the first-time home visit). Questionnaires were designed by our research team based on the existing literature reports, and then consulted related experts. All questionnaires were executed by trained investigators from our research group in a meeting room or clinic room at each PHC sector. HCWs, who were willing to voluntary participated in the study, were asked

to read the informed consent form and then sign the informed consent form. Each completed questionnaire was checked and examined by trained investigators for quality control.

Qualitative study

In-depth interviews were utilized to explore the current status and identify barriers to the TTMS delivery from HCWs to TB patients. Purposive sampling method was used to selected participants with different background, age, and experiences related to TTMS. The integrated TB control model was established and TTMS provided in all included counties/districts. Therefore, in-depth interviews were conducted with: HCWs from the PHC sectors of different socioeconomic levels who had delivered TTMS for at least one year during the study period; leaders from the local CDC and the Health Commission who were responsible for TB control program during the study period; and patients from regions of different socioeconomic levels who had received TTMS and were about to end their TB treatment during the study, which ensured patients had sufficient experiences related to TTMS. During recruitment, all HCWs, leaders, and patients were approached and provided with detailed explanations about the study and its objectives. Those who expressed interest in volunteering to participate in the in-depth interview were asked to read and sign the informed consent form as a confirmation of their voluntary participation in the study.

The sample size of the qualitative study was determined by the point of data 'saturation' [24]. The recruitment continued until evidence of data saturation was obtained, whereby adding further participants did not generate new findings. For enhancing the information's trustworthiness and credibility of interviews, each interview was conducted face-to-face by at

least two trained interviewers. During each interview, one interviewer performed the interview according to the semi-structured topic guides, while the other interviewer was responsible for making notes of key information and may supplement questions to the interview as necessary. At the end of each interview, interviewers discussed the findings and key information obtained from the interview to confirm whether a supplementary interview was required. The information related to TTMS delivery was cross validated between patients (service receivers) and HCWs (service providers) to increase information trustworthiness. Documentary sources, such as regulations and standard service procedures, were also utilized to enhance information credibility. A total of nine purposely selected leaders, seven HCWs and four patients participated in the in-depth interviews in this study.

Semi-structured topic guides with open-ended questions were used for all interviews. The guiding framework for the topic design was the Practical Robust Implementation and Sustainability Model (PRISM) [25]. This model considered how the intervention design, recipients, external environment, and implementation and sustainability infrastructure influence health program implementation and success, which widely used as theoretical framework in implementation research [25-27]. With the guide of the PRISM, this study collected data on barriers on TTMS delivery in the following aspects: (1) intervention design; (2) recipients; (3) external environment; and (4) implementation and sustainability infrastructure. The adaptation of PRISM for this study is illustrated in Figure1. All interviews were conducted in Mandarin or local language (Chongqing dialect and Guizhou dialect) in meeting rooms in PHC sectors. Only participant and interviewers in the interview location.

Each interview lasted about 40-60 minutes and was audio-recorded with consent of the participants.

Data analysis

Quantitative analysis

Data were entered using Epi Data 3.1 and then analyzed using the Statistical Package for the Social Sciences (SPSS 22.0 (IBM Corporation, Armonk, NY, USA)). Missing data were excluded during analyze (when analyzing gender, age, medical school education, major, professional title, number of BPHS programs undertook, monthly Income and working satisfaction of HCWs etc., only 259, 249, 247, 256, 240, 225, 242 and 259 HCWs respectively responded those questions in survey, and so we deleted the HCWs who did not respond this question). A two-tailed probability level of $p<0.05$ was chosen as the level of statistical significance. Missing data were excluded from analysis. Descriptive statistics were used to describe study participants' demographic characteristics and TTMS delivery rates. Factors associated with lower delivery rate (<90%) screened by the Chi-square test ($p<0.05$) (Appendix A) were entered into multivariate logistic regression models (delivery rate <90% = 1, delivery rate >90% = 0), which were used to examine the effects of those factors on TTMS delivery.

Qualitative analysis

The framework approach was used to analyze all qualitative data following a five steps process: (1) familiarization, (2) creating theoretical framework, (3) indexing, (4) summarizing and (5) data synthesis and interpretation [28-29]. Following that, all interviews

were carefully transcribed into Word Documents, reviewed for accuracy, and then being coded and classified by our research team members. We identified themes on TTMS delivery barriers for four domains of the PRISM [25], including: (1) intervention design (PHC sectors resource and patient-centered manner); (2) the recipients (human resource and incentives, training support, socio-economy and health literacy); (3) external environment (health insurance, cross-sectional coordination, and social stigma); and (4) implementation and sustainability infrastructure (performance assessment). All the names of participants were removed in quotations of the results to keep anonymity. According to the 13th Five-Year TB Prevention and Control Plan, the targeted TTMS delivery rate from HCWs to TB patients is >90% [5]. Therefore, delivery rate below 90% is described as lower delivery rate in this manuscript.

Definitions

Primary healthcare (PHC) sectors in China include the community health centers (CHCs) and stations in urban areas, township hospital centers (THCs) and village health clinics in rural areas [4]. Tuberculosis healthcare workers (TB HCWs) include health professionals in PHC sectors who are responsible for TTMS delivery. Tuberculosis treatment management service (TTMS) is one of the key basic public health services for all residents in China, which are delivered by TB HCWs in PHC sectors, including 7 themes: the first-time home visit, health education, supervising drug intake, follow-up supervision, case closing evaluation, other services, and services among patient's family members [6, 7]. Both the Chinese National

BPHS guideline and the 13th Five-Year TB Prevention and Control Plan set a target TTMS rate of >90% [6, 7]. Therefore, in this study, a delivery rate <90% is described as a lower delivery rate.

Patient and public involvement

There were no patients or public involvement in the design, conduct, reporting and in the dissemination plans of this research.

Results

Characteristics of participants

Participants for the quantitative study

A total of 261 TB HCWs and 459 TB patients were included in the quantitative analysis (Table 1). Among the HCWs, 66.4% (n=172) were female, 71.5% (n=178) were aged 20-39 years old, 72.4% (n=189) worked at THCs, 50.0% (n=120) and 35.8% (n=86) had junior and non-professional titles respectively. Near 60% (n=155) of the HCWs had junior college education and over 80% (n=202) had medical school education background (32.4% majored in clinical medicine and 30.5% majored in nursing). More than half (56.4%, n=127) of the HCWs undertook 2-3 BPHS programs in PHC sector, and only 7.6% (n=17) were dedicatedly in charge of TB program. The majority (67.4%, n=163) had a monthly income of 2500-4500 CNY, and notably, 40.5% (n=105) reported a low working satisfaction.

Among the TB patients, the majority of the patients were male (70%, n=324), married (69.7%, n=320), Han ethnicity (78.2%, n=359), and 41.6% (n=191) were aged ⩾60. 82.4% (n=378) of the patients were rural residences and 95.2% (n=437) were permanent residences.

Almost 70% (n=315) of the patients were farmer/migrant workers, and 56.0% (n=257) had only primary/below education.

Table 1 Characteristics of TB HCW participants surveyed by questionnaires

Demographic characteristic	Number	Percentage
HCWs in questionnaire survey		
Gender（n=259）		
female	172	66.4
male	87	33.6
Age（n=249）		
20-29	94	37.8
30-39	84	33.7
40-50	52	20.9
>50	19	7.6
Education（n=259）		
Technical secondary school or below	60	23.2
Junior college	155	59.8
Undergraduate college or above	44	17.0
Medical school education (n=247)		
Yes	202	81.8
No	45	18.2
Major (n=256)		
Clinical Medicine	83	32.4
Nursing	78	30.5
Public Health	33	12.9
Chinese Medicine	27	10.5
Other	17	6.6
Region (n=261)		
Relatively developed	93	35.6
Medium developed	89	34.1
Less developed	79	30.3
Working place (n=261)		
Township health center	189	72.4
Community health center	72	27.6
Professional Title (n=240)		
Non	86	35.8
Junior	120	50.0
Intermediate	31	12.9
Deputy senior	3	1.3
Number of BPHS programs undertook (n=225)		

TB program only	17	7.6
2-3	127	56.4
⩾4	80	36.0
Monthly Income (CNY) (n=242)		
<2500	52	21.5
2500-3500	89	36.8
3500-4500	74	30.6
>4500	27	11.2
Working satisfaction （n=259）		
High satisfaction	58	22.4
Middle satisfaction	96	37.1
Low satisfaction	105	40.5
TB patients in questionnaire survey		
Gender (n=459)		
Male	324	70.6
Female	135	29.4
Age (n=459)		
<40	94	20.5
40-49	96	20.9
50-59	78	17.0
⩾60	191	41.6
Ethnicity (n=459)		
Han	359	78.2
Ethnic minority	100	21.8
Marital status (n=459)		
Single	69	15.0
Married	320	69.7
Divorced/Widowed	70	15.3
Residence (n=459)		
Urban	81	17.6
Rural	378	82.4
Registered information (n=459)		
Permanent resident	437	95.2
Migrant	22	4.8
Education (n=459)		
Primary and below	257	56.0
Junior middle school	125	27.2
High school and above	77	16.8
Occupation (n=459)		
Staff/Cadre/Retiree	50	10.9
Self-employed	10	2.2
Farmer/Migrant worker	315	68.6

Student	20	4.4
Others	64	13.9

Note: *TB* refers to tuberculosis, *HCW* refers to health care worker, *BPHS* refers to basic public health services.

Participants for the qualitative study

9 leaders, 7 HCWs, and 4 TB patients were interviewed. Most leaders were male (7/9) with deputy senior titles (5/9) and worked for 7.6 years on average. The majority of HCWs were female (5/7), technical secondary school educated (6/7), majored in clinical medicine (4/5), 4/5 came from CHCs with had none or junior professional titles. Besides, among the 4 interviewed patients, drug-sensitive TB (DS-TB) and 2 DR-TB respectively, all of them completed anti-TB therapy (6-8 months therapy for DS-TB, and 24 months therapy for DR-TB).

Quantitative results about TTMS delivery status

TB patient's survey showed that 76.0% (n=349) of the patients ever received TTMS from HCWs in CHCs during the whole course of treatment (it was 83.7% and 76.7% during their intensive and continuation phase respectively). Just around 40.0% (n=189) ever received TTMS from HCWs in THCs/village clinics during their whole course of treatment (it was 45.1% and 42.3% during intensive and continuation phase respectively). Only 17.0% (n=78) received standard TTMS from HCWs during the whole course of treatment (it was 18.1% and 55.8% for intensive and continuation phase respectively). 2.8% (n=13) were never received TTMS from HCWs (it was 3.9 % and 7.2% during intensive and continuation phase respectively). (Table 2)

Table 2 TTMS TB patient received from HCWs during treatment (n=459)

Variable	Number	Percentage
Ever received TTMS from HCWs in CHCs		
Intensive phase	384	83.7
Continuation phase	352	76.7
Whole course of treatment	349	76.0
Ever received TTMS from HCWs in THCs/village clinics		
Intensive phase	207	45.1
Continuation phase	194	42.3
Whole course of treatment	189	41.2
Received standard TTMS from HCWs		
Intensive phase	83	18.1
Continuation phase	256	55.8
Whole course of treatment	78	17.0
Never received TTMS from HCWs		
Intensive phase	18	3.9
Continuation phase	33	7.2
Whole course of treatment	13	2.8

Note: *TB* refers to tuberculosis, *TTMS* refers to tuberculosis treatment management services, *CHC* refers to community health center, *THC* refers to township health center, *HCW* refers to health care worker.

HCWs' survey showed that the average delivery rate of TTMS (totally involved 60 service items) in PHC sectors was 88.4 %, and 13 TTMS items reported a lower delivery rate (<90%). Notably, the delivery rates of DOT in intensive phase and continuation phase were low, with only 54.7% and 53.0% respectively. Besides, less than half (44.9%) of HCWs in PHC sectors provided service of collecting patients' sputum samples during the follow-up supervision. Less than half of the HCWs provided food or transport assistances for poor TB patient (45.2%), provided subsistence allowance or psychological support for migrant patient (49.6%), and provided injection treatment for MDR-TB patient (41.0%). Moreover, less than 60% provided supervision for newly released prison patient (58.9%) and established platform

for TB patient communication (57.8%). (Table 3)

Table 3 TTMS with lower delivery rate provided by HCWs in PHC sectors (n=239)

Services	Delivery rate N (%)
First time home visit	
Patients' peer supervision establish (n=235）	185 (78.7)
DOT	
Intensive phase DOT (n=236）	129 (54.7)
Continuation phase DOT (n=236）	125 (53.0)
Regular medicine delivery (n=234）	160 (68.4)
Follow-up supervision	
Sputum sample collection (n=236）	106 (44.9)
Others	
Providing food or transport assistances for poor TB patient (n=230）	104 (45.2)
Providing subsistence allowance or psychological support for migrant patient (n=236）	117 (49.6)
Providing DOT for migrant TB patient at their convenient time (n=235）	203 (86.4)
Providing injection treatment for MDR-TB patient (n=234）	96 (41.0)
Providing supervision for newly released prison patient (n=236）	139 (58.9)
Training cured TB patients to provide peer education (n=237）	208 (87.8)
Establishing platform for TB patients communication (n=237）	137 (57.8)
Referring TB patient with mental/psychological problems or alcohol/drug addiction to receive professional therapy (n=235）	182 (77.4)

Note: *Lower delivery rate* refers to a rate below 90%, *TB* refers to tuberculosis, *TTMS* refers to tuberculosis treatment management service, *DOT* refers to directly observed therapy, *MDR-TB* refers to multidrug-resistant tuberculosis

Factors associated with TTMS with lower delivery rate

Multivariate logistic regression analysis showed that HCWs with high working satisfaction were less likely to have a lower delivery rate to establish patients peer supervision as needed (OR=0.182, 95%CI: 0.059-0.562). Among both intensive and continuation phase DOT, HCWs with junior title (OR=0.424, 95%CI: 0.215-0.835) and high working satisfaction (OR=0.326, 95%CI: 0.140-0.766) were less likely to have lower delivery rate. Similarly, HCWs with junior title (OR=0.458, 95%CI: 0.242-0.865) and high working satisfaction (OR=0.395, 95%CI: 0.160-0.826) were more likely to deliver sputum sample collection

service (Table 4).

Table 4 Multivariate logistic regression analysis of factors associated with lower delivery rate of TTMS by HCWs

Variable	Patients' peer supervision establish (n=235) OR (95%*CI*)	Intensive phase DOT (n=236) OR (95%*CI*)	Continuation phase DOT (n=236) OR (95%*CI*)	Regular medicine delivery (n=234) OR (95%*CI*)	Sputum sample collection (n=236) OR (95%*CI*)	Injection treatment for MDR-TB patient (n=234) OR (95%*CI*)	Providing supervision for newly released prison patient (n=236) OR (95%*CI*)
Gender							
Female	Reference			Reference			
Male	0.577（0.258-1.270）			0.605(0.320-1.147)			
Age							
>50		Reference					
40-50		2.053(0.985-4.279)					
30-39		2.230(0.947-5.248)					
<30		Default					
Professional Title							
Non		Reference	Reference		Reference	Reference	Reference
Junior		0.424(0.215-0.835)*	0.419(0.228-0.771) *		0.458(0.242-0.865) *	0.307(0.159-0.594)	0.681(0.364-1.273)
Intermediate		0.625(0.233-1.787)	0.860(0.355-2.804)		1.137(0.432-2.993)	0.686(0.258-1.827)	2.107(0.829-5.353)
Deputy senior		0.276(0.021-3.605)	0.415(0.024-5.020)		1.644(0.131-20.598)	0.809(0.054-12.031)	2.534(0.179-35.887)
Training frequency							
0/6 months					Reference	Reference	Reference
1/6 months					2.474(0.566-10.822)	3.533(0.767-16.277)	4.752(0.858-26.335)
2/6 months					2.890(0.729-11.465)	2.217(0.534-9.199)	2.568(0.500-13.182)
3/6 months					0.776(0.165-3.660)	0.607(0.126-2.923)	0.990(0.162-6.048)
>3/6 months					2.307(0.432-12.317)	2.841(0.503-16.-54)	3.346(0.508-22.044)
Working satisfaction							
Low satisfaction	Reference	Reference	Reference	Reference	Reference		
Middle satisfaction	0.354(0.168-0.745) *	0.449(0.219-0.903) *	0.584 (0.312-1.095)	0.582(0.309-1.094)	0.661(0.304-1.53[illegible]		
High satisfaction	0.182(0.059-0.562) *	0.326(0.140-0.766) *	0.347(0.163-0.741) *	0.375(0.165-0.853)	0.395(0.160-0.826) *		

Note: *Lower delivery rate* refers to rate below 90%, *TTMS* refers to tuberculosis treatment management service, *DOT* refers to directly observed therapy, *MDR-TB* refers to multidrug-resistance tuberculosis, *CI* refers to confidence interval,* refers to p<0.05.

