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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2021-053797
Article Type:	Original research
Date Submitted by the Author:	07-Jun-2021
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Keywords:	Tuberculosis < INFECTIOUS DISEASES, PRIMARY CARE, HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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

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22 **Abstract**

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

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

32 **Setting** Primary healthcare sectors in West China

33 **Results** Our results showed that TTMS delivery rate by HCWs in PHC sectors was <90%  
34 (88.4%) on average, and the delivery rates of intensive and continuation phase DOT were  
35 only 54.7% and 53.0% respectively. HCWs with high working satisfaction and junior title  
36 were more likely to deliver first-time home visit and DOT services. Our results suggested that  
37 barriers to TTMS delivery in organizational level included limited patient-centered  
38 approaches, poor cross-sectional coordination, inadequate resources and incentives, and strict  
39 performance assessment. In patient level, barriers include low socioeconomic characteristics,  
40 poor health literacy, and TB-related social stigma.

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

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5 43 needed to address those barriers in organizational and patient levels to promote TB control  
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8 44 in West China.  
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10 45 **Key words:** tuberculosis, treatment management, healthcare worker, primary healthcare  
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13 46 **Strengths and limitations of this study**  
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16 47 ● This is a mixed method study on accessing the status of and barriers to tuberculosis  
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18 48 treatment management services (TTMS) delivery by healthcare workers (HCWs) in  
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21 49 primary healthcare sectors (PHC) in West China.  
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24 50 ● This study collected both perspectives from organizations and patients followed by using  
25  
26 51 the PRISM model to evaluate specific barriers to TTMS delivery.  
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29 52 ● We collected a total of 720 questionnaires with HCWs and patients, and conducted 16  
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31 53 interviews with leaders, HCWs and patients in totally 71 PHC sectors.  
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34 54 ● Further studies are required to provide more evidence for producing more effective TB  
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36 55 control strategies since well-evidenced implementation strategies that able to address  
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39 56 current barriers in TTMS delivery were not able to be provided in this study.  
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## 64 **Introduction**

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

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

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5 85 DR-TB [3]. Since Chinese National 12th Five-Year TB Control Plan (2011-2015) came out  
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8 86 in 2011, TB control model in China started using the integrated TB control model in most  
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11 87 regions [4]. Under the integrated TB control model, the Centers of Disease Control (CDCs)  
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14 88 are responsible for TB program governance, surveillance, training and health promotion; the  
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16 89 TB designated hospitals are responsible for diagnosis and treatment; and the Primary  
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18 90 Healthcare (PHC) sectors are responsible for referrals, tracing, health education and TB  
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21 91 treatment management services (TTMS) [4]. Later, China's National 13th Five-Year TB  
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24 92 Control Plan (2016-2020) combined with the Action Plan to Stop TB (2019-2022) requested  
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26 93 to further strengthen TB prevention and control which emphasized TTMS and strengthened  
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29 94 the implementation of various measures to reduce TB epidemic in China [2, 5]. In addition,  
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32 95 the new Chinese National Basic Public Health Service (BPHS) Guideline issued in 2017  
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34 96 specifies that TTMS provided by healthcare workers (HCWs) in PHC sectors into 7  
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36 97 themes, including: the first-time home visit, health education, supervising drug intake,  
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39 98 follow-up supervision, case closing evaluation, other services and services among patient's  
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42 99 family members [6]. TTMS is one of the key BPHS programs for all residents in China (one  
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45 100 of the priorities of the new health reform launched in 2009) which are delivered by HCWs in  
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47 101 PHC sectors [5, 6]. The BPHS guideline sets a target to accomplish both standard TTMS rate  
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50 102 and treatment success rate above 90% [5, 6]. TTMS for diagnosed TB patients are delivered  
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53 103 by HCWs in PHC sector under the supervision of CDC with coordination from other  
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55 104 departments, such as assistances from the TB designated hospital to deal with patients  
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58 105 side-effects and supports from department of education to conduct health education to student  
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5 106 population [6]. In China, PHC sectors include the community health centers (CHCs) and  
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8 107 stations in urban areas, township hospital centers (THCs) and village health clinics in rural  
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11 108 areas [3]. The HCWs in PHC sectors who are in charge of TTMS delivery involve HCWs in  
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13 109 CHCs, THCs and village health clinics.