Qualitative results about barriers to TTMS delivery

The in-depth interviews disclosed numerous barriers to TTMS delivery from the four core PRISM domains as follows (Table 5):

Table 5 Barriers of TTMS delivery by HCWs in PHC sectors

Core PRISM domains	Results	Quotations
Intervention: TTMS program	**Patient-centered manner:** Both DS-TB and MDR-TB patients stated they received TTMS from HCWs in PHC sectors by telephone. Some HCWs reported that some patients expressed antipathy to DOT and the current approach to deliver TTMS, maybe new e-health approach should be considered.	*Got telephone calls during the first 2 months, very few afterwards...I didn't like (DOT). (DS-TB patient)* *Only received telephone calls from HCW in town, once per month. (MDR-TB patient)* *There is one MDR-TB patient...say it is annoying to call him every day (by us to deliver TTMS program). (HCW)* *I think that we can remind patients to take medicine via digital technologies. Although, the elders may not use phone adroitly, we find that they missed drug taking less frequently than the young patients. So, we can remind young patients through APP in mobile phone. (HCW)*
Recipients	**Resources and incentive in PHC sectors:** Majority HCWs and leaders stated that PHC sectors, particularly THCs faced insufficient human resource HCWs to deliver TTMS program. HCWs often undertook more than 2 BPHS programs which led to hardship to deliver standard TTMS to TB patients. And inadequate professional capability, particularly village doctors, led to patients' distrusts and therefore hindered TTMS delivery. Many HCWs claimed that PHC sectors lacked transportation tools to facilitate home-visits especially for remote rural patients Moreover, majority HCWs and leaders reported that lack of incentive for HCWs in TTMS program, and almost all HCWs unsatisfied with low subsidy, allowance, and salary regarding their heavy workload and infection risk. Out-of-pocket expenditure for transportations and telephone charges for TTMS delivery was also reported by HCWs.	*Too many works, it is hard to communicated well with patients...I have 2-3 days a week to give phone calls to TB patients, too tired...we often take two works by one person, the workloads are huge. (HCW)* *Insufficient and unstable* HCWs *...one HCW leave, then we need to train a new one…(CDC leader)* *HCWs, especially at TCHs, low quality, patients don't trust them. (CDC leader)* *Lacking transportation tools for home-visit, some (patients) live in rural area, far away...need to take a long distance to visit one patient. (HCW)* *We face high risks of infection. There are no subsidies for us to provide manage. Funding for* TTMS *delivery is not separated from* subsidies *for the whole BPHS program. Actually, those subsidies from BPHS is not even enough for my telephone and transportation costs. (HCW)* *Without subsidies, the HCWs motivation and working satisfaction is low...they just to complete tasks and will not really care about the quality of TTMS. (CDC leader)*
	Training support to HCWs in PHC sectors: Many HCWs stated that TB trainings lack of adequate professional knowledge and communication skill for TTMS delivery. Both HCWs and leaders mentioned lack of	*2-3 TB trainings each year, from CDC...combined with other (BPHS) trainings...and I think this training is not effective. (HCW)* *It is harder to communicate with MDR-TB patients. Sometimes they seem know more about*

	TB-specific training for HCWs.	*treatment than me. Prolonged illness makes a doctor of a patient. (HCW)*
	Patient's socio-economy: Most HCWs and leaders consistently agreed that most TB patients were old age and living with low socioeconomic status, have high risk to reject TTMS. Due to the long treatment period, the financial burden on MDR-TB patients is particularly heavy, resulting in poor adherence and TTMS difficulty. Some HCWs also stated the hardship to deliver TTMS among migrant patients since hard to reach them.	*During treatment in later period, I didn't (take sputum test), no money, no money for transportation. (DS-TB patient)* *Cannot bear the financial burden... costs of follow-up examinations, CT, and medicines. (MDR-TB patient)* *Because TB itself is a "disease of the poor", most TB patients have financial difficulties with bad lifestyles and poor literacy. (HC leader) Migrant patients are hard to reach...some have no stable work and often change their phone numbers...don't like TTMS. (HCW)* *I told him/her the dangerousness and seriousness of MDR-TB, he/she still didn't keep treatment, only told me: 'no money'. (HCW)*
	Patient's health literacy: Vast majorities of HCWs stated that some patients refused to receive TTMS to manage their nonadherence behaviors due to poor health literacy and weak TB-related awareness.	*I stopped treatment because I felt good about myself. (MDR-TB patient)* *Some (patients) don't prioritize their health and dislike our TTMS...they are aged and less educated...Some have very poor adherence to TB treatment. (HCW)*
External environment	**Health insurance:** All patients stated they still faced financial hardship even with health insurance. Most HCWs and leaders stated that the current health insurance for DS-TB patients cannot cover all medicines and examinations related to side-effect, and it is more inadequate for MDR-TB patients with longer treatment, which added financial burden among poor TB patients and led to hardship for TTMS delivery.	*(After reimbursement,) medicines would cost hundreds, and the costs of CT scans can't be reimbursed. (MDR-TB patient)* *The health insurance of reimbursement of TB treatment is very strict, anti-TB drugs are free, and other liver protection medicines and tests are not. (HC leader)*
	Cross-sectional coordination: Majority HCWs and leaders reported the difficulties to conduct cross-sectional coordination for TTMS delivery, especially coordination from TB designated hospitals. One leaders also stated a poor cross-sectional coordination between PHC sectors with the departments of education, public security, civil affair, and finance for TTMS delivery.	*It is hard to connect with TB designated hospitals' doctors, they are very busy. One patients stopped treatment and said it is doctors' advice...but I cannot confirm. (HCW)* *The department of finance, education, civil affairs, public security, and others， ... they are not highly motivated (to give us support in TTMS program). (CDC leader)*
	Social stigma: TB-related social stigma was mentioned by many HCWs. Urban and young patients with more concerns of privacy issue were more likely to refuse home-visit from HCWs.	*There is one patient, it's impossible to go to his/her home... due to privacy, he/she doesn't like people around know they have TB. (HCW)* *Some TB patients, especially urban and youth patients, don't like us to go to their home for home-visit... (They are) worried about how people around would think of them. (HCW)*
Implementation and Sustainability	**Performance assessment:** All HCWs and some of the leaders stated that the performance assessment for TTMS may exist	*(Performance) assessment is unreasonable, more works you do, more mistakes you make, and this is unfair. There are no rewards when you perform*

infrastructure	irrationality considering heavy workload. And leaders pointed out that this could lead to substandard TTMS, and also hinder HCW's working enthusiastic.	*well...while, any negative feedbacks (such as patients' dissatisfactions with treatment costs) would affect our performance assessment. (HCW) The indexes are quite high (considering HCW's workload). Sometimes, the purpose becomes to complete indexes but not to really care about patients. (CDC leader)*

Note: *TTMS* refers to tuberculosis treatment management service, *TB* refers to tuberculosis, *HCW* refers to healthcare workers, *PHC* refers to primary healthcare, *BPHC* refers to basic primary healthcare, *DS-TB* refers to drug-sensitive tuberculosis, *DOT* refers to directly observed therapy, *MDR-TB* refers to multidrug-resistant TB, *CT* refers to Computed Tomography.

1）Interventions

Current TTMS program was mainly delivered via telephone calls and lacked of sufficient patient-centered manner which led to patient's antipathy to DOT. HCW suggested that e-health approach, including APP would be good choice to deliver TTMS.

2）Recipients:

Most PHC sectors faced insufficient health human resource to deliver TTMS program. Every HCW often undertook more than 2 BPHS programs. HCWs with this heavy work load of BPHS had difficulty to deliver standard TTMS delivery. On the other hand, PHC sectors lacked of transportation tools to facilitate home-visits especially for remote rural TB patients. HCWs in PHC sectors also faced inadequate professional capability, especially village doctors, which led to patients' distrusts and therefore hindered TTMS delivery by those HCWs. On the other hand, PHC sectors lack of sufficient incentive for HCWs in TTMS program, and almost all HCWs unsatisfied with low salary, and subsidy regarding their heavy workload and infection risk of TB. In addition, out-of-pocket expenditure for transportation and telephone charge for TTMS delivery could further influence HCW's working motivation, performance, and attrition. Moreover, inadequate qualified training (the content lack of communication skills and professional knowledge for TTMS delivery, and the training

approach of TB trainings mixed with other BPHS programs and lacking of high quality TB-specific training for HCWs) supports for TB HCWs were also reported by interviewers. So current training could not provide much support in HCWs' capabilities and performance.

In terms of patient characteristics, the majority of interviewers claimed that TB is a disease of the poor and most TB patients were disadvantaged group (aging, low education, migrant and financial difficulty), particular MDR-TB patients with longer treatment period, who had poor TB-related health literacy and had high risk to reject TTMS. HCWs also mentioned the hardship to deliver TTMS among migrant patients due to hard to reach them.

3）External environment:

On the one hand, inadequate health insurance coverage for medicines and tests related to side-effects accentuated financial burden among poor DS-TB patients and the health coverage was more inadequate for MDR-TB patients with longer treatment period, which reduced willingness to receive TTMS. On the other hand, difficulties in cross-sectional coordination to assist TTMS delivery were reported, especially supports from TB designated hospitals and also other departments like departments of public security and education. Furthermore, TB-related social stigma was reported as one of the main barriers to conduct home-visits among urban and young patients who care much privacy and were more likely to refuse to accept home-visits from HCWs.

4）Implementation and sustainability infrastructure:

The performance assessment for TB HCWs might exist irrationality considering their heavy workload. One leader pointed out that to the purpose of TTMS delivery could become to

complete the targeted indicators, and therefore, lead to substandard TTMS to patients. Moreover, inappropriate performance assessment also hinder working motivation and increased working attrition among HCWs to deliver TTMS.

Discussion

In China, HCWs in PHC sectors are considered as an important part of the TB integrated model and taking responsibility for TTMS delivery. This study assessed the delivery of TTMS program by HCWs in PHC sectors in West China. Though we found that the TTMS delivery rates in intensive phase and continuation phase were higher than previous study in West China [15], the standard TTMS (at least 24 times TTMS during their treatment course) delivery rate is far below the required rate of >90% according to the National TB Control Plan [6]. Besides, our study showed that TB patients received DOT from HCW in CHCs (in urban regions) was higher than that from HCW in THCs (in rural regions). This difference might be explained by our qualitative results as interviewed HCWs reported the challenges to delivery TTMS to remote rural patients due to patients' poor health literacy which is also reported in other studies [18, 30], and our study also pointed the far away distance with insufficient transportation tools for HCWs blocked TTMS delivery. In addition, our study revealed that less than half of HCWs provided services of collecting patients' sputum samples during follow-up supervision, which is much lower than the result reports in the study in Guizhou (96.56%) [30]. Furthermore, we found a low level of working satisfaction (22.4%) among TB HCWs, while, it is higher than previous study (12.2%) [31]. Our study results indicated that HCWs with low working satisfaction were more likely to have a low

delivery rate of first-time home visit, DOT, and sputum sample collection services. Efforts should be made to maintain and promote HCWs' working satisfaction to enhance TTMS delivery.

Our study disclosed that the current TTMS delivery was confronted with various barriers, despite that TB HCWs in PHC sectors carried out TTMS program had made many achievements in West China. In the organizational level, we found that the TTMS programs itself existed several barriers for HCWs to delivery services. On the one hand, the national TB action plans and nationwide TB survey in China [2, 9, 32] mentioned the cross-sectional coordination for TTMS delivery, however, we found that HCWs in PHC sectors still lack of well coordination with other departments, such as coordination from department of education to support students treatment management, help from department of public security to trace migrant patients' information. Particularly, HCWs from some PHC sectors faced barriers to access timely connections with TB HCWs from TB designated hospital in addressing TB patients' side effects and treatment adherence. It is difficult to realize the participation of the whole society in TB control in China so far [33]. As the call by the Action Plan to Stop TB (2019 to 2022) in China [2], it is an emergent need to build a multi-sectorial collaboration mechanism led by the National Health Commission (NHC) in order to coordinate cross-sectional efforts to support TB prevention and control program [29].

The second barrier emerged at health organizational level is the approaches to delivery TTMS. We found TTMS were mainly delivered by telephone call, which consistent with previous studies in West China [15, 33], and the insufficient patient-centered manners could

result in patients' rejects to DOT and TTMS by HCWs. Previous study in Indonesia also reported that insufficient patient-centered care was the main treatment barriers for TB patients in high-burden TB settings [34]. Although research showed that home-visits and DOT did lead to positive treatment outcome [35, 36], our study pointed out the need to provide TTMS with e-health approach, which was consistent with previous studies, and previous studies demonstrated the effectiveness of e-health technology for promoting patients' treatment adherence [37-42]. It is deserved to explore internet-based case management model, such as digital supported self-management, and with the help of HCWs in PHC sectors to deliver TTMS to TB patients who live in remote mountain area or against face-to-face DOT.

The third barrier at organizational level is the health human resource for TTMS in PHC sectors. Other studies reported that PHC sectors especial in rural areas had a limited number of HCWs to conduct BPHS programs which led to heavy workload and "shortage of hands" since HCWs often carried out multiple assigned services [43-45]. We consistently found that PHC sectors, particularly in THCs, faced human resource barriers in terms of insufficient number and inadequate professional capability to deliver TTMS program. On the one side, our study showed that heavy workload with multiple BPHS programs could led to hardship to deliver standard TTMS to TB patients. On the other side, we found that inadequate professional capability, especially village doctors, could led to patients' distrusts and hence impeded TTMS delivery. Simultaneously, our study disclosed that PHC sectors lack of adequate TB training for HCWs, particularly training related to communicational and

professional knowledge for TTMS delivery resulted in substandard TTMS. Other studies proved the on-the-job training is important to improve professional skills among HCWs [33, 44, 46, 47], especially trainings emphasized both knowledge and practice [48]. Furthermore, we found that the performance assessment for HCWs in TTMS program may exist irrationality regarding their heavy workload which led to hardship to deliver standard TTMS and hindered their working enthusiastic.

In addition, our results showed that PHC sectors lack of sufficient funding for TTMS program, and most HCWs unsatisfied with low salary, allowance or subsidy which was consistent with other study [30]. Many research also indicated that the diverse issues of financial incentives combined with heavy workload could influence HCW's motivation and performance [44, 49-52]. The appropriate use of incentives for HCWs is a means of promoting health outcomes with a direct impact on the effectiveness and sustainability of a health program, and also able to improve services delivery through enhancing motivation and reducing attrition [48]. Notably, we found that HCWs faced out-of-pocket expenditure for transportations and telephone charges for TTMS delivery which could further impact their work enthusiastic.

Our results also identified barriers at patient level to TTMS delivery included their susceptible socioeconomic characteristics（aging, low education, migrant, and poor financial status） and lower literacy related to TB control. Previous nationwide TB epidemiology survey in China revealed that near half (48.8%) of the TB patients were aged ≥60, less educated, and over 80% of TB patients had household incomes below local levels [18]. Our

results indicated that poor socioeconomic characteristics and low TB-related health literacy together highly impeded TTMS delivery. As patients with low socioeconomic features were often found with lower education background, poor health literacy, and more likely to be have nonadherence, hence, they were more likely to refuse to HCWs' supervision, which is consistent with other studies [18, 53, 54]. In addition, we found that TTMS delivery among migrant patients was challenging for HCWs due to hard to reach. Other studies also reported that migrant patients with frequently movement and low socioeconomic status had relatively poorer TB-related awareness [55-57] which could future hindered TB case management. Previous studies revealed that West China had a higher proportion of rural mountain areas as well as domestic migrants compared with other regions in China, and TB-related awareness among rural, less educated, and migrants was particularly serious [18, 55, 57-59].

Our study also discovered that the health insurance cannot cover all medicines and tests related to side-effects which accentuated financial burden among poor TB patients and led to hardship for TTMS delivery. In order to relief barriers from TB patients, on the one hand, addressing financial burden due to TB treatment among poor patients is crucial. Notwithstanding, previous national TB epidemiology survey in China reported that over 90% of TB patients had medical insurance combined with the policy of free TB diagnosis and treatment, the proportion of out-of-pocket among patients was still around 75.0%-84.2% [18]. Studies and reports mentioned the necessary to increase reimbursement ratio and amount for TB treatment, to expand the scope of current free TB treatment policy, and to strengthen care and assistance for TB patients [2, 6, 36, 60]. Particularly need to target DR-TB and

impoverished patients with transportation, accommodation and nutrition allowance during TTMS delivery to promote TB control outcomes.

On the other hand, promoting TB-related health literacy among patients and enhancing TB-related awareness among the public are urgently necessary. As our study revealed that not only poor TB heath literacy is a barrier from patients, TB-related social stigma also impeded TTMS delivery especially in urban areas. Previous studies suggested to provide easily understandable TB health education to particular target population (the aged, less educated, close contacts, etc.) with certain modes of health education [18, 58]. Other study indicated that a combination of mass media approaches and interpersonal communications between patients and HCWs could lead to more effective TB control [59]. Similarly, Chinese Action Plan to Stop TB called for various publicity activities to raise awareness of TB which includes traditional media such as television broadcasting and newspaper, and also the use of new media such as WeChat applet to promote dissemination of scientific TB knowledge and eliminate social discrimination [2].

Strengthens and limitations

Our study used a mixed research method combining quantitative research (questionnaire survey) with qualitative research (semi-structured, open-ended in-depth interviews) to assess TTMS program delivery by HCWs in PHC sectors. Perspectives from organizations and patients were both included by using the PRISM model to evaluate specific barriers to TTMS delivery. Three levels of the local health organization were all involved in our study, which contained the HCWs as the frontline staffs, the CDC leaders as the managers, and the Health

Commission leaders as the policy makers. However, there are a number of limitations in the current study. First, the sample size of both questionnaire survey and in-depth interviews could be further expanded to enhance the representativeness of study. Second, as we only explore the status of and barriers to TTMS delivery by HCWs in PHC sectors, well-evidenced implementation strategies that able to solve current problems successfully were not able to be provided in this study. Further studies are required to provide more evidence for producing more comprehensive and effective TB control strategies.

Conclusion

All the engagements of HCWs in TTMS program suggests that the government realized the importance of HCWs in PHC sectors in promoting TB patients treatment adherence and outcomes and underscored their integration into the TB control model. We identified barriers operating in organizational level (cross-sectional coordination, patient-centered approach, resources and incentives, training support, reimbursement issue, and performance assessment) and patient level (socioeconomic characteristics, health literacy and social stigma) to TTMS delivery by HCWs in PHC sectors. There is an urgent need to identify comprehensive measures to effectively overcome barriers to TTMS delivery and further promote TB control in Southwest China.

Acknowledgements We would like to thank the participants who responded our questionnaires. We also thank all leaders and healthcare workers in the PHCs in study places who supported this study by facilitating implementation of the field questionnaire survey and participated in our interviews.

Contributions JZ, JP and YL have designed this survey, JZ, JP, GW, WX, TZ, SL and QW

have collected data, JZ, JP, RZ, YC and JL have managed and analyzed data, YL and DH have controlled the quality of data collection and analysis, JZ has drafted the manuscript. YL has edited the manuscript. All authors have interpreted the results, revised the report and completed the final version. The author(s) read and approved the final manuscript.

Funding The study was funded by the National Natural Science Foundation of China (No.81773489), the Chongqing outstanding youth project (No.cstc2020jcyj-jq0035), Social Science and Technology Innovation Subject in Chongqing (No.cstc2015shmszx120070).

Disclaimer The funders had no role in study design, data collection and analysis, interpretation of the data, writing the paper and the decision to submit the paper for publication.

Competing interests Not declared

Patient consent Obtained.

Ethics approval Ethics approval was obtained from the Institutional Review Board of Army Medical University (Third Military Medical University), Chongqing, China (No.AF/SC-08/1.0) before starting the study. This study was conducted in accordance with the Declaration of Helsinki. A full explanation of the purpose and procedure of the study was provided to participants prior to obtain their written informed consent. All demographic data and quotes used in this study were deidentified to maintain the anonymity of participants.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

References:

[1].World Health Organization. Global tuberculosis report 2021. Geneva: World Health Organization; 2021. Licence: CC BY-NC-SA 3.0 IGO

[2].National Health Commission. Stop TB Action Plan (2019-2022). 2019. Available: http://www.nhc.gov.cn/jkj/s3589/201906/b30ae2842c5e4c9ea2f9d5557ad4b95f.shtml. [Accessed 11 Feb 2022].

[3]. Li T, Du X, Liu X, Li Y, Zhao Y. Implementation Performance of Tuberculosis Control in China: 2011-2020. *China CDC Wkly*. 2021 Mar 19;3(12):252-255.

[4].World Health Organization: Treatment of tuberculosis: Guidelines for national programmes (4thedition), 2010. Available: https://www.ncbi.nlm.nih.gov/books/NBK138748/pdf/Bookshelf_NBK138748.pdf. [Accessed 11 Feb 2022].

[5].Ministry of Health of the People's Republic of China. National tuberculosis control programme (2011-2015). 2011. National Health Commission. Stop TB Action Plan (2019-2022). 2019. Available: http://www.gov.cn/gongbao/content/2011/content_2020914.htm. [Accessed 11 Feb 2022].

[6].General Office of the State Council of the People's Republic of China. The 13th five-year plan for the prevention and control of tuberculosis. 2017. Available: http://www.gov.cn/zhengce/content/2017-02/16/content_5168491.htm. [Accessed 11 Feb 2022].

[7].National Health Commission of the People's Republic of China. National basic public health service standard (3rd edition). 2017. Available:http://www.nhc.gov.cn/jws/s3578/201703/d20c37e23e1f4c7db7b8e25f34473e1b.shtml. [Accessed 11 Feb 2022].

[8].Chen YF. Discussion on the effect of the integrated tuberculosis prevention and control model in Dongxiang County. *Foreign Medical science section of medgeograpgy*, 2014; 35 (3).

[9].Chen XJ, Feng ZC. Analysis of the implementation effect of the integrated tuberculosis prevention and control model in Wuhan. *Medicine and society*. 2014;27(2):62–4.

[10].Wu XD. The impact of community supervisors' supervision and management visits on the rate and curative effect of non-hospital pulmonary tuberculosis patients. *World Latest Medicine*

Information. 2018;18(90):210.

[11]. Zhang SN, Yuan ZA, Mei J, et al. The effectiveness of the new TB control network in Shanghai. *Chin J Antituberc.* 2007;29(1):74–7.

[12]. Wang XY. Evaluation on effectiveness of the new trinity TB control network in Wujin District of Changzhou. *Jiangsu J Prev Med.* 2013;24(5):18–20.

[13]. Jing GQ, Qian QW, Ding TD. The effects of tuberculosis prevention and control using the integrated mode in Bengbu. *Anhui J Prev Med*. 2012;18(6): 425–6.

[14]. Xie MF, Lai SF, Lian ST. Analysis on the effect of integrated tuberculosis control mode, Wuping county. *Prev Med Trib.* 2018;24(1):76–8

[15]. Pu J, Chen W, Jiang WX, et al. Is tuberculosis patients management improved in the integrated TB control model in West China? A survey in Guizhou Province, China. *Infect Dis Poverty.* 2019 Jul 2;8(1):55.

[16]. Li Y, Ehiri J, Oren E, et al. Are we doing enough to stem the tide of acquired MDR-TB in countries with high TB burden? Results of a mixed method study in Chongqing, China. *PLoS One.* 2014 Feb 5; 9 (2):e88330.

[17]. Fetters MD, Curry LA, Creswell JW. Achieving integration in mixed methods designs-principles and practices. *Health Serv Res.* 2013;48:2134 – 56.

[18]. Yu Wang. The fifth national tuberculosis epidemiological sampling survey. *Beijing: Military Medical Science Press*. 2011.10

[19]. Chongqing Statistics Bureau. Chongqing Statistical Yearbook 2021. (2021). Available: http://tjj.cq.gov.cn/cqtjj2021/indexch.htm. [Accessed 11 Feb 2022].

[20]. Q Wang, T Li, X Du, et al. Analysis in the incidence of national tuberculosis reports from 2015-2019. *Chinese Journal of Antituberculosis.* 2021; 43(02):107-112.

[21]. Guizhou Statistics Bureau. Guizhou Statistical Yearbook 2021. (2021). Available: http://hgk.guizhou.gov.cn/publish/tj/2021/zk/indexch.ht. [Accessed 11 Feb 2022].

[22]. National Bureau of Statistics. China Statistical Year book: China Statistics Press. 2018. Available: http://www.stats.gov.cn/tjsj/ndsj/2018/indexch.htm. [Accessed 11 Feb 2022].

[23]. Bolarinwa OA. Sample size estimation for health and social science researchers: The principles and considerations for different study designs. *Niger Postgrad Med J*. 2020 Apr-Jun;27(2):67-75.

[24]. Saunders B, Sim J, Kingstone T, Baker S, Waterfield J, Bartlam B, et al. Saturation in qualitative research: exploring its conceptualization and operationalization. *Qual Quant*. 2018;52(4):1893-1907.

[25]. Feldstein, A.C, R.E. Glasgow. A practical, robust implementation and sustainability model (PRISM) for integrating research findings into practice. *Jt Comm J Qual Patient Saf*. 2008; 34(4): p. 228-43.

[26]. Liles, E.G, et al. Implementation challenges and successes of a population-based colorectal cancer screening program: a qualitative study of stakeholder perspectives. *Implementation*

Science. 2015; 10(1).

[27]. Schneider, J.L, et al Stakeholder perspectives on implementing a universal Lynch syndrome screening program: a qualitative study of early barriers and facilitators. *Genetics in Medicine.* 2016; 18(2): p. 152-161.

[28]. Smith J, Firth J. Qualitative data analysis: the framework approach. *Nurse Researcher*. 2011; 18(2): 52–62.

[29]. Ward DJ, Furber C, Tierney S, Swallow V. Using Framework Analysis in nursing research: A worked example. *J Adv Nurs*. 2013; 69(11): 2423–31.

[30]. YY He, JL Li, W Chen, L Luo, Y Shang, JH Xu. Analysis on the implementation of basic public health tuberculosis service items in Guizhou Province. *Studies of Trace Elements and Health.* 2020; 37(02):54-57.

[31]. Gaspar LMDS, Braga C, Albuquerque GDM, Silva MPN, Maruza M, Montarroyos UR, et al. Knowledge, attitudes and practices of community health agents regarding pulmonary tuberculosis in a capital city in northeastern Brazil. *Cien Saude Colet*. 2019; 26;24(10):3815-3824.

[32]. Hui Z, Xiaoqiu L, Caihong X, Dongmei H, Xue L, Tao L, et al. Guiding Tuberculosis Control Through the Healthy China Initiative 2019−2030. *China CDC Weekly*. 2020, 2(49): 948-950.

[33]. Liu GH, Deng J, Chen W. Investigation on the status of needs on community doctors for tuberculosis management in Guizhou Province. *China Health Industry.* 2019;16(21):11-13.

[34]. Pradipta IS, Idrus LR, Probandari A, Lestari BW, Diantini A, Alffenaar JC, Hak E. Barriers and strategies to successful tuberculosis treatment in a high-burden tuberculosis setting: a qualitative study from the patient's perspective. *BMC Public Health.* 2021 Oct 21;21(1):1903.

[35]. Xu L, Gai R, Wang X, Liu Z, Cheng J, Zhou C, Liu J, Zhang H, Li H, Tang W. Socio-economic factors affecting the success of tuberculosis treatment in six counties of Shandong Province China. *The International Journal of Tuberculosis and Lung Disease.* 2010;14(4):440–6.

[36]. Noé A, Ribeiro RM, Anselmo R, et al. Knowledge, attitudes and practices regarding tuberculosis care among health workers in Southern Mozambique. *BMC Pulm Med*. 2017 Jan 5;17(1):2.

[37]. Chongqing tuberculosis dispensary. Implementation plan of the Chongqing Stop Tuberculosis Action (2019-2022). 2020. Available: http://www.cqtb.org/html/zcfg/20/01/1121.html. [Accessed 11 Feb 2022].

[38]. Zhang H, Liu JJ. The overview and prospect of tuberculosis control in China since the founding of the Peoples Republic of China. *Chin J Antituberc.* 2019; 41(9):913 − 6.

[39]. Liu X, Lewis JJ, Zhang H, et al. Effectiveness of Electronic Reminders to Improve Medication Adherence in Tuberculosis Patients: A Cluster-Randomised Trial. *PLoS Med.* 2015 Sep 15; 12 (9):e1001876.

[40]. 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 Jul 3;15 (7):e1002595.

[41]. Nhavoto JA, Grönlund Å, Klein GO. Mobile health treatment support intervention for HIV and tuberculosis in Mozambique: Perspectives of patients and healthcare workers. *PLoS One*. 2017 Apr 18;12(4):e0176051.

[42]. Wang N, Zhang H, Zhou Y, et al. Using electronic medication monitoring to guide differential management of tuberculosis patients at the community level in China. *BMC Infect Dis*. 2019 Oct 15;19(1):844.

[43]. Huang et al. Global Health Research and Policy. 2018. (3):18. Available: https://doi.org/10.1186/s41256-018-0072-0. [Accessed 11 Feb 2022].

[44]. Tao T, Zhao Q, Jiang S, et al. Motivating health workers for the provision of directly observed treatment to TB patients in rural China: does cash incentive work? A qualitative study. *Int J Health Plann Manag*. 2013;28(4):e310–24.

[45]. Liang S, Deng H, Liu S, et al. Competency building for lay health workers is an intangible force driving basic public health services in Southwest China. *BMC Health Serv Res*. 2019 Aug 23;19(1):596.

[46]. Edwards NC, Roelofs SM. Sustainability: The elusive dimension of international health projects. Can J Public Health. 2006;97:45–9. Available: http://www.jstor.org/stable/41994677. [Accessed 11 Feb 2022].

[47]. Li N, Yan LL, Niu W, et al. The effects of a community-based sodium reduction program in rural China–a clusterrandomized trial. *PLoS One*. 2016;11(12):e0166620..

[48]. World Health Organization. WHO guideline on health policy and system support to optimize healyhcare worker programmes. Geneva: World Health Organization. 2018.

[49]. Campbell C, Scott K. Retreat from Alma Ata? The WHOs report on task shifting to healyhcare workers for AIDS care in poor countries. *Glob Public Health*. 2011;6 (2):125–38.

[50]. Jaskiewicz W, Tulenko K. Increasing healyhcare worker productivity and effectiveness: a review of the influence of the work environment. *Hum Resour Health*. 2012; 10 (1):1.

[51]. Hemminki E, Long Q, Zhang W-H, et al. Impact of financial and educational interventions on maternity care: results of cluster randomized trials in rural China, CHIMACA. *Matern Child Health J*. 2013; 17 (2):208–21.

[52]. Meng Q, Li R, Cheng G, et al. Provision and financial burden of TB services in a financially decentralized system: a case study from Shandong, China. *Int J Health Plann Manag*. 2004;19(S1):S45–62.

[53]. Hutchison C, Khan MS, Yoong J, et al. Financial barriers and coping strategies: a qualitative study of accessing multidrug-resistant tuberculosis and tuberculosis care in Yunnan, China. *BMC Public Health*. 2017 Feb 22;17(1):221.

[54]. Onah CK, Azuogu BN, Ossai EN, et al. Addressing constraints to informal providers' involvement in tuberculosis control: a qualitative study of patent medicine dealers and

tuberculosis programme managers. *Glob Health Res Policy*. 2021 Nov 8;6(1):43.

[55]. Wang SN, Deng YH, Shi YY, et al. Investigation on knowledge of tuberculosis prevention and treatment among floating population tuberculosis patients in Putuo District, Shanghai. *Health Education and Promotion*.2020,15(06):636-638.

[56]. Ma Y, Liu YH, Du J, et al. Survey on awareness of core information of tuberculosis prevention and control knowledge in pulmonary tuberculosis patients. *Chinese Anti-tuberculosis Journal.* 2015 (10).

[57]. Zou X, Zhou L, Wu H, et al. The role of tuberculosis control institutes in delivering tuberculosis information to domestic migrants in China: A multi-level analysis of a nationwide cross-sectional survey. *Int J Infect Dis.* 2019; 86:94-101.

[58]. Chen W, Li Y, Yang H, et al. Is tuberculosis health education reaching the public in China? A cross-sectional survey in Guizhou Province. *BMJ Open*. 2016; 6(9):e013534.

[59]. Arulchelvan S, Elangovan R. Effective communication approaches in tuberculosis control: Health workers' perceptions and experiences. *Indian J Tuberc.* 2017;64(4):318-322.

[60]. Rawal LB, Kanda K, Biswas T, et al. Health problems and utilization of health services among Forcibly Displaced Myanmar Nationals in Bangladesh. *Glob Health Res Policy.* 2021 Oct 11;6(1):39.

Figure legends

Figure 1 Adapted PRISM for barriers on TTMS delivery in PHC sectors. This figure presents the four core domains of the Practical Robust Implementation and Sustainability Model (PRISM) for barriers on TTMS delivery in PHC sectors, including: 1) TTMS program design; 2) the recipients, 3) the external environment, and 4) the implementation and sustainability infrastructure. Activated elements for each domains were presented in boxes. Notes: *TTMS* refers to tuberculosis treatment management service; *PHC* refers to primary healthcare; *HCW* refers to healthcare worker).