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16 110 Study in Jiangxi indicated that TTMS under the integrated TB control model did improve  
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18 111 treatment outcomes [7]. Study in Wuhan pointed that TTMS was crucial important for  
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20 112 monitoring treatment complications and reducing the development of DR-TB [8, 9]. Other  
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23 113 studies showed that in more developed areas in China, TTMS coverage was highly improved  
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26 114 and produced impressive effects [7, 8, 10-13]. Few studies reported the delivery status to  
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29 115 TTMS delivery in resource-limited and mountain regions with high TB/DR-TB burden in  
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32 116 China. One study found that only 37.1% of TB patients received TTMS by HCWs in West  
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34 117 China [14] and study in Chongqing found that 34.3% of TB patients never received TTMS by  
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37 118 HCWs [15]. However, very few studies focus on the perspective of HCWs to evaluate the  
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39 119 current TTMS program under the integrated TB control model. Therefore, this study not only  
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42 120 aim to assess the delivery status of TTMS program from the perspectives of both  
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45 121 organizations and patients, but also to explore the specific barriers to TTMS delivery faced  
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47 122 by HCWs in PHC sectors to provide evidence for promote TB control and treatment  
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50 123 outcome.

## 51 52 124 **Methods**

### 53 54 55 125 **Study design**

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57 126 Our study utilized mixed research methods to collect data from June 2018 to December 2018.  
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5 127 Questionnaire surveys and semi-structured in-depth interviews were conducted to evaluate  
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8 128 the delivery of TTMS in PHC sectors from both health organizational (CHWs and leaders)  
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11 129 and patient's perspectives.

### 13 130 **Study Setting**

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16 131 The prevalence of TB in the western region was significantly higher than the central and  
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18 132 eastern regions in China [16]. We purposively selected Chongqing municipality (region with  
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21 133 relatively developed socioeconomic status with Gross Domestic Product (GDP) at 2.04  
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23 134 trillion RMB and per capita GDP at 66.2 thousand RMB) and Guizhou province (region with  
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26 135 relatively less developed socioeconomic status with GDP at 1.48 trillion RMB and per capita  
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28 136 GDP at 41.4 thousand RMB) as the study regions [17]. Chongqing's reported TB incidence  
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31 137 rate has dropped from 85.57/100,000 in 2012 to 73.37/100,000 in 2018, and the treatment  
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34 138 success rate has remained above 90%. However, the current epidemic situation of TB in  
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37 139 Chongqing is still severe, with an average of about 23,000 new cases reported each year, and  
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40 140 the reported incidence of TB in 2018 ranked 8th in the country [2]. The TB epidemic status in  
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42 141 Guizhou was more severe which TB incidence ranked 3rd in China [18]. According to the  
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44 142 fifth national TB epidemiological survey, the active and smear positive TB prevalence in  
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47 143 Guizhou were 1226/100,000 and 231/100,000 [19]

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50 144 A stratified random sampling method was used to select study sites based on socioeconomic  
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52 145 developing status. All counties/districts in Chongqing municipality and Guizhou province  
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55 146 were grouped into three levels according to the per capita GDP [17]. A total of twelve  
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57 147 districts/counties were included in this study. All of the PHC sectors (included both CHCs  
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5 148 and THCs) in the 12 selected counties/districts, totally 71 PHC sectors were included in this  
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8 149 study.

## 10 150 **Study participants and data Collection**

### 13 151 *Quantitative study*

15 152 All adult pulmonary TB patients who met the following criteria were targeted for recruitment  
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18 153 from the 71 PHC sectors in the 12 selected counties/districts: (1) registered at TB  
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21 154 dispensaries and were diagnosed as drug-sensitive pulmonary TB patients according to  
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24 155 national TB diagnosis standards, (2) completed standard anti-TB drug treatment for at least 4  
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26 156 months which indicated that received TTMS for both intensive (first 2 months) and  
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29 157 continuation phases (following 4 months), (3) aged 15 years and older. Patients who: (1) with  
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32 158 extra-pulmonary TB, (2) could not express themselves clearly (had disturbance of  
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34 159 consciousness or difficulties with speech or hearing), (3) unwilling to participated in the  
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37 160 study were excluded. Patient recruitment was facilitated by TB dispensaries in the study  
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40 161 counties/districts. First, research group members provided a detailed explanation about the  
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42 162 study objectives to all potential participants. Then, those who were willing to participate in  
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45 163 the study were asked to read and sign the informed consent form to assure of confidentiality.

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47 164 All HCWs who were working at the selected 71 PHC sectors and met the following criteria  
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50 165 were targeted for recruitment: (1) responsible for the TB prevention and control program, (2)  
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52 166 in charge of TTMS delivery to TB patients. HCWs who: (1) didn't work at the PHC sectors  
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55 167 in selected county/district, (2) didn't responsible for the TB prevention and control program,  
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58 168 (3) didn't provide TTMS for TB patients were excluded in this study.