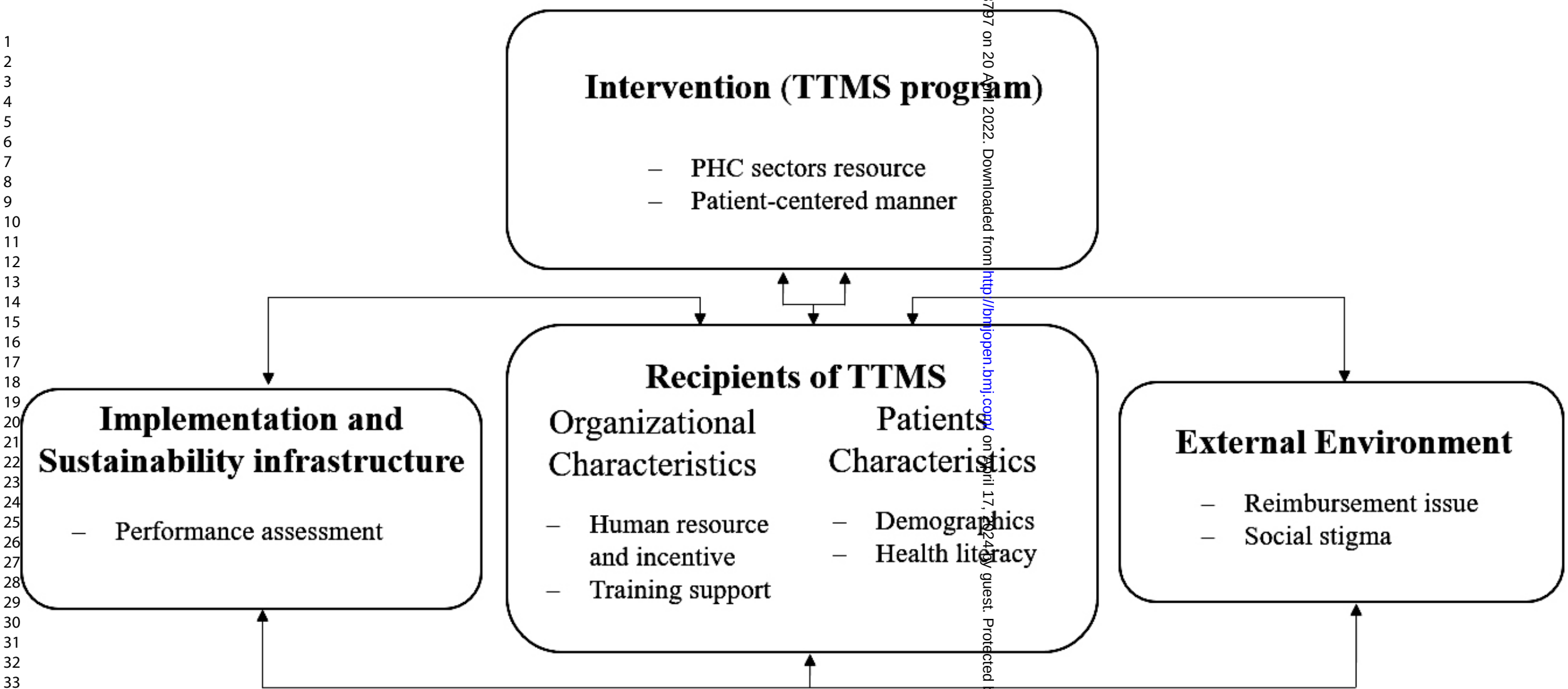

Figure 1: Adapted PRISM for barriers on TTMS delivery in PHC sectors

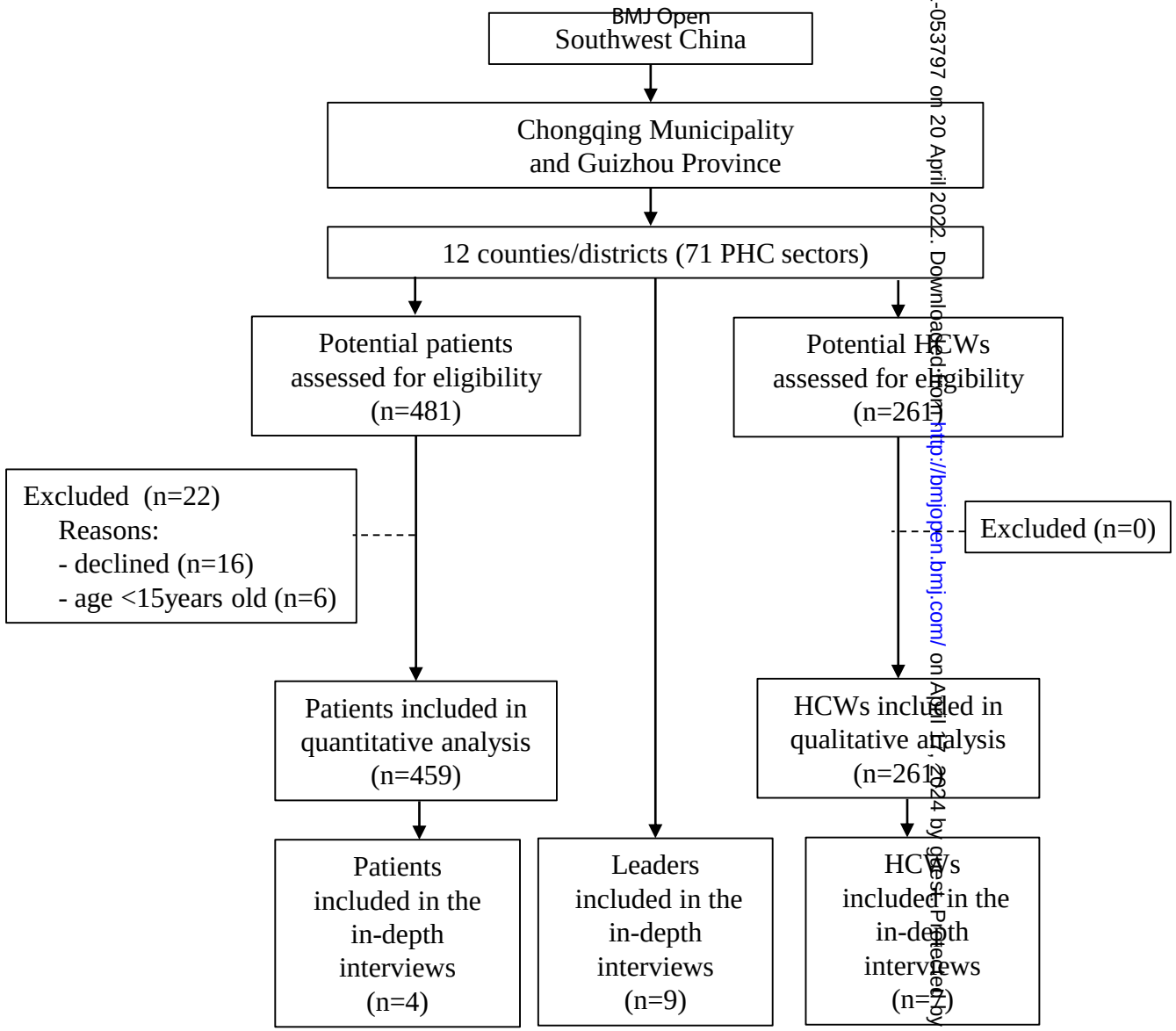

Figure: the flow diagram of the participant recruitment

Appendix 1: Chi-square test results

Factors associated with TTMS with lower delivery rate

Variable	Patients' peer supervision establish (n=235)		Train patient to use smart tools to assist TTMS (n=236)		Intensive phase DOT (n=236)		Continuation phase DOT (n=236)		Regular medicine delivery (n=234)		Sputum sample collection (n=236)	
	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)
Gender		0.025*		0.429		0.370		0.867		0.033*		0.760
Female	115(74.7)		88(57.1)		81(52.6)		81(52.6)		97(63.0)		68(44.2)	
Male	69(87.3)		50(62.5)		47(58.8)		43(53.8)		62(77.5)		37(46.3)	
Age		0.23		0.496		0.023*		0.478		0.261		0.950
20-29	73(83.9)		47(53.4)		55(61.8)		51(57.3)		63(70.8)		40(44.9)	
30-39	60(78.9)		46(60.5)		37(49.3)		36(48.0)		46(61.3)		31(41.9)	
40-50	33(68.8)		28(58.3)		19(43.2)		24(50.0)		35(74.5)		22(44.9)	
>50	9(75.0)		9(75.0)		13(81.3)		8(66.7)		10(83.3)		6(50.0)	
Education		0.927		0.607		0.123		0.247		0.815		0.139
Technical secondary school and below	40(76.9)		33(64.7)		27(51.9)		25(48.1)		36(70.6)		25(49.0)	
College	112(79.4)		81(57.0)		84(59.2)		81(57.0)		94(66.7)		67(47.2)	
University and above	32(78.0)		24(57.1)		17(41.5)		18(43.9)		29(70.7)		13(31.0)	
Regions		0.468		0.323		0.367		0.399		0.360		0.820
Relatively developed	54(77.1)		47(66.2)		37(53.6)		38(55.1)		46(67.6)		32(45.1)	
Medium developed	66(75.9)		48(55.2)		53(60.2)		50(56.8)		64(73.6)		41(47.1)	
Less developed	65(83.3)		44(65.4)		39(49.4)		37(46.8)		50(63.3)		33(42.3)	
Primary Health Sector Type		0.044*		0.529		0.574		0.586		0.386		0.607
Township health center	141(82.0)		104(60.1)		97(55.7)		94(54.0)		121(69.9)		79(45.9)	
Community health center	44(69.8)		35(55.6)		32(51.6)		31(50.0)		39(63.9)		27(42.2)	
Professional Title		0.317		0.591		0.010*		0.036*		0.801		0.019*
Non	67(82.7)		46(56.8)		37(45.7)		36(44.4)		52(64.2)		30(37.0)	
Junior	82(78.8)		65(62.5)		70(66.7)		67(63.8)		73(70.2)		58(55.8)	
Intermediate	19(67.9)		15(53.6)		12(42.9)		13(46.4)		17(63.0)		9(32.1)	
Deputy senior	2(66.7)		1(33.3)		2(66.7)		2(66.7)		2(66.7)		1(33.3)	
Times of training received in the past six month		0.299		0.007*		0.147		0.214		0.963		0.022*
0	11(91.7)		10(83.3)		8(66.7)		8(66.7)		8(72.7)		7(58.3)	
1	37(78.7)		28(57.1)		22(44.9)		21(42.9)		34(69.4)		20(41.7)	
2	93(76.2)		68(56.2)		63(51.6)		62(50.8)		82(67.8)		46(37.4)	
3	31(88.6)		27(77.1)		23(67.6)		22(64.7)		22(64.7)		23(67.6)	
>3	13(68.4)		6(31.6)		13(68.4)		12(63.2)		14(73.7)		10(52.6)	
Working satisfaction		0.000*		0.042*		0.016*		0.012*		0.008*		0.027*
Dissatisfied	32(68.1)		27(56.3)		20(43.5)		20(43.5)		30(66.7)		19（40.4）	
General	26(60.5)		20(45.5)		19(43.2)		17(38.6)		22(50.0)		14（31.8）	
Satisfied	76(85.4)		51(57.3)		52(57.8)		51(56.7)		64(71.9)		39（43.8）	

Very satisfied	50(92.6)	39(73.6)	38(70.4)	37(68.5)	44(81.5)	33(61.1）

Note: *p<0.05, TTMS refers to tuberculosis treatment management service, DOT refers to directly observed therapy, MDR-TB refers to multi-drug resistance tuberculosis, Lower delivery rate refers to a rate below 90%, DOT refers to directly observed therapy

Factors associated with TTMS with lower delivery rate (Continue)

Variable	Providing food or transport assistances for poor TB patient (n=230)		Providing DOT for migrant TB patient at their convenient time (n=235)		Providing subsistence allowance or psychological support for migrant patient (n=236)		Providing injection treatment for MDR-TB patient (n=234)		Providing supervision for newly released prison patient (n=236)		Referring TB patient with mental/psychological problems or alcohol/drug addiction (n=235)		Training cured TB patients to provide peer education (n=237)		Establishing platform for TB patients communication (n=237)	
	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)
Gender		0.215		0.153		0.313		0.274		0.669		0.431		0.957		0.845
Female	40(51.3)		72(91.1)		36(45.0)		37(46.3)		46(57.5)		59(74.7)		70(87.5)		47(58.8)	
Male	64(42.7)		130(84.4)		80(51.9)		59(38.8)		93(60.4)		122(79.2)		136(87.7)		89(57.4)	
Age		0.174		0.573		0.243		0.561		0.408		0.242		0.016*		0.783
<30	43(49.4)		74(83.1)		50(56.8)		37(42.5)		57(64.0)		71(79.8)		84(94.4)		55(61.8)	
30-39	26(35.1)		65(86.7)		32(42.1)		26(34.2)		40(52.6)		56(73.7)		61(80.3)		42(55.3)	
40-50	25(53.2)		44(91.7)		22(45.8)		21(43.8)		26(54.2)		39(83.0)		44(91.7)		28(58.3)	
>50	6(50.0)		10(83.3)		7(58.3)		6(50.0)		8(66.7)		7(58.3)		9(75.0)		6(50.0)	
Education		0.847		0.526		0.352		0.198		0.073		0.189		0.136		0.194
Technical secondary school and below	22(44.0)		45(88.2)		23(44.2)		23(45.1)		35(68.6)		43(84.3)		47(90.4)		32(61.5)	
College	64(46.4)		123(87.2)		75(53.2)		60(42.9)		84(59.2)		110(77.5)		127(89.4)		85(59.9)	
University and above	17(41.5)		34(81.0)		18(42.9)		12(28.6)		19(45.2)		28(68.3)		33(78.6)		19(45.2)	
Regions		0.277		0.327		0.104		0.613		0.299		0.343		0.048		0.737
Relatively developed	28(40.6)		63(90.0)		36(50.7)		31(44.3)		44(62.9)		56(80.0)		57(80.3)		39(54.9)	
Medium developed	36(42.4)		77(87.5)		49(57.0)		36(42.4)		54(62.1)		70(80.5)		81(93.1)		53(60.9)	
Less developed	40(52.6)		63(81.8)		32(40.5)		29(36.7)		41(51.9)		56(71.8)		70(88.6)		45(57.0)	

Primary Health Sector Type		0.885		0.498		0.613		0.394		0.127		0.528		0.157		0.768
Township health center	76(45.5)		147(85.5)		87(50.6)		73(42.7)		107(61.8)		135(78.5)		115(89.6)		101(58.4)	
Community health center	28(44.4)		56(88.9)		30(46.9)		23(36.5)		32(50.8)		47(74.6)		53(82.8)		36(56.3)	
Professional Title		0.438		0.327		0.038*		0.004*		0.043*		0.870		0.683		0.789
Non	35(43.8)		67(82.7)		44(62.0)		23(28.4)		47(58.0)		61(76.3)		71(87.7)		43(53.1)	
Junior	50(50.0)		92(89.3)		26(47.3)		55(53.4)		68(64.8)		80(76.2)		94(88.7)		64(60.4)	
Intermediate	9(33.3)		22(78.6)		16(53.3)		9(33.3)		10(37.0)		22(81.5)		22(81.5)		16(59.3)	
Deputy senior	1(33.3)		3(100.0)		31(38.8)		1(33.3)		1(33.3)		2(66.7)		3(100.0)		2(66.7)	
Times of training received in the past six month		0.256		0.579		0.497		0.001*		0.022*		0.140		0.788		0.099
0	6(54.5)		9(81.8)		7(58.3)		6(54.5)		8(72.7)		11(100.0)		10(83.3)		6(50.0)	
1	21(43.8)		41(83.7)		23(46.9)		15(3.5)		22(44.9)		36(73.5)		42(85.7)		30(61.2)	
2	46(39.3)		103(85.1)		55(45.5)		42(35.0)		70(57.4)		90(74.4)		106(86.9)		63(51.6)	
3	20(57.1)		33(94.3)		21(60.0)		25(71.4)		28(80.0)		31(88.6)		32(91.4)		27(77.1)	
>3	11(57.9)		17(89.5)		11(57.9)		8(42.1)		11(57.9)		14(73.7)		18(94.7)		11(57.9)	
Working satisfaction		0.094		0.027*		0.115		0.263		0.452		0.021*		0.114		0.054
Dissatisfied	19(40.4)		38(80.9)		18(37.5)		16(34.0)		24(51.1)		34（72.3）		40(83.3)		24(50.0)	
General	15(35.7)		33(76.7)		23(52.3)		16(36.4)		25(56.8)		28（63.6）		36(81.8)		21(47.7)	
Satisfied	68(43.7)		78(87.6)		42(47.7)		35(40.2)		53(59.6)		70（79.5）		25(50.0)		52(58.4)	
Very satisfied	31(59.6)		52(96.3)		33(61.1)		28(51.9)		36(66.7)		48（88.9）		52(96.3)		39(72.2)	

Note: *p<0.05, TTMS refers to tuberculosis treatment management service, DOT refers to directly observed therapy, MDR-TB refers to multi-drug resistance tuberculosis, Lower delivery rate refers to a rate below 90%, DOT refers to directly observed therapy

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	8，9
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8，9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	10，11
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	10
		(*e*) Describe any sensitivity analyses	10
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11,12
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11,12
		(b) Indicate number of participants with missing data for each variable of interest	11,12
Outcome data	15*	Report numbers of outcome events or summary measures	12-15
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	16-20
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	21
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	21
Generalisability	21	Discuss the generalisability (external validity) of the study results	21
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	22

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Tuberculosis treatment management in primary healthcare sectors: a mixed-methods study investigating delivery status and barriers from organizational and patient perspectives

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-053797.R2
Article Type:	Original research
Date Submitted by the Author:	28-Mar-2022
Complete List of Authors:	Zhou, Jiani; Army Medical University, Department of Social Medicine and Health Service Management Pu, Jie; Army Medical University, Department of Social Medicine and Health Service Management Wang, Qingya; Chongqing institute of Tuberculosis prevention and Treatment, Department of districts and counties Zhang, Rui; Army Medical University, Department of Social Medicine and Health Service Management Liu, Shili; Army Medical University, Department of Social Medicine and Health Service Management Wang, Geng; Army Medical University, Department of Social Medicine and Health Service Management Zhang, Ting; Chongqing Institute of Tuberculosis Prevention and Treatment, Department of districts and counties Chen, Yong; Army Medical University, Department of Social Medicine and Health Service Management Xing, Wei; Army Medical University, Department of Social Medicine and Health Service Management Liu, Jiaqing; Army Medical University, Department of Social Medicine and Health Service Management Hu, Daiyu; Chongqing Institute of Tuberculosis Prevention and Treatment, Department of districts and counties Li, Ying; Army Medical University, Department of Social Medicine and Health Service Management
Primary Subject Heading:	Health services research
Secondary Subject Heading:	Health services research, Infectious diseases
Keywords:	Tuberculosis < INFECTIOUS DISEASES, PRIMARY CARE, HEALTH SERVICES ADMINISTRATION & MANAGEMENT

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Tuberculosis treatment management in primary health care sectors: a mixed-methods study investigating delivery status and barriers from organizational and patient perspectives

Jiani Zhou[1], Jie Pu[1], Qingya Wang[2], Rui Zhang[1], Shili Liu[1], Geng Wang[1], Ting Zhang[2], Yong Chen[1], Wei Xing[1], Jiaqing Liu[1], Daiyu Hu[2§], YingLi[1§]

[1] Department of Social Medicine and Health Service Management, Army Medical University (Third Military Medical University), Chongqing, China.

[2] Department of districts and counties, Chongqing Institute of TB Prevention and Treatment, Jiulongpo District, Chongqing, China.

[§] Correspondence: Daiyu Hu, Chongqing Institute of TB Prevention and Treatment, Jiulongpo District, Chongqing, China (E-mail:hukaixiu@263.com); Ying Li, Department of Social Medicine and Health Service Management, Army Medical University (Third Military Medical University), China (E-mail:lilyliying2012@163.com).

ABSTRACT

Objective Tuberculosis (TB) treatment management services (TTMSs) are crucial for improving patient treatment adherence. Under the TB integrated control model in China, healthcare workers (HCWs) in the primary healthcare (PHC) sectors are responsible for TTMS delivery. This mixed method study aimed to explore the status of and barriers to TTMS delivery faced by HCWs in PHC sectors from the health organizational and patient perspectives.

Design We completed a questionnaire survey of 261 TB HCWs and 459 TB patients in the PHC sector and conducted 20 semi-structured interviews with health organizational leaders, TB HCWs, and TB patients. SPSS 22.0 and the framework approach were used for data analysis.

Setting Primary healthcare sectors in Southwest China.

Results Our results showed that TTMS delivery rate by HCWs in PHC sectors was <90% (88.4%) on average, and the delivery rates of intensive and continuation phase DOT (directly observed therapy) were only 54.7% and 53.0%, respectively. HCWs with high work satisfaction and junior titles were more likely to deliver first-time home visits and DOT services. Our results suggest that barriers to TTMS delivery at the organizational level include limited patient-centered approaches, inadequate resources and incentives, insufficient training, poor cross-sectional coordination, and strict performance assessment. At the patient level, barriers include low socioeconomic status, poor health literacy, and TB-related social stigma.

Conclusion: TTMSs in Southwest China still need further improvement, and this study highlighted specific barriers to TTMS delivery in the PHC sector. Comprehensive measures

are urgently needed to address these barriers at the organizational and patient levels to promote TB control in southwest China.

Key words: tuberculosis, treatment management, healthcare worker, primary healthcare

Strengths and limitations of this study

- This is a mixed method study on accessing the status of and barriers to tuberculosis treatment management service (TTMS) delivery by healthcare workers (HCWs) in the primary healthcare sectors (PHC) of Southwest China.
- This study collected perspectives from organizations and patients and used the PRISM model to evaluate specific barriers to TTMS delivery.
- We collected 720 questionnaires from HCWs and patients and conducted 20 interviews with leaders, HCWs, and patients in a total of 71 PHC sectors.
- Further studies are required to provide more evidence for producing more effective TB control strategies, as well-evidenced implementation strategies that can address current barriers in TTMS delivery could not be provided in this study.