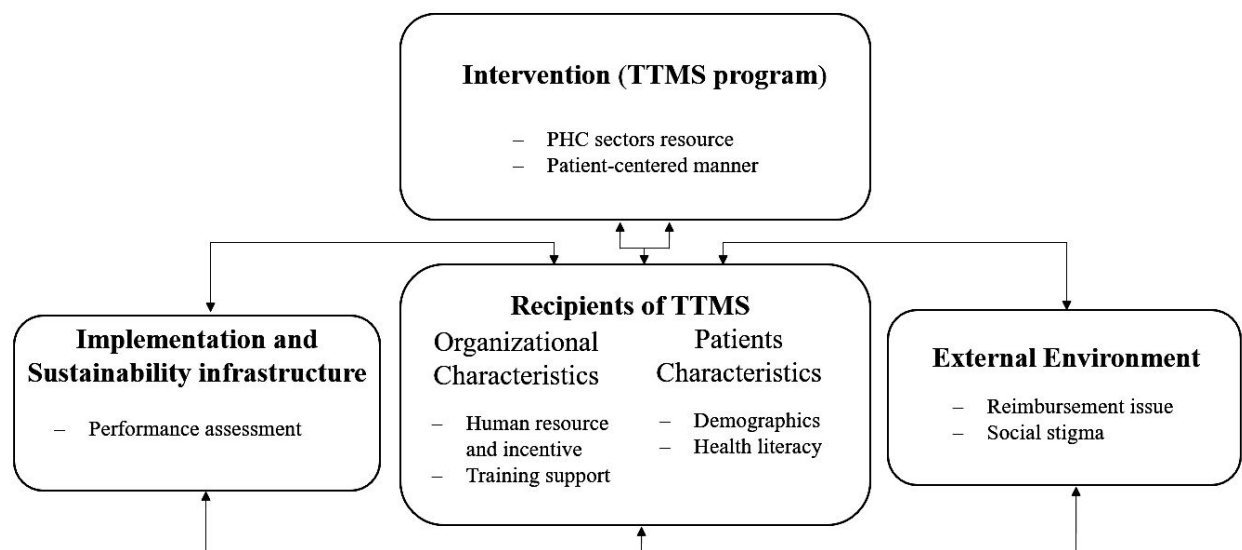
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5 169 Structured questionnaires were conducted to collect data among the participated TB patients  
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8 170 and HCWs. Among TB patients, structured survey involved demographic information (such  
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11 171 as gender, age, and residence), and TTMS received from HCWs during treatment (such as  
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13 172 intensive phase DOT and continuation phase DOT). Among HCWs, the questionnaire  
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16 173 included demographic and working-related information (such as gender, age, professional  
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18 174 title, and working years), working satisfaction, and delivery situation of TTMS (such as the  
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21 175 first-time home visit). Questionnaires were designed by our research team based on the  
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24 176 existing literature reports, and then consulted related experts. All questionnaires were  
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26 177 executed by trained investigators from our research group in a meeting room or clinic room at  
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29 178 each PHC sector. HCWs, who were willing to voluntary participated in the study, were asked  
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32 179 to read the informed consent form and then sign the informed consent form. Each completed  
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34 180 questionnaire was checked and examined by trained investigators for quality control.

### 181 *Qualitative study*

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39 182 In-depth interviews were utilized to explore the current status and identify barriers to the  
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42 183 TTMS delivery from HCWs to TB patients. Purposive sampling method was used to selected  
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45 184 participants for in-depth interview and the sample size was decided by the point of data  
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47 185 ‘saturation’. In-depth interviews were conducted with nine purposely selected local CDC and  
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50 186 Health Commission leaders, five HCWs and two TB patients.

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52 187 Semi-structured topic guides with open-ended questions were used for interviews. The  
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55 188 guiding framework for the topic design was the Practical Robust Implementation and  
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57 189 Sustainability Model (PRISM) [20]. This model considered how the intervention design,  
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5 190 recipients, external environment, and implementation and sustainability infrastructure  
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8 191 influence health program implementation and success, which widely used as theoretical  
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11 192 framework in implementation research [20-22]. With the guide of the PRISM, this study  
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14 193 collected data on barriers on TTMS delivery in the following aspects: (1) intervention design;  
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16 194 (2) recipients; (3) external environment; and (4) implementation and sustainability  
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19 195 infrastructure. The adaptation of PRISM for this study is illustrated in Figure1. All interviews  
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21 196 were conducted in Mandarin or local language at the meeting rooms in PHC sectors. Each  
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24 197 interview lasted about 40-60 minutes and was audio-recorded with consent of the  
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26 198 participants.



199  
200 **Figure 1** Adapted PRISM for barriers on TTMS delivery in PHC sectors. This figure presents  
201 the four core domains of the Practical Robust Implementation and Sustainability Model  
202 (PRISM) for barriers on TTMS delivery in PHC sectors, including: 1) TTMS program  
203 design; 2) the recipients, 3) the external environment, and 4) the implementation and  
204 sustainability infrastructure. Activated elements for each domains were presented in boxes.  
205 Notes: *TTMS* refers to tuberculosis treatment management service; *PHC* refers to primary  
206 healthcare; *HCW* refers to healthcare worker).