INTRODUCTION

Tuberculosis (TB) is a leading cause of death worldwide.[1] According to the World Health Organization (WHO) global TB report 2021, there was a large global drop in the number of newly diagnosed TB cases (fall from 7.1 million in 2019 to 5.8 million in 2020).[1] However, the most immediate consequence of this large drop is an increase in the number of deaths from TB in 2020 (from an estimated 1.2 million deaths among HIV-negative people in 2019 to an estimated 1.3 million in 2020).[1] The Chinese government pays great attention to addressing the TB epidemic and aims to reduce the incidence of TB to less than 55/100,000 by 2022 and maintain a low mortality rate below 3/100,000 population.[2, 3] Although TB case notification in China has decreased from 70.6/100,000 population in 2012 to 58/100,000 population in 2019, with a treatment success rate above 90%,[1, 2] China is listed as high-burden country with TB, HIV-associated TB, and multidrug/rifampicin-resistant TB (MDR/RR-TB) for 2021–2025 in the WHO global TB report 2021.[1]

The goal of China's latest Action Plan to Stop TB (2019–2022) is to reduce the incidence of TB nationwide to less than 55/100,000 population by 2022 and maintain a low mortality rate below 3/100,000 population.[2] To accomplish this goal, TB prevention and control programs have been further improved with enhanced service capacity, strengthening the prevention and control measures for key populations and key areas, advancing standardized diagnosis and treatment coverage, and increasing the public awareness level of tuberculosis prevention and control.[2] Patient adherence to anti-TB treatment plays an important role in curing and avoiding DR-TB (drug-resistant TB); hence, treatment management is essential for TB patients to ensure

treatment adherence, monitor adverse side effects from treatment, and avoid the development of DR-TB.[4] Since the Chinese National 12th Five-Year TB Control Plan (2011–2015) came out in 2011, the TB control model in China has started using the integrated TB control model in most regions.[5] Under the integrated TB control model, the Centers of Disease Control (CDCs) are responsible for TB program governance, surveillance, training, and health promotion; TB-designated hospitals are responsible for diagnosis and treatment; and primary healthcare (PHC) sectors are responsible for referrals, tracing, health education, and TB treatment management services (TTMS).[5] Later, China's National 13th Five-Year TB Control Plan (2016–2020) combined with the Action Plan to Stop TB (2019–2022) requested further strengthening of TB prevention and control, which emphasized TTMSs and strengthened the implementation of various measures to reduce the TB epidemic in China.[2, 6] TTMSs are one of the key BPHS (basic public health services) programs available to all residents in China (one of the priorities of the new health reform launched in 2009) and is delivered by TB HCWs in the PHC sector.[6, 7] The BPHS guidelines aimed to raise standard TTMS rates and treatment success rates to above 90%.[6, 7] The TTMSs for diagnosed TB patients is delivered by HCWs in the PHC sector, under the supervision of the CDC, with coordination from other departments, such as assistance from the TB-designated hospital to deal with patient side effects and support from the Department of Education to conduct health education in the student population.[7]

A study in Jiangxi indicated that TTMS under an integrated TB control model improved treatment outcomes.[8] A study in Wuhan indicated that TTMSs are crucial for monitoring treatment complications and reducing the development of DR-TB.[9, 10] Other studies have

shown that, in more developed areas in China, TTMS coverage was highly improved and produced impressive effects.[8, 9, 11-14] Few studies have reported the status of TTMS delivery in resource-limited and mountainous regions with a high TB/DR-TB burden in China. One study found that only 37.1% of TB patients received TTMSs from HCWs in West China,[15] and study in Chongqing found that 34.3% of TB patients never received TTMSs from HCWs.[16] However, few studies have focused on the perspective of HCWs to evaluate the current TTMS program under the integrated TB control model. Therefore, this study not only aimed to assess the delivery status of the TTMS program from the perspectives of both organizations and patients, but also to explore the specific barriers to TTMS delivery faced by HCWs in PHC sectors in order to provide evidence for promoting TB control and treatment outcomes.

METHODS

Study design

This cross-sectional study used mixed research methods[17] to collect data from June to December 2018. Questionnaire surveys and semi-structured in-depth interviews were conducted to evaluate the delivery of TTMSs in the PHC sector from both health organizations (HCWs and leaders) and patients' perspectives.

Study Setting

The prevalence of TB in the western region is significantly higher than that in the central and eastern regions of China.[18] Chongqing Municipality is located at the junction of the Yangtze and Jialing rivers, and it has a population of 32.09 million.[19] This region has a relatively developed socioeconomic status, with a gross domestic product (GDP) of 2.5 trillion CNY and

a per capita GDP of 55.6 thousand CNY in 2020.19 Chongqing's growing population depends more on secondary and tertiary industries as the main economic activity.[19] Its urbanization rate and literacy rates were 69.5% and 98.4% respectively in 2021.[19] The TB incidence in Chongqing Municipality (2019) ranks tenth (75/100,000) in China.[20]

Guizhou Province is a mountainous province in West China with a population of 38.6 million.[21] A total of 50.9% of its population depends on tertiary industries as the main source of income.[21] The employment rate and literacy rates were 49.0% and 93.3% respectively in 2020.[21] The area maintains a relatively less developed socioeconomic status, with a GDP of 1.8 trillion CNY and a per capita GDP of 46.3 thousand CNY in 2020.[21] The incidence of TB in Guizhou Province (2019) was ranked third (133.5/100,000) in Xinjiang and Tibet.[20]

A stratified random sampling method was used to select the study sites in Chongqing Municipality and Guizhou Province. All counties/districts in Chongqing Municipality and Guizhou Province were grouped into three levels according to their socioeconomic status (GDP) in 2018[22]: the relatively developed (GDP in the highest 30%), the medium developed (GDP in the middle 40%), and the relatively less developed (DGP in the lowest 30%). From each group of counties/districts, four counties/districts were randomly selected as study sites. Twelve districts/counties were included in this study. All of the PHC sectors (including both CHCs and THCs) in the 12 selected counties/districts and a total of 71 PHC sectors were included in this study.

Study participants and data collection

Quantitative study

All adult pulmonary TB patients who met the following criteria were recruited from the 71 PHC sectors in the 12 selected counties/districts: (1) registered at TB dispensaries and were diagnosed with drug-sensitive pulmonary TB according to national TB diagnosis standards; (2) completed standard anti-TB drug treatment for at least 4 months, which indicated that they received TTMSs for both intensive (first 2 months) and continuation phases (following 4 months); and (3) aged 15 years and older. Patients who (1) had extra-pulmonary TB, (2) could not express themselves clearly (had disturbance of consciousness or difficulties with speech or hearing), and (3) were unwilling to participate in the study were excluded. Patient recruitment was facilitated by the local PHC sectors in the study counties/districts. First, the research group members provided a detailed explanation of the study objectives to all the potential participants. Those who were willing to participate in the study were asked to read and sign the informed consent form to ensure confidentiality.

The sample size was estimated using the Kish and Leslie formula [23]:

$$n=Z_{\alpha}^{2}P\ (1-P)/d^{2}.$$

Where, n is the minimum desired sample size. Z_{α} is the standard normal deviate, usually set as 1.96, corresponding to a 5% level of significance. P is the average rate of TB treatment management, set at 37.1% based on estimates from the available literature,[15] and d is the degree of accuracy (precision) set at 5% (0.05). Therefore, the calculated minimum sample size for patient participants was 359. A total of 481 patients with TB were recruited to participate in the survey, of whom 16 declined. Six TB patients <15 years old were excluded, and finally, 459 TB patients were included in the analysis (response rate: 95.4%).

All HCWs who were TB control medical staff in the PHC sectors in the selected counties/districts and who were willing to participate in the study were recruited as participants. TB HCWs unwilling to participate in the study were excluded. There were 261 TB HCWs in the selected counties/districts. Finally, all 261 TB HCWs were recruited and willing to participate in the survey, and zero declined (response rate: 100.0%). Local CDCs in the study districts/counties facilitated HCW recruitment.

Structured questionnaires were administered to collect data from participating TB patients and HCWs. Among TB patients, the structured survey that was administered asked the participants about their demographic information (e.g., gender, age, and residence) and TTMSs received from HCWs during their treatment (e.g., intensive phase DOT (directly observed therapy) and continuation phase DOT). Among HCWs, the questionnaire included demographic and work-related information (e.g., gender, age, professional title, and working years), work satisfaction, and delivery situation of TTMSs (e.g., first-time home visit). Questionnaires were designed by our research team based on existing literature reports and then we consulted with related experts.

In the reliability evaluation, Cronbach's α was calculated to determine the reliability of the questionnaire for TB patients and the HCWs' questionnaire. Cronbach's α ranges from 0 to 1; the higher the coefficient value (>0.8), the better the reliability and internal consistency. Both the TB patients (Cronbach's α=0.816) and HCWs (Cronbach's α=0.910) questionnaires had good reliability and internal consistency. In the validity evaluation, the face validity coefficient was calculated through the Pearson correlation coefficient (r) to determine the validity of the

questionnaire for TB patients. The questionnaire had r>0.4 and *P*<0.001, indicating good face validity. The questionnaire for the HCWs, which contained 60 TTMS questions, also had good construct validity (*I-CVI*=0.850–1.000; *S-CVI*=0.960).

In the reliability evaluation, Cronbach's α was calculated to determine the reliability of the questionnaire for TB patients and the HCWs' questionnaire. Cronbach's α ranges from 0 to 1; the higher the coefficient value (>0.8), the better the reliability and internal consistency. Both the TB patients (Cronbach's α=0.816) and HCWs (Cronbach's α=0.910) questionnaires had good reliability and internal consistency. In the validity evaluation, the face validity coefficient was calculated through the Pearson correlation coefficient (r) to determine the validity of the questionnaire for TB patients. The questionnaire had r>0.4 and *P*<0.001, indicating good face validity. The questionnaire for the HCWs, which contained 60 TTMS questions, also had good construct validity (*I-CVI*=0.850–1.000; *S-CVI*=0.960).

All questionnaires were administered by trained investigators from our research group in a meeting or clinic room in each PHC sector. TB patients and HCWs who volunteered to participate in the study were asked to read the informed consent form and sign it. Each completed questionnaire was checked and examined for quality control by trained investigators.

Qualitative study

In-depth interviews were conducted to explore the current status and identify the barriers of TTMS delivery from HCWs to patients with TB. Purposive sampling was used to select participants with different backgrounds, ages, and experiences related to TTMS. An integrated TB control model was established, and TTMSs were provided in all included counties/districts.

Therefore, in-depth interviews were conducted with: HCWs from the PHC sectors of different socioeconomic levels who had delivered TTMSs for at least one year during the study period; leaders from the local CDC and the Health Commission who were responsible for the TB control program during the study period; and patients from regions of different socioeconomic levels who had received TTMSs and were about to end their TB treatment during the study, which ensured that patients had sufficient experience related to TTMS. During recruitment, all HCWs, leaders, and patients were approached and provided detailed explanations of the study and its objectives. Those who expressed an interest in volunteering to participate in the in-depth interview were asked to read and sign an informed consent form to confirm their voluntary participation in the study.

The sample size of the qualitative study was determined by the point of data 'saturation.'[24] Recruitment continued until evidence of data saturation was obtained and adding further participants did not generate new findings. Each interview was conducted face-to-face by at least two trained interviewers to enhance the information's trustworthiness and credibility. During each interview, one interviewer performed the interview according to the semi-structured topic guides, while the other interviewer was responsible for taking notes of the key information and could supplement questions to the interview as necessary. At the end of each interview, the interviewers discussed the findings and key information obtained to confirm whether a supplementary interview was required. Information related to TTMS delivery was cross-validated between patients (service receivers) and HCWs (service providers) to increase information trustworthiness. Documentary sources such as regulations and standard service

procedures have also been utilized to enhance information credibility. Nine purposely selected leaders, 7 HCWs, and 4 patients participated in the in-depth interviews.

Semi-structured topic guides with open-ended questions were used in all interviews. The guiding framework for topic design was the practical robust implementation and sustainability model (PRISM).[25] This model considers how the intervention design, recipients, external environment, and implementation and sustainability infrastructure influence health program implementation and success, and is widely used as a theoretical framework in implementation research.[25-27] Using the PRISM guide, this study collected data on the barriers to TTMS delivery in terms of the following aspects: (1) intervention design, (2) recipients, (3) external environment, and (4) implementation and sustainability infrastructure. The adaptation of PRISM in this study is illustrated in figure 1. All interviews were conducted in Mandarin or the local language in meeting rooms in the PHC sector. Only participants and interviewers were present at the interview location. Each interview lasted approximately 40–60 minutes and was audio-recorded with the consent of the participants.

Data analysis

The data analysis integrated quantitative and qualitative data to assess the status of and barriers to TTMS program delivery by HCWs in the PHC sectors. For example, patients' demographic information from questionnaires integrated with the results from in-depth interviews allowed us to determine how patients' social economy and healthy literacy affected TTMS delivery. In addition, qualitative results regarding patient-centered manners, training support provided to HCWs, the workload and performance evaluations of HCWs, and so on, clarified the

quantitative results regarding the proportion of TTMSs received and the delivery rate of TTMSs by HWCs.

Quantitative analysis

Data were entered using Epi Data 3.1 and then analyzed using the Statistical Package for the Social Sciences (SPSS 22.0 (IBM Corporation, Armonk, NY, USA)). Missing data were excluded from the analysis—when analyzing gender, age, medical school education, major, professional title, number of BPHS programs undertaken, monthly income, and work satisfaction of HCWs, and so on, only 259, 249, 247, 256, 240, 225, 242, and 259 HCWs responded to the questions in the survey; therefore, we removed the data from the HCWs who did not respond to these questions. A two-tailed probability level of $P<0.05$ was chosen as the level of statistical significance. Descriptive statistics were used to describe the participants' demographic characteristics and TTMS delivery rates. Factors associated with lower delivery rates (<90%), as screened by the chi-square test ($P<0.05$) (appendix 1), were entered into multivariate logistic regression models (delivery rate <90%=1, delivery rate >90%=0), which were used to examine the effects of these factors on TTMS delivery.

Qualitative analysis

The framework approach was used to analyze all qualitative data following a five-step process: (1) familiarization, (2) adapting the theoretical framework, (3) indexing, (4) summarizing, and (5) data synthesis and interpretation.[28-29] Subsequently, all interviews were carefully transcribed into Word documents, reviewed for accuracy, and coded and classified by our research team members. We identified themes of the theoretical framework on TTMS delivery

barriers based on the four domains of PRISM,[25] including: (1) intervention design (PHC sector resource and patient-centered mannerisms); (2) recipients (human resources and incentives, training support, socio-economy, and health literacy); (3) external environment (health insurance, cross-sectional coordination, and social stigma); and (4) implementation and sustainability infrastructure (performance assessment). All the names of the participants were removed from the results to maintain anonymity. According to the 13th Five-Year TB Prevention and Control Plan, the targeted TTMS delivery rate from HCWs to TB patients is >90%.[5] Therefore, a delivery rate below 90% was described as a lower delivery rate in this study.

Definitions

Primary healthcare (PHC) sectors in China include community health centers (CHCs) and stations in urban areas, township hospital centers (THCs), and village health clinics in rural areas.[4] Tuberculosis healthcare workers (TB HCWs) include healthcare professionals in the PHC sector that are responsible for TTMS delivery. Tuberculosis treatment management services (TTMSs) are one of the key basic public health services available to all residents in China, and these are delivered by TB HCWs in the PHC sector, with seven themes: first-time home visits, health education, supervising drug intake, follow-up supervision, case closing evaluation, other services, and services among patient's family members.[6, 7] Both the Chinese National BPHS guidelines and the 13th Five-Year TB Prevention and Control Plan set a target TTMS rate of >90%.[6, 7] Therefore, in this study, a delivery rate <90% is described as a lower

delivery rate.

Patient and public involvement

There were no patients or public involvement in the design, conduct, reporting, or dissemination plans of this study.

RESULTS

Characteristics of participants

Participants for the quantitative study

In total, 261 TB HCWs and 459 TB patients were included in the quantitative analysis (table 1). Among the HCWs, 66.4% (n=172) were female, 71.5% (n=178) were aged 20–39 years old, 72.4% (n=189) worked at THCs, and 50.0% (n=120) and 35.8% (n=86) had junior and non-professional titles, respectively. Nearly 60% (n=155) of the HCWs had junior college education, and over 80% (n=202) had a medical school education background (32.4% majored in clinical medicine and 30.5% majored in nursing). More than half (56.4%, n=127) of the HCWs undertook 2–3 BPHS programs in PHC sectors, and only 7.6% (n=17) were dedicatedly in charge of TB programs. The majority (67.4%, n=163) had a monthly income of 2500–4500 CNY, and notably, 40.5% (n=105) reported low work satisfaction.

Among the TB patients, the majority of the patients were male (70%, n=324), married (69.7%, n=320), of Han ethnicity (78.2%, n=359), and 41.6% (n=191) were aged ≥60 years. A total of 82.4% (n=378) of the patients lived in rural residences, and 95.2% (n=437) lived in permanent residences. Almost 70% (n=315) of the patients were farmer/migrant workers, and 56.0% (n=257) had only primary education or below.

315 **Table 1 Characteristics of participants surveyed by questionnaires**

Demographic characteristic	Number	Percentage
HCWs in questionnaire survey		
Gender (n=259)		
female	172	66.4
male	87	33.6
Age (n=249)		
20-29	94	37.8
30-39	84	33.7
40-50	52	20.9
>50	19	7.6
Education (n=259)		
Technical secondary school or below	60	23.2
Junior college	155	59.8
Undergraduate college or above	44	17.0
Medical school education (n=247)		
Yes	202	81.8
No	45	18.2
Major (n=256)		
Clinical Medicine	83	32.4
Nursing	78	30.5
Public Health	33	12.9
Chinese Medicine	27	10.5
Other	17	6.6
Region (n=261)		
Relatively developed	93	35.6
Medium developed	89	34.1
Less developed	79	30.3
Working place (n=261)		
Township health center	189	72.4
Community health center	72	27.6
Professional Title (n=240)		
Non	86	35.8
Junior	120	50.0
Intermediate	31	12.9
Deputy senior	3	1.3
Number of BPHS programs undertook (n=261)		
TB program only	34	13.0
2-3	139	53.3
⩾4	88	33.7
Monthly Income (CNY) (n=242)		

<2500	52	21.5
2500-3500	89	36.8
3500-4500	74	30.6
>4500	27	11.2
Training frequency (n=261)		
0/6 months	13	5.0
1/6 months	56	21.5
2/6 months	135	51.7
3/6 months	36	13.8
>3/6 months	21	8.0
Work satisfaction（n=259）		
High satisfaction	58	22.4
Middle satisfaction	96	37.1
Low satisfaction	105	40.5
TB patients in questionnaire survey		
Gender (n=459)		
Male	324	70.6
Female	135	29.4
Age (n=459)		
<40	94	20.5
40-49	96	20.9
50-59	78	17.0
⩾60	191	41.6
Ethnicity (n=459)		
Han	359	78.2
Ethnic minority	100	21.8
Marital status (n=459)		
Single	69	15.0
Married	320	69.7
Divorced/Widowed	70	15.3
Residence (n=459)		
Urban	81	17.6
Rural	378	82.4
Registered information (n=459)		
Permanent resident	437	95.2
Migrant	22	4.8
Education (n=459)		
Primary and below	257	56.0
Junior middle school	125	27.2
High school and above	77	16.8
Occupation (n=459)		
Staff/Cadre/Retiree	50	10.9

Self-employed	10	2.2
Farmer/Migrant worker	315	68.6
Student	20	4.4
Others	64	13.9

Note: *TB* refers to tuberculosis, *HCW* refers to health care worker, *BPHS* refers to basic public health services.

Participants for the qualitative study

Nine organizational leaders, 7 HCWs, and 4 TB patients with TB were interviewed. Most organizational leaders were male (7/9), with deputy senior titles (5/9), and worked for 7.6 years an average. The majority of HCWs were female (5/7), technical secondary school educated (6/7), majored in clinical medicine (4/5), and 4/5 came from CHCs with no or junior professional titles. In addition, among four interviewed patients, which included two drug-sensitive TB (DS-TB) and two DR-TB patients, respectively, and all patients completed anti-TB therapy (6–8 months therapy for DS-TB, and 24 months therapy for DR-TB).

Quantitative results regarding TTMS delivery status

The TB patient survey showed that 76.0% (n=349) of the patients received TTMSs from HCWs in CHCs at some point during their entire course of treatment (83.7% and 76.7% during their intensive and continuation phases, respectively). Just around 40.0% (n=189) received TTMSs from HCWs in THCs/village clinics during their whole course of treatment (45.1% and 42.3% during their intensive and continuation phases, respectively). Only 17.0% (n=78) received standard TTMSs from HCWs during their entire course of treatment (18.1% and 55.8% for their intensive and continuation phases, respectively). A total of 2.8% (n=13) did not receive TTMSs from HCWs (3.9% and 7.2% during their intensive and continuation phases, respectively; table 2).

Table 2 TTMS TB patient received from HCWs during treatment (n=459)

Variable	Number	Percentage
Ever received TTMS from HCWs in CHCs		
Intensive phase	384	83.7
Continuation phase	352	76.7
Whole course of treatment	349	76.0
Ever received TTMS from HCWs in THCs/village clinics		
Intensive phase	207	45.1
Continuation phase	194	42.3
Whole course of treatment	189	41.2
Received standard TTMS from HCWs		
Intensive phase	83	18.1
Continuation phase	256	55.8
Whole course of treatment	78	17.0
Never received TTMS from HCWs		
Intensive phase	18	3.9
Continuation phase	33	7.2
Whole course of treatment	13	2.8

Note: *TB* refers to tuberculosis, *TTMS* refers to tuberculosis treatment management services, *CHC* refers to community health center, *THC* refers to township health center, *HCW* refers to health care worker.

The HCWs survey showed that the average delivery rate of TTMSs (involving 60 service items in total) in the PHC sector was 88.4%, and 13 TTMS items had a lower delivery rate (<90%). Notably, the delivery rates of DOT in the intensive phase and continuation phases were low, with proportions of 54.7% and 53.0%, respectively. In addition, less than half (44.9%) of HCWs in PHC sectors provided services related to collecting patient sputum samples during the follow-up supervision phase. Less than half of the HCWs provided food or transport assistance for poor TB patients (45.2%), provided subsistence allowance or psychological support for migrant patients (49.6%), and provided injection treatment for MDR-TB patients (41.0%). Moreover, less than 60% provided supervision for newly released prison patients

(58.9%) and established platforms for TB patient communication (57.8%). (table 3)

Table 3 TTMS with lower delivery rate provided by HCWs in PHC sectors (n=239)

Services	Delivery rate N (%)
First time home visit	
Patients' peer supervision establish (n=235）	185 (78.7)
DOT	
Intensive phase DOT (n=236）	129 (54.7)
Continuation phase DOT (n=236）	125 (53.0)
Regular medicine delivery (n=234）	160 (68.4)
Follow-up supervision	
Sputum sample collection (n=236）	106 (44.9)
Others	
Providing food or transport assistances for poor TB patient (n=230）	104 (45.2)
Providing subsistence allowance or psychological support for migrant patient (n=236）	117 (49.6)
Providing DOT for migrant TB patient at their convenient time (n=235）	203 (86.4)
Providing injection treatment for MDR-TB patient (n=234）	96 (41.0)
Providing supervision for newly released prison patient (n=236）	139 (58.9)
Training cured TB patients to provide peer education (n=237）	208 (87.8)
Establishing platform for TB patients communication (n=237）	137 (57.8)
Referring TB patient with mental/psychological problems or alcohol/drug addiction to receive professional therapy (n=235）	182 (77.4)

Note: *Lower delivery rate* refers to a rate below 90%, *TB* refers to tuberculosis, *TTMS* refers to tuberculosis treatment management service, *DOT* refers to directly observed therapy, *MDR-TB* refers to multidrug-resistant tuberculosis

Factors associated with TTMSs with lower delivery rates

Multivariate logistic regression analysis showed that HCWs with high work satisfaction were less likely to have a lower delivery rate to establish patient peer supervision as needed (OR=0.182, 95%CI: 0.059–0.562). Among both intensive and continuation phase DOT, HCWs with junior titles (OR=0.424, 95%CI: 0.215–0.835) and high work satisfaction (OR=0.326, 95%CI: 0.140–0.766) were less likely to have lower delivery rates. Similarly, HCWs with junior titles (OR=0.458, 95%CI: 0.242–0.865) and high work satisfaction (OR=0.395, 95%CI: 0.160–0.826) were more likely to deliver sputum sample collection services (table 4).

354 **Table 4** Multivariate logistic regression analysis of factors associated with lower delivery rate of TTMS by HCWs

Variable	Patients' peer supervision establish (n=235) OR (95%*CI*)	Intensive phase DOT (n=236) OR (95%*CI*)	Continuation phase DOT (n=236) OR (95%*CI*)	Regular medicine delivery (n=234) OR (95%*CI*)	Sputum sample collection (n=236) OR (95%*CI*)	Injection treatment for MDR-TB patient (n=234) OR (95%*CI*)	Providing supervision for newly released prison patient (n=236) OR (95%*CI*)
Gender							
Female	Reference			Reference			
Male	0.577（0.258-1.270）			0.605(0.320-1.147)			
Age							
>50		Reference					
40-50		2.053(0.985-4.279)					
30-39		2.230(0.947-5.248)					
<30		Default					
Professional Title							
Non		Reference	Reference		Reference	Reference	Reference
Junior		0.424(0.215-0.835)*	0.419(0.228-0.771) *		0.458(0.242-0.868) *	0.307(0.159-0.594)	0.681(0.364-1.273)
Intermediate		0.625(0.233-1.787)	0.860(0.355-2.804)		1.137(0.432-2.993)	0.686(0.258-1.827)	2.107(0.829-5.353)
Deputy senior		0.276(0.021-3.605)	0.415(0.024-5.020)		1.644(0.131-20.598)	0.809(0.054-12.031)	2.534(0.179-35.887)
Training frequency							
0/6 months					Reference	Reference	Reference
1/6 months					2.474(0.566-10.822)	3.533(0.767-16.277)	4.752(0.858-26.335)
2/6 months					2.890(0.729-11.465)	2.217(0.534-9.199)	2.568(0.500-13.182)
3/6 months					0.776(0.165-3.660)	0.607(0.126-2.923)	0.990(0.162-6.048)
>3/6 months					2.307(0.432-12.317)	2.841(0.503-16.-54)	3.346(0.508-22.044)
Work satisfaction							
Low satisfaction	Reference	Reference	Reference	Reference	Reference		
Middle satisfaction	0.354(0.168-0.745) *	0.449(0.219-0.903) *	0.584 (0.312-1.095)	0.582(0.309-1.094)	0.661(0.304-1.533)		
High satisfaction	0.182(0.059-0.562) *	0.326(0.140-0.766) *	0.347(0.163-0.741) *	0.375(0.165-0.853)	0.395(0.160-0.826) *		

Note: *Lower delivery rate* refers to rate below 90%, *TTMS* refers to tuberculosis treatment management service, *DOT* refers to directly observed therapy, *MDR-TB* refers to multidrug-resistance tuberculosis, *CI* refers to confidence interval,* refers to $p<0.05$.

355

Qualitative results regarding barriers to TTMS delivery

The in-depth interviews revealed numerous barriers to TTMS delivery from the four core PRISM domains (table 5).

1) Interventions

The current TTMS program was mainly delivered via telephone calls and lacked a sufficient patient-centered approach, which led to patient antipathy to DOT. HCWs suggested that e-health approaches, including APP, would be good methods for delivering TTMSs.

2) Recipients:

Most PHC sectors faced insufficient human resources with which to deliver TTMS programs. Every HCWs often undertook more than two BPHS programs. HCWs with this heavy BPHS workload had difficulty delivering standard TTMSs. On the other hand, the PHC sectors also lacked transportation tools with which to facilitate home visits, especially for remote rural TB patients.

HCWs in the PHC sectors also faced inadequate professional capabilities, especially village doctors, which led to patient distrust and therefore hindered TTMS delivery by HCWs. On the other hand, the PHC sector also lacked sufficient incentives for HCWs in the TTMS program, and almost all HCWs were unsatisfied with their low salaries and subsidies due to their heavy workloads and infection risk of TB. In addition, out-of-pocket expenditures for transportation and telephone charges related to TTMS delivery could further influence HCW's working motivation, performance, and attrition. Moreover, inadequate qualified training (lacked of communication skills and professional knowledge related to TTMS delivery, the

training approach of TB training mixed with other BPHS programs, and lacked of high-quality TB-specific training for HCWs) support for TB HCWs was also reported by interviewees. Therefore, the current training methods do not provide much support for HCWs' capabilities and performance.

In terms of patient characteristics, the majority of interviewers claimed that TB is a disease of the poor and that most TB patients were disadvantaged (of older ages, with low education, migrant workers, or with financial difficulties), particularly MDR-TB patients with longer treatment periods, who had poor TB-related health literacy, and had a high risk of rejecting TTMSs. HCWs also mentioned the difficulty of delivering TTMSs to migrant patients because it was difficult to reach them.

3) External environment:

On the one hand, inadequate health insurance coverage for medications and tests related to side effects accentuated the financial burden among poor DS-TB patients, and the health coverage was more inadequate for MDR-TB patients with longer treatment periods, which reduced their willingness to receive TTMSs. On the other hand, difficulties in cross-sectional coordination to assist TTMS delivery have been reported, especially support from TB-designated hospitals and other departments, such as departments of public security and education. Furthermore, TB-related social stigma has been reported as one of the main barriers to conducting home visits among urban and young patients who cared about privacy, and these patients were therefore more likely to refuse home visits from HCWs.

4) Implementation and sustainability infrastructure:

The performance assessment of TB HCWs might be irrational, considering their heavy workload. One leader pointed out that the purpose of TTMS delivery could be to complete the target indicators, and therefore, lead to substandard TTMSs in patients. Moreover, inappropriate performance assessments also hinder working motivation and increase working attrition among HCWs when delivering TTMSs.

DISCUSSION

In China, HCWs in the PHC sector are considered an important part of the integrated TB model, and these workers are responsible for TTMS delivery. This study assessed the delivery of the TTMS program by HCWs in the PHC sector in West China. Although we found that the TTMS delivery rates in the intensive and continuation phases were higher than in a previous study in West China,[15] the standard TTMS (at least 24 times TTMS during their treatment course) delivery rate was far below the required rate of >90%, according to the National TB Control Plan.[6] In addition, our study showed that the number of TB patients receiving DOT from HCW in CHCs (in urban regions) was higher than that from HCW in THCs (in rural regions). This difference might be explained by our qualitative results, as interviewed HCWs reported challenges in delivering TTMSs to remote rural patients due to patients' poor health literacy, which has also been reported in other studies.[18, 30] Our study also indicated that far distances with insufficient transportation tools for HCWs were preventing TTMS delivery. In addition, our study revealed that less than half of HCWs provided services related to collecting patient sputum samples during follow-up supervision, which is much lower than the results reported in a study in Guizhou (96.56%).[30] Furthermore, we found a low level of work satisfaction

(22.4%) among TB HCWs, although it was higher than in a previous study (12.2%).[31] Our study results indicated that HCWs with low work satisfaction were more likely to have a low delivery rate of first-time home visits, DOT, and sputum sample collection services. Efforts should be made to maintain and promote HCWs' work satisfaction to enhance TTMS delivery.

Our study revealed that the current TTMS delivery was confronted with various barriers, despite the fact that TB HCWs in PHC sectors who carried out TTMS programs had made many achievements in West China. At the organizational level, we found that the TTMS programs themselves had several barriers affecting the delivery of services from HCWs. On the one hand, the national TB Action Plan and nationwide TB survey in China[2, 9, 32] mentioned cross-sectional coordination of TTMS delivery; however, we found that HCWs in the PHC sectors still lacked good coordination with other departments, such as coordination from the Department of Education to support students' treatment management and help from the Department of Public Security to trace migrant patients' information. In particular, HCWs from some PHC sectors faced barriers to accessing timely connections with TB HCWs from TB-designated hospitals when addressing TB patients' side effects and treatment adherence. It is difficult to realize the participation of the whole society in terms of TB control in China so far.[33] According to the Action Plan to Stop TB (2019 to 2022) in China,[2] in order to coordinate cross-sectional efforts to support TB prevention and control programs, there is an urgent need to build a multi-sectorial collaboration mechanism led by the National Health Commission (NHC).[29]

The second barrier that emerges at the health organizational level is the approach to TTMS

delivery. We found that TTMSs were mainly delivered via telephone calls, results that are consistent with previous studies in West China,[15, 33] and insufficient patient-centered mannerisms could result in patient rejection of DOT and TTMSs by HCWs. A previous study in Indonesia also reported that insufficient patient-centered care was the main treatment barrier for TB patients in high-burden settings.[34] Although research has shown that home visits and DOT led to positive treatment outcomes,[35, 36] our study pointed out the need to provide TTMSs through an e-health approach, which was consistent with previous studies that demonstrated the effectiveness of e-health technology for promoting patient treatment adherence.[37-42] It is necessary to explore internet-based case management models, including digitally supported self-management, deliver TTMSs to TB patients living in remote mountainous areas with the help of HCWs in PHC sectors, or provide face-to-face DOT.

The third barrier at the organizational level is the human health resources for TTMSs in the PHC sectors. Other studies reported that PHC sectors, especially those in rural areas, had a limited number of HCWs with which to conduct BPHS programs, which led to heavy workloads and a "shortage of hands," as HCWs often carried out multiple assigned services.[43-45] We consistently found that PHC sectors, particularly THCs, faced human resource barriers in terms of insufficient and inadequate professional capabilities to deliver the TTMS program. On the one hand, our study showed that a heavy workload with multiple BPHS programs could lead to difficulties in delivering standard TTMSs to TB patients. On the other hand, we found that inadequate professional capabilities, especially village doctors, could lead to patient distrust and hence impede TTMS delivery. Simultaneously, our study revealed that PHC

sectors lack adequate TB training for HCWs, particularly training related to communication and professional knowledge related to TTMS delivery, resulting in substandard TTMSs. Other studies have proved that on-the-job training is important to improve professional skills among HCWs,[33, 44, 46, 47] especially training emphasizing both knowledge and practice.[48] Furthermore, we found that the performance assessment of HCWs in the TTMS program may be irrational considering their heavy workload, and this led to difficulties in delivering standard TTMSs and hindered their enthusiasm.

Our results showed that the PHC sectors lack sufficient funding for the TTMS program, and most HCWs are unsatisfied with their low salaries, allowances, or subsidies, which is consistent with other studies.30 Many studies have also indicated that the diverse issues of financial incentives combined with heavy workloads could influence HCW's motivation and performance.[44, 49-52] The appropriate use of incentives for HCWs is a means of promoting health outcomes with a direct impact on the effectiveness and sustainability of a health program, and this can also improve service delivery rates by enhancing motivation and reducing attrition.[48] Notably, we found that HCWs faced out-of-pocket expenditures related to transportation and telephone charges when delivering TTMSs, which could further impact their work enthusiasm.

Our results also identified barriers at the patient level regarding TTMS delivery, including their susceptible socioeconomic characteristics (older ages, with low education, migrant status, or poor financial status) and lower literacy regarding TB control. A previous nationwide TB epidemiology survey in China revealed that nearly half (48.8%) of TB patients were aged ≥60, less educated, and over 80% of TB patients had household incomes below local levels.[18] Our

results indicate that poor socioeconomic characteristics and low TB-related health literacy together impede TTMS delivery. As patients with low socioeconomic features were often found to have a lower educational background, poor health literacy, and were more likely to be non-adherent, they were more likely to refuse HCWs' supervision, which is consistent with other studies.[18, 53, 54] In addition, we found that TTMS delivery among migrant patients was challenging for HCWs because it was difficult to reach them. Other studies also reported that migrant patients that frequently moved residences and had low socioeconomic status had relatively poorer TB-related awareness,[55-57] which could hinder their TB case management. Previous studies revealed that West China had a higher proportion of rural mountain areas as well as domestic migrants than other regions in China, and TB-related awareness among rural, less educated, and migrants was particularly serious.[18, 55, 57-59]

Our study also discovered that health insurance could not cover all medicines and tests related to side effects, which accentuates the financial burden among poor TB patients and leads to barriers to TTMS delivery. To relieve barriers to TB treatment, it is crucial to address the financial burden of TB treatment among poor patients. Notwithstanding, a previous national TB epidemiology survey in China reported that although over 90% of TB patients had medical insurance, in combination with the policy of free TB diagnosis and treatment, the proportion of patients paying out-of-pocket was still around 75.0%–84.2%.[18] Several studies and reports mentioned the need to increase the reimbursement ratio and amount provided for TB treatment, to expand the scope of the currently free TB treatment policy, and to strengthen the care and assistance provided to TB patients.[2, 6, 36, 60] In particular, there is a need to target DR-TB and

impoverished patients with transportation, accommodation, and nutrition allowances during TTMS delivery in order to promote TB control outcomes.

Promoting TB-related health literacy among patients and enhancing TB-related awareness among the public is urgently necessary. As revealed in our study, not only was poor TB health literacy a barrier to patients, TB-related social stigma also impeded TTMS delivery, especially in urban areas. Previous studies have suggested providing easily understandable TB health education to a particular target population (older ages, less educated, close contacts, and others) with certain modes of health education.[18, 58] Another study indicated that a combination of mass media approaches and interpersonal communication between patients and HCWs could lead to more effective TB control.[59] Similarly, the Chinese Action Plan to Stop TB called for various publicity activities with which to raise awareness of TB, including through traditional media such as television broadcasts and newspapers, as well as through the use of new media such as the WeChat app, to promote the dissemination of scientific TB knowledge and eliminate social discrimination.[2]

Strengths and limitations

Our study used a mixed research method combining quantitative research (questionnaire surveys) with qualitative research (semi-structured, open-ended in-depth interviews) to assess TTMS program delivery by HCWs in the PHC sectors. Perspectives from organizations and patients were included using the PRISM model to evaluate specific barriers to TTMS delivery. Three levels of the local health organization were involved in our study, which included HCWs as frontline staff, CDC leaders as managers, and health commission leaders as policy makers.

However, the current study had several limitations. First, the sample size of both the questionnaire survey and the in-depth interviews could be further expanded to enhance the representativeness of the study. Second, as we only explored the status of and barriers to TTMS delivery by HCWs in PHC sectors, well-evidenced implementation strategies that can solve the current problems successfully were not provided in this study. Further studies are required to provide evidence for the development of more comprehensive and effective TB control strategies.

Conclusion

The HCWs in the TTMS program suggested that the government realized the importance of HCWs in the PHC sectors in promoting TB patient treatment adherence and outcomes and underscored their integration into the TB control model. We identified barriers operating at the organizational level (cross-sectional coordination, patient-centered approaches, resources and incentives, training support, reimbursement issues, and performance assessments) and patient level (socioeconomic characteristics, health literacy, and social stigma) to TTMS delivery by HCWs in the PHC sector. There is an urgent need to identify comprehensive measures to effectively overcome barriers to TTMS delivery and further promote TB control in southwest China.

Acknowledgements We would like to thank the participants who responded our questionnaires. We also thank all leaders and healthcare workers in the PHCs in study places who supported this study by facilitating implementation of the field questionnaire survey and participated in our interviews. We would like to thank Editage (www.editage.cn) for English language editing.

Contributions JZ, JP and YL have designed this survey, JZ, JP, GW, WX, TZ, SL and QW

have collected data, JZ, JP, RZ, YC and JL have managed and analyzed data, YL and DH have controlled the quality of data collection and analysis, JZ has drafted the manuscript. YL has edited the manuscript. All authors have interpreted the results, revised the report and completed the final version. The author(s) read and approved the final manuscript.

Funding The study was funded by the National Natural Science Foundation of China (No.81773489), the Chongqing outstanding youth project (No.cstc2020jcyj-jq0035), Social Science and Technology Innovation Subject in Chongqing (No.cstc2015shmszx120070).

Disclaimer The funders had no role in study design, data collection and analysis, interpretation of the data, writing the paper and the decision to submit the paper for publication.

Competing interests Not declared

Patient consent Obtained.

Ethics approval Ethics approval was obtained from the Institutional Review Board of Army Medical University (Third Military Medical University), Chongqing, China (No.AF/SC-08/1.0) before starting the study. This study was conducted in accordance with the Declaration of Helsinki. A full explanation of the purpose and procedure of the study was provided to participants prior to obtain their written informed consent. All demographic data and quotes used in this study were deidentified to maintain the anonymity of participants.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

References:

[1].World Health Organization. Global tuberculosis report 2021. Geneva: World Health Organization; 2021. Licence: CC BY-NC-SA 3.0 IGO

[2].National Health Commission. Stop TB Action Plan (2019-2022). 2019. Available: http://www.nhc.gov.cn/jkj/s3589/201906/b30ae2842c5e4c9ea2f9d5557ad4b95f.shtml. [Accessed 11 Feb 2022].

[3]. Li T, Du X, Liu X, Li Y, Zhao Y. Implementation Performance of Tuberculosis Control in China: 2011-2020. *China CDC Wkly*. 2021 Mar 19;3(12):252-255.

[4].World Health Organization: Treatment of tuberculosis: Guidelines for national programmes (4thedition), 2010. Available: https://www.ncbi.nlm.nih.gov/books/NBK138748/pdf/Bookshelf_NBK138748.pdf. [Accessed 11 Feb 2022].

[5].Ministry of Health of the People's Republic of China. National tuberculosis control programme (2011-2015). 2011. National Health Commission. Stop TB Action Plan (2019-2022). 2019. Available: http://www.gov.cn/gongbao/content/2011/content_2020914.htm. [Accessed 11 Feb 2022].

[6].General Office of the State Council of the People's Republic of China. The 13th five-year plan for the prevention and control of tuberculosis. 2017. Available: http://www.gov.cn/zhengce/content/2017-02/16/content_5168491.htm. [Accessed 11 Feb 2022].

[7].National Health Commission of the People's Republic of China. National basic public health service standard (3rd edition). 2017. Available:http://www.nhc.gov.cn/jws/s3578/201703/d20c37e23e1f4c7db7b8e25f34473e1b.shtml. [Accessed 11 Feb 2022].

[8].Chen YF. Discussion on the effect of the integrated tuberculosis prevention and control model in Dongxiang County. *Foreign Medical science section of medgeograpgy*, 2014; 35 (3).

[9].Chen XJ, Feng ZC. Analysis of the implementation effect of the integrated tuberculosis prevention and control model in Wuhan. *Medicine and society*. 2014;27(2):62–4.

[10].Wu XD. The impact of community supervisors' supervision and management visits on the rate and curative effect of non-hospital pulmonary tuberculosis patients. *World Latest Medicine Information.* 2018;18(90):210.

[11]. Zhang SN, Yuan ZA, Mei J, et al. The effectiveness of the new TB control network in Shanghai. *Chin J Antituberc.* 2007;29(1):74–7.

[12]. Wang XY. Evaluation on effectiveness of the new trinity TB control network in Wujin District of Changzhou. *Jiangsu J Prev Med.* 2013;24(5):18–20.

[13]. Jing GQ, Qian QW, Ding TD. The effects of tuberculosis prevention and control using the integrated mode in Bengbu. *Anhui J Prev Med*. 2012;18(6): 425–6.

[14]. Xie MF, Lai SF, Lian ST. Analysis on the effect of integrated tuberculosis control mode, Wuping county. *Prev Med Trib.* 2018;24(1):76–8

[15]. Pu J, Chen W, Jiang WX, et al. Is tuberculosis patients management improved in the integrated TB control model in West China? A survey in Guizhou Province, China. *Infect Dis Poverty.* 2019 Jul 2;8(1):55.

[16]. Li Y, Ehiri J, Oren E, et al. Are we doing enough to stem the tide of acquired MDR-TB in countries with high TB burden? Results of a mixed method study in Chongqing, China. *PLoS One.* 2014 Feb 5; 9 (2):e88330.

[17]. Fetters MD, Curry LA, Creswell JW. Achieving integration in mixed methods designs-principles and practices. *Health Serv Res.* 2013;48:2134 – 56.

[18]. Yu Wang. The fifth national tuberculosis epidemiological sampling survey. *Beijing: Military Medical Science Press*. 2011.10

[19]. Chongqing Statistics Bureau. Chongqing Statistical Yearbook 2021. (2021). Available: http://tjj.cq.gov.cn/cqtjj2021/indexch.htm. [Accessed 11 Feb 2022].

[20]. Q Wang, T Li, X Du, et al. Analysis in the incidence of national tuberculosis reports from 2015-2019. *Chinese Journal of Antituberculosis.* 2021; 43(02):107-112.

[21]. Guizhou Statistics Bureau. Guizhou Statistical Yearbook 2021. (2021). Available: http://hgk.guizhou.gov.cn/publish/tj/2021/zk/indexch.ht. [Accessed 11 Feb 2022].

[22]. National Bureau of Statistics. China Statistical Year book: China Statistics Press. 2018. Available: http://www.stats.gov.cn/tjsj/ndsj/2018/indexch.htm. [Accessed 11 Feb 2022].

[23]. Bolarinwa OA. Sample size estimation for health and social science researchers: The principles and considerations for different study designs. *Niger Postgrad Med J*. 2020 Apr-Jun;27(2):67-75.

[24]. Saunders B, Sim J, Kingstone T, Baker S, Waterfield J, Bartlam B, et al. Saturation in qualitative research: exploring its conceptualization and operationalization. *Qual Quant*. 2018;52(4):1893-1907.

[25]. Feldstein, A.C, R.E. Glasgow. A practical, robust implementation and sustainability model (PRISM) for integrating research findings into practice. *Jt Comm J Qual Patient Saf*. 2008; 34(4): p. 228-43.

[26]. Liles, E.G, et al. Implementation challenges and successes of a population-based colorectal cancer screening program: a qualitative study of stakeholder perspectives. *Implementation Science*. 2015; 10(1).

[27]. Schneider, J.L, et al Stakeholder perspectives on implementing a universal Lynch syndrome screening program: a qualitative study of early barriers and facilitators. *Genetics in Medicine.* 2016; 18(2): p. 152-161.

[28]. Smith J, Firth J. Qualitative data analysis: the framework approach. *Nurse Researcher*. 2011; 18(2): 52–62.

[29]. Ward DJ, Furber C, Tierney S, Swallow V. Using Framework Analysis in nursing research: A worked example. *J Adv Nurs*. 2013; 69(11): 2423–31.

[30]. YY He, JL Li, W Chen, L Luo, Y Shang, JH Xu. Analysis on the implementation of basic public health tuberculosis service items in Guizhou Province. *Studies of Trace Elements and Health.* 2020; 37(02):54-57.

[31]. Gaspar LMDS, Braga C, Albuquerque GDM, Silva MPN, Maruza M, Montarroyos UR, et al. Knowledge, attitudes and practices of community health agents regarding pulmonary tuberculosis in a capital city in northeastern Brazil. *Cien Saude Colet*. 2019; 26;24(10):3815-3824.

[32]. Hui Z, Xiaoqiu L, Caihong X, Dongmei H, Xue L, Tao L, et al. Guiding Tuberculosis Control Through the Healthy China Initiative 2019−2030. *China CDC Weekly*. 2020, 2(49): 948-950.

[33]. Liu GH, Deng J, Chen W. Investigation on the status of needs on community doctors for tuberculosis management in Guizhou Province. *China Health Industry.* 2019;16(21):11-13.

[34]. Pradipta IS, Idrus LR, Probandari A, Lestari BW, Diantini A, Alffenaar JC, Hak E. Barriers and strategies to successful tuberculosis treatment in a high-burden tuberculosis setting: a qualitative study from the patient's perspective. *BMC Public Health.* 2021 Oct 21;21(1):1903.

[35]. Xu L, Gai R, Wang X, Liu Z, Cheng J, Zhou C, Liu J, Zhang H, Li H, Tang W. Socio-economic factors affecting the success of tuberculosis treatment in six counties of Shandong Province China. *The International Journal of Tuberculosis and Lung Disease.* 2010;14(4):440–6.

[36]. Noé A, Ribeiro RM, Anselmo R, et al. Knowledge, attitudes and practices regarding tuberculosis care among health workers in Southern Mozambique. *BMC Pulm Med*. 2017 Jan 5;17(1):2.

[37]. Chongqing tuberculosis dispensary. Implementation plan of the Chongqing Stop Tuberculosis Action (2019-2022). 2020. Available: http://www.cqtb.org/html/zcfg/20/01/1121.html. [Accessed 11 Feb 2022].

[38]. Zhang H, Liu JJ. The overview and prospect of tuberculosis control in China since the founding of the Peoples Republic of China. *Chin J Antituberc.* 2019; 41(9):913 − 6.

[39]. Liu X, Lewis JJ, Zhang H, et al. Effectiveness of Electronic Reminders to Improve Medication Adherence in Tuberculosis Patients: A Cluster-Randomised Trial. *PLoS Med.* 2015 Sep 15; 12 (9):e1001876.

[40]. 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 Jul 3;15 (7):e1002595.

[41]. Nhavoto JA, Grönlund Å, Klein GO. Mobile health treatment support intervention for HIV and

tuberculosis in Mozambique: Perspectives of patients and healthcare workers. *PLoS One*. 2017 Apr 18;12(4):e0176051.

[42]. Wang N, Zhang H, Zhou Y, et al. Using electronic medication monitoring to guide differential management of tuberculosis patients at the community level in China. *BMC Infect Dis*. 2019 Oct 15;19(1):844.

[43]. Huang et al. Global Health Research and Policy. 2018. (3):18. Available: https://doi.org/10.1186/s41256-018-0072-0. [Accessed 11 Feb 2022].

[44]. Tao T, Zhao Q, Jiang S, et al. Motivating health workers for the provision of directly observed treatment to TB patients in rural China: does cash incentive work? A qualitative study. *Int J Health Plann Manag*. 2013;28(4):e310–24.

[45]. Liang S, Deng H, Liu S, et al. Competency building for lay health workers is an intangible force driving basic public health services in Southwest China. *BMC Health Serv Res*. 2019 Aug 23;19(1):596.

[46]. Edwards NC, Roelofs SM. Sustainability: The elusive dimension of international health projects. Can J Public Health. 2006;97:45–9. Available: http://www.jstor.org/stable/41994677. [Accessed 11 Feb 2022].

[47]. Li N, Yan LL, Niu W, et al. The effects of a community-based sodium reduction program in rural China–a clusterrandomized trial. *PLoS One*. 2016;11(12):e0166620..

[48]. World Health Organization. WHO guideline on health policy and system support to optimize healyhcare worker programmes. Geneva: World Health Organization. 2018.

[49]. Campbell C, Scott K. Retreat from Alma Ata? The WHOs report on task shifting to healyhcare workers for AIDS care in poor countries. *Glob Public Health*. 2011;6 (2):125–38.

[50]. Jaskiewicz W, Tulenko K. Increasing healyhcare worker productivity and effectiveness: a review of the influence of the work environment. *Hum Resour Health*. 2012; 10 (1):1.

[51]. Hemminki E, Long Q, Zhang W-H, et al. Impact of financial and educational interventions on maternity care: results of cluster randomized trials in rural China, CHIMACA. *Matern Child Health J*. 2013; 17 (2):208–21.

[52]. Meng Q, Li R, Cheng G, et al. Provision and financial burden of TB services in a financially decentralized system: a case study from Shandong, China. *Int J Health Plann Manag*. 2004;19(S1):S45–62.

[53]. Hutchison C, Khan MS, Yoong J, et al. Financial barriers and coping strategies: a qualitative study of accessing multidrug-resistant tuberculosis and tuberculosis care in Yunnan, China. *BMC Public Health*. 2017 Feb 22;17(1):221.

[54]. Onah CK, Azuogu BN, Ossai EN, et al. Addressing constraints to informal providers' involvement in tuberculosis control: a qualitative study of patent medicine dealers and tuberculosis programme managers. *Glob Health Res Policy*. 2021 Nov 8;6(1):43.

[55]. Wang SN, Deng YH, Shi YY, et al. Investigation on knowledge of tuberculosis prevention and

treatment among floating population tuberculosis patients in Putuo District, Shanghai. *Health Education and Promotion*.2020,15(06):636-638.

[56]. Ma Y, Liu YH, Du J, et al. Survey on awareness of core information of tuberculosis prevention and control knowledge in pulmonary tuberculosis patients. *Chinese Anti-tuberculosis Journal.* 2015 (10).

[57]. Zou X, Zhou L, Wu H, et al. The role of tuberculosis control institutes in delivering tuberculosis information to domestic migrants in China: A multi-level analysis of a nationwide cross-sectional survey. *Int J Infect Dis.* 2019; 86:94-101.

[58]. Chen W, Li Y, Yang H, et al. Is tuberculosis health education reaching the public in China? A cross-sectional survey in Guizhou Province. *BMJ Open*. 2016; 6(9):e013534.

[59]. Arulchelvan S, Elangovan R. Effective communication approaches in tuberculosis control: Health workers' perceptions and experiences. *Indian J Tuberc.* 2017;64(4):318-322.

[60]. Rawal LB, Kanda K, Biswas T, et al. Health problems and utilization of health services among Forcibly Displaced Myanmar Nationals in Bangladesh. *Glob Health Res Policy.* 2021 Oct 11;6(1):39.

FIGURE LEGENDS

Figure 1 Adapted PRISM for barriers on TTMS delivery in PHC sectors. This figure presents the four core domains of the Practical Robust Implementation and Sustainability Model (PRISM) for barriers on TTMS delivery in PHC sectors, including: 1) TTMS program design; 2) the recipients, 3) the external environment, and 4) the implementation and sustainability infrastructure. Activated elements for each domains were presented in boxes. Notes: *TTMS* refers to tuberculosis treatment management service; *PHC* refers to primary healthcare; *HCW* refers to healthcare worker).

Table 5 Barriers of TTMS delivery by HCWs in PHC sectors

Core PRISM domains	Results	Quotations

Intervention: TTMS program	**Patient-centered manner:** Both DS-TB and MDR-TB patients stated they received TTMS from HCWs in PHC sectors by telephone. Some HCWs reported that some patients expressed antipathy to DOT and the current approach to deliver TTMS, maybe new e-health approach should be considered.	*Got telephone calls during the first 2 months, very few afterwards...I didn't like (DOT). (DS-TB patient)* *Only received telephone calls from HCW in town, once per month. (MDR-TB patient)* *There is one MDR-TB patient...say it is annoying to call him every day (by us to deliver TTMS program). (HCW)* *I think that we can remind patients to take medicine via digital technologies. Although, the elders may not use phone adroitly, we find that they missed drug taking less frequently than the young patients. So, we can remind young patients through APP in mobile phone. (HCW)*
Recipients	**Resources and incentive in PHC sectors:** Majority HCWs and leaders stated that PHC sectors, particularly THCs faced insufficient human resource HCWs to deliver TTMS program. HCWs often undertook more than 2 BPHS programs which led to hardship to deliver standard TTMS to TB patients. And inadequate professional capability, particularly village doctors, led to patients' distrusts and therefore hindered TTMS delivery. Many HCWs claimed that PHC sectors lacked transportation tools to facilitate home-visits especially for remote rural patients Moreover, majority HCWs and leaders reported that lack of incentive for HCWs in TTMS program, and almost all HCWs unsatisfied with low subsidy, allowance, and salary regarding their heavy workload and infection risk. Out-of-pocket expenditure for transportations and telephone charges for TTMS delivery was also reported by HCWs.	*Too many works, it is hard to communicated well with patients...I have 2-3 days a week to give phone calls to TB patients, too tired...we often take two works by one person, the workloads are huge. (HCW)* *Insufficient and unstable* HCWs *...one HCW leave, then we need to train a new one…(CDC leader)* *HCWs, especially at TCHs, low quality, patients don't trust them. (CDC leader)* *Lacking transportation tools for home-visit, some (patients) live in rural area, far away...need to take a long distance to visit one patient. (HCW)* *We face high risks of infection. There are no subsidies for us to provide manage. Funding for* TTMS *delivery is not separated from* subsidies *for the whole BPHS program. Actually, those subsidies from BPHS is not even enough for my telephone and transportation costs. (HCW)* *Without subsidies, the HCWs motivation and working satisfaction is low...they just to complete tasks and will not really care about the quality of TTMS. (CDC leader)*
	Training support to HCWs in PHC sectors: Many HCWs stated that TB trainings lack of adequate professional knowledge and communication skill for TTMS delivery. Both HCWs and leaders mentioned lack of TB-specific training for HCWs.	*2-3 TB trainings each year, from CDC...combined with other (BPHS) trainings...and I think this training is not effective. (HCW)* *It is harder to communicate with MDR-TB patients. Sometimes they seem know more about treatment than me. Prolonged illness makes a doctor of a patient. (HCW)*
	Patient's socio-economy: Most HCWs and leaders consistently agreed that most TB patients were old age and living with low socioeconomic status, have high risk to reject TTMS. Due to the long treatment period, the financial burden on MDR-TB patients is particularly heavy, resulting in poor adherence and TTMS difficulty. Some HCWs also stated the hardship to deliver TTMS among migrant patients since hard to reach them.	*During treatment in later period, I didn't (take sputum test), no money, no money for transportation. (DS-TB patient)* *Cannot bear the financial burden... costs of follow-up examinations, CT, and medicines. (MDR-TB patient)* *Because TB itself is a "disease of the poor", most TB patients have financial difficulties with bad lifestyles and poor literacy. (HC leader) Migrant patients are hard to reach...some have no stable*

		work and often change their phone numbers...don't like TTMS. (HCW) *I told him/her the dangerousness and seriousness of MDR-TB, he/she still didn't keep treatment, only told me: 'no money'. (HCW)*
	Patient's health literacy: Vast majorities of HCWs stated that some patients refused to receive TTMS to manage their nonadherence behaviors due to poor health literacy and weak TB-related awareness.	*I stopped treatment because I felt good about myself. (MDR-TB patient)* *Some (patients) don't prioritize their health and dislike our TTMS...they are aged and less educated...Some have very poor adherence to TB treatment. (HCW)*
External environment	**Health insurance:** All patients stated they still faced financial hardship even with health insurance. Most HCWs and leaders stated that the current health insurance for DS-TB patients cannot cover all medicines and examinations related to side-effect, and it is more inadequate for MDR-TB patients with longer treatment, which added financial burden among poor TB patients and led to hardship for TTMS delivery.	*(After reimbursement,) medicines would cost hundreds, and the costs of CT scans can't be reimbursed. (MDR-TB patient)* *The health insurance of reimbursement of TB treatment is very strict, anti-TB drugs are free, and other liver protection medicines and tests are not. (HC leader)*
	Cross-sectional coordination: Majority HCWs and leaders reported the difficulties to conduct cross-sectional coordination for TTMS delivery, especially coordination from TB designated hospitals. One leader also stated a poor cross-sectional coordination between PHC sectors with the departments of education, public security, civil affair, and finance for TTMS delivery.	*It is hard to connect with TB designated hospitals' doctors, they are very busy. One patient stopped treatment and said it is doctors' advice...but I cannot confirm. (HCW)* *The department of finance, education, civil affairs, public security, and others， ... they are not highly motivated (to give us support in TTMS program). (CDC leader)*
	Social stigma: TB-related social stigma was mentioned by many HCWs. Urban and young patients with more concerns of privacy issue were more likely to refuse home-visit from HCWs.	*There is one patient, it's impossible to go to his/her home... due to privacy, he/she doesn't like people around know they have TB. (HCW)* *Some TB patients, especially urban and youth patients, don't like us to go to their home for home-visit... (They are) worried about how people around would think of them. (HCW)*
Implementation and Sustainability infrastructure	**Performance assessment:** All HCWs and some of the leaders stated that the performance assessment for TTMS may exist irrationality considering heavy workload. And leaders pointed out that this could lead to substandard TTMS, and hinder HCW's working enthusiastic.	*(Performance) assessment is unreasonable, more works you do, more mistakes you make, and this is unfair. There are no rewards when you perform well...while, any negative feedbacks (such as patients' dissatisfactions with treatment costs) would affect our performance assessment. (HCW)* *The indexes are quite high (considering HCW's workload). Sometimes, the purpose becomes to complete indexes but not to really care about patients. (CDC leader)*

Note: *TTMS* refers to tuberculosis treatment management service, *TB* refers to tuberculosis, *HCW* refers to healthcare workers, *PHC* refers to primary healthcare, *BPHC* refers to basic primary healthcare, *DS-TB* refers to drug-sensitive tuberculosis, *DOT* refers to directly observed therapy, *MDR-TB* refers to multidrug-resistant TB, *CT* refers to Computed Tomography.

746

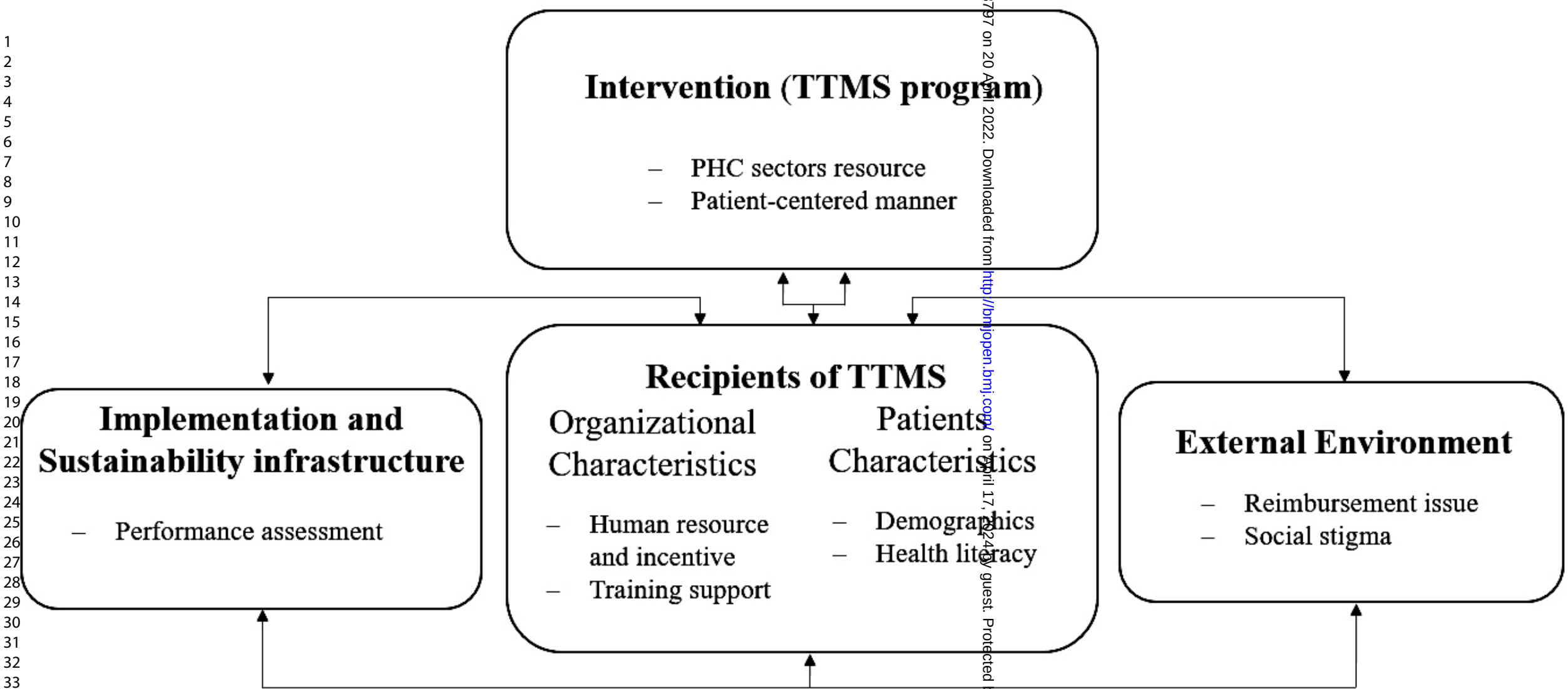

Figure 1: Adapted PRISM for barriers on TTMS delivery in PHC sectors

Appendix 1: Chi-square test results

Factors associated with TTMS with lower delivery rate

Variable	Patients' peer supervision establish (n=235)		Train patient to use smart tools to assist TTMS (n=236)		Intensive phase DOT (n=236)		Continuation phase DOT (n=236)		Regular medicine delivery (n=234)		Sputum sample collection (n=236)	
	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)
Gender		0.025*		0.429		0.370		0.867		0.033*		0.760
Female	115(74.7)		88(57.1)		81(52.6)		81(52.6)		97(63.0)		68(44.2)	
Male	69(87.3)		50(62.5)		47(58.8)		43(53.8)		62(77.5)		37(46.3)	
Age		0.23		0.496		0.023*		0.478		0.261		0.950
20-29	73(83.9)		47(53.4)		55(61.8)		51(57.3)		63(70.8)		40(44.9)	
30-39	60(78.9)		46(60.5)		37(49.3)		36(48.0)		46(61.3)		31(41.9)	
40-50	33(68.8)		28(58.3)		19(43.2)		24(50.0)		35(74.5)		22(44.9)	
>50	9(75.0)		9(75.0)		13(81.3)		8(66.7)		10(83.3)		6(50.0)	
Education		0.927		0.607		0.123		0.247		0.815		0.139
Technical secondary school and below	40(76.9)		33(64.7)		27(51.9)		25(48.1)		36(70.6)		25(49.0)	
College	112(79.4)		81(57.0)		84(59.2)		81(57.0)		94(66.7)		67(47.2)	
University and above	32(78.0)		24(57.1)		17(41.5)		18(43.9)		29(70.7)		13(31.0)	
Regions		0.468		0.323		0.367		0.399		0.360		0.820
Relatively developed	54(77.1)		47(66.2)		37(53.6)		38(55.1)		46(67.6)		32(45.1)	
Medium developed	66(75.9)		48(55.2)		53(60.2)		50(56.8)		64(73.6)		41(47.1)	
Less developed	65(83.3)		44(65.4)		39(49.4)		37(46.8)		50(63.3)		33(42.3)	
Primary Health Sector Type		0.044*		0.529		0.574		0.586		0.386		0.607
Township health center	141(82.0)		104(60.1)		97(55.7)		94(54.0)		121(69.9)		79(45.9)	
Community health center	44(69.8)		35(55.6)		32(51.6)		31(50.0)		39(63.9)		27(42.2)	
Professional Title		0.317		0.591		0.010*		0.036*		0.801		0.019*
Non	67(82.7)		46(56.8)		37(45.7)		36(44.4)		52(64.2)		30(37.0)	
Junior	82(78.8)		65(62.5)		70(66.7)		67(63.8)		73(70.2)		58(55.8)	
Intermediate	19(67.9)		15(53.6)		12(42.9)		13(46.4)		17(63.0)		9(32.1)	
Deputy senior	2(66.7)		1(33.3)		2(66.7)		2(66.7)		2(66.7)		1(33.3)	
Times of training received in the past six month		0.299		0.007*		0.147		0.214		0.963		0.022*
0	11(91.7)		10(83.3)		8(66.7)		8(66.7)		8(72.7)		7(58.3)	
1	37(78.7)		28(57.1)		22(44.9)		21(42.9)		34(69.4)		20(41.7)	
2	93(76.2)		68(56.2)		63(51.6)		62(50.8)		82(67.8)		46(37.4)	
3	31(88.6)		27(77.1)		23(67.6)		22(64.7)		22(64.7)		23(67.6)	
>3	13(68.4)		6(31.6)		13(68.4)		12(63.2)		14(73.7)		10(52.6)	
Working satisfaction		0.000*		0.042*		0.016*		0.012*		0.008*		0.027*
Dissatisfied	32(68.1)		27(56.3)		20(43.5)		20(43.5)		30(66.7)		19（40.4）	
General	26(60.5)		20(45.5)		19(43.2)		17(38.6)		22(50.0)		14（31.8）	
Satisfied	76(85.4)		51(57.3)		52(57.8)		51(56.7)		64(71.9)		39（43.8）	

Very satisfied	50(92.6)	39(73.6)	38(70.4)	37(68.5)	44(81.5)	33(61.1）

Note: *p<0.05, TTMS refers to tuberculosis treatment management service, DOT refers to directly observed therapy, MDR-TB refers to multi-drug resistance tuberculosis, Lower delivery rate refers to a rate below 90%, DOT refers to directly observed therapy

Factors associated with TTMS with lower delivery rate (Continue)

Variable	Providing food or transport assistances for poor TB patient (n=230)		Providing DOT for migrant TB patient at their convenient time (n=235)		Providing subsistence allowance or psychological support for migrant patient (n=236)		Providing injection treatment for MDR-TB patient (n=234)		Providing supervision for newly released prison patient (n=236)		Referring TB patient with mental/psychological problems or alcohol/drug addiction (n=235)		Training cured TB patients to provide peer education (n=237)		Establishing platform for TB patients communication (n=237)	
	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)	N(%)	P(X2)
Gender		0.215		0.153		0.313		0.274		0.669		0.431		0.957		0.845
Female	40(51.3)		72(91.1)		36(45.0)		37(46.3)		46(57.5)		59(74.7)		70(87.5)		47(58.8)	
Male	64(42.7)		130(84.4)		80(51.9)		59(38.8)		93(60.4)		122(79.2)		136(87.7)		89(57.4)	
Age		0.174		0.573		0.243		0.561		0.408		0.242		0.016*		0.783
<30	43(49.4)		74(83.1)		50(56.8)		37(42.5)		57(64.0)		71(79.8)		84(94.4)		55(61.8)	
30-39	26(35.1)		65(86.7)		32(42.1)		26(34.2)		40(52.6)		56(73.7)		61(80.3)		42(55.3)	
40-50	25(53.2)		44(91.7)		22(45.8)		21(43.8)		26(54.2)		39(83.0)		44(91.7)		28(58.3)	
>50	6(50.0)		10(83.3)		7(58.3)		6(50.0)		8(66.7)		7(58.3)		9(75.0)		6(50.0)	
Education		0.847		0.526		0.352		0.198		0.073		0.189		0.136		0.194
Technical secondary school and below	22(44.0)		45(88.2)		23(44.2)		23(45.1)		35(68.6)		43(84.3)		47(90.4)		32(61.5)	
College	64(46.4)		123(87.2)		75(53.2)		60(42.9)		84(59.2)		110(77.5)		127(89.4)		85(59.9)	
University and above	17(41.5)		34(81.0)		18(42.9)		12(28.6)		19(45.2)		28(68.3)		33(78.6)		19(45.2)	
Regions		0.277		0.327		0.104		0.613		0.299		0.343		0.048		0.737
Relatively developed	28(40.6)		63(90.0)		36(50.7)		31(44.3)		44(62.9)		56(80.0)		57(80.3)		39(54.9)	
Medium developed	36(42.4)		77(87.5)		49(57.0)		36(42.4)		54(62.1)		70(80.5)		81(93.1)		53(60.9)	
Less developed	40(52.6)		63(81.8)		32(40.5)		29(36.7)		41(51.9)		56(71.8)		70(88.6)		45(57.0)	

Primary Health Sector Type		0.885		0.498		0.613		0.394		0.127		0.528		0.157		0.768
Township health center	76(45.5)		147(85.5)		87(50.6)		73(42.7)		107(61.8)		135(78.5)		115(89.6)		101(58.4)	
Community health center	28(44.4)		56(88.9)		30(46.9)		23(36.5)		32(50.8)		47(74.6)		53(82.8)		36(56.3)	
Professional Title		0.438		0.327		0.038*		0.004*		0.043*		0.870		0.683		0.789
Non	35(43.8)		67(82.7)		44(62.0)		23(28.4)		47(58.0)		61(76.3)		71(87.7)		43(53.1)	
Junior	50(50.0)		92(89.3)		26(47.3)		55(53.4)		68(64.8)		80(76.2)		94(88.7)		64(60.4)	
Intermediate	9(33.3)		22(78.6)		16(53.3)		9(33.3)		10(37.0)		22(81.5)		22(81.5)		16(59.3)	
Deputy senior	1(33.3)		3(100.0)		31(38.8)		1(33.3)		1(33.3)		2(66.7)		3(100.0)		2(66.7)	
Times of training received in the past six month		0.256		0.579		0.497		0.001*		0.022*		0.140		0.788		0.099
0	6(54.5)		9(81.8)		7(58.3)		6(54.5)		8(72.7)		11(100.0)		10(83.3)		6(50.0)	
1	21(43.8)		41(83.7)		23(46.9)		15(3.5)		22(44.9)		36(73.5)		42(85.7)		30(61.2)	
2	46(39.3)		103(85.1)		55(45.5)		42(35.0)		70(57.4)		90(74.4)		106(86.9)		63(51.6)	
3	20(57.1)		33(94.3)		21(60.0)		25(71.4)		28(80.0)		31(88.6)		32(91.4)		27(77.1)	
>3	11(57.9)		17(89.5)		11(57.9)		8(42.1)		11(57.9)		14(73.7)		18(94.7)		11(57.9)	
Working satisfaction		0.094		0.027*		0.115		0.263		0.452		0.021*		0.114		0.054
Dissatisfied	19(40.4)		38(80.9)		18(37.5)		16(34.0)		24(51.1)		34（72.3）		40(83.3)		24(50.0)	
General	15(35.7)		33(76.7)		23(52.3)		16(36.4)		25(56.8)		28（63.6）		36(81.8)		21(47.7)	
Satisfied	68(43.7)		78(87.6)		42(47.7)		35(40.2)		53(59.6)		70（79.5）		25(50.0)		52(58.4)	
Very satisfied	31(59.6)		52(96.3)		33(61.1)		28(51.9)		36(66.7)		48（88.9）		52(96.3)		39(72.2)	

Note: *p<0.05, TTMS refers to tuberculosis treatment management service, DOT refers to directly observed therapy, MDR-TB refers to multi-drug resistance tuberculosis, Lower delivery rate refers to a rate below 90%, DOT refers to directly observed therapy

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	8，9
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8，9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	10，11
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	10
		(*e*) Describe any sensitivity analyses	10
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11,12
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11,12
		(b) Indicate number of participants with missing data for each variable of interest	11,12
Outcome data	15*	Report numbers of outcome events or summary measures	12-15
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	16-20
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	21
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	21
Generalisability	21	Discuss the generalisability (external validity) of the study results	21
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	22

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.