## 207 Data analysis

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5 208 ***Quantitative analysis***  
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8 209 Data were entered using Epi Data 3.1 and then analyzed using the Statistical Package for the  
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10 210 Social Sciences (SPSS 22.0 (IBM Corporation, Armonk, NY, USA)). Missing data were  
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13 211 excluded during analyze. A two-tailed probability level of  $p < 0.05$  was chosen as the level of  
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16 212 statistical significance. Missing data were excluded from analysis. Descriptive statistics were  
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18 213 used to describe study participants' demographic characteristics and TTMS delivery rates.  
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21 214 According to the 13th Five-Year TB Prevention and Control Plan, the targeted TTMS  
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24 215 delivery rate from HCWs to TB patients is  $>90\%$  [5]. Therefore, delivery rate below 90% is  
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26 216 described as lower delivery rate in this manuscript. Factors associated with lower delivery  
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29 217 rate ( $<90\%$ ) screened by the Chi-square test ( $p < 0.05$ ) (Appendix A) were entered into  
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31 218 multivariate logistic regression models (delivery rate  $<90\% = 1$ , delivery rate  $>90\% = 0$ ),  
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34 219 which were used to examine the effects of those factors on TTMS delivery.  
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36 220 ***Qualitative analysis***  
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39 221 The framework approach was used to analyze all qualitative data following a five steps  
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42 222 process: (1) familiarization, (2) creating theoretical framework, (3) indexing, (4)  
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45 223 summarizing and (5) data synthesis and interpretation [23-24]. Following that, all interviews  
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47 224 were carefully transcribed into Word Documents, reviewed for accuracy, and then being  
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50 225 coded and classified by our research team members. We identified themes on TTMS delivery  
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53 226 barriers for four domains of the PRISM, including: (1) intervention design (PHC sectors  
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55 227 resource and patient-centered manner); (2) the recipients (human resource and incentives,  
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58 228 training support, socio-economy and health literacy); (3) external environment (health  
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5 229 insurance, cross-sectional coordination, and social stigma); and (4) implementation and  
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8 230 sustainability infrastructure (performance assessment). All the names of participants were  
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11 231 removed in quotations of the results to keep anonymity.

## 13 232 **Patient and public involvement**

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16 233 There were no patients or public involvement in the design, conduct, reporting and in the  
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18 234 dissemination plans of this research.

## 21 235 **Results**

### 23 236 **Characteristics of participants**

#### 26 237 *Participants for the quantitative study*

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29 238 Total of 261 HCWs and 459 TB patients completed the questionnaire survey (Table 1).  
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31 239 Among the HCWs, 66.4% (172) were female, 71.5% (178) were aged 20-40 years old, 70%  
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33 240 (189) worked at THCs, 50.0% and 35.8% had junior and non-professional titles respectively.  
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35 241 Near 60% of the HCWs had junior college education and over 80% had medical school  
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37 242 education background (32.4% majored in clinical medicine and 30.5% majored in nursing).  
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39 243 More than half (56.4%) of the HCWs undertook 2-3 BPHS programs in PHC sector, and only  
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41 244 7.6% were dedicatedly in charge of TB program. The majority (67.5%) had a monthly  
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43 245 income of 2500-4500 CNY, and notably, 40.5% reported low working satisfaction.  
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45 246 Among the TB patients, the majority of the patients were male (70%), married (69.7%), Han  
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47 247 ethnicity (78.2%), and 41.6% were aged  $\geq 60$ . 82.4% of the patients were rural residences  
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49 248 and 95.2% were permanent residences. Almost 70% of the patients were farmer/migrant  
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51 249 workers, and 56.0% had only primary/below education.  
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250 ***Participants for the qualitative study***

251 9 leaders, 5 HCWs, and 2 patients were interviewed. Most leaders were male (7/9) with  
 252 deputy senior titles (5/9) and worked for 7.6 years on average. The majority of HCWs were  
 253 technical secondary school educated (4/5) and majored in clinical medicine (4/5), 4/5 came  
 254 from CHCs with had none or junior professional titles. Besides, among the 2 interviewed  
 255 patients, aged mid-20s and late-50s respectively, both of them completed anti-TB therapy.

256 **Table 1** Demographic characteristics of the participants for quantitative study

Demographic characteristic	Number	Percentage
<b><i>HCWs in questionnaire survey</i></b>		
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)		



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5	Township health center	189	72.4
6	Community health center	72	27.6
7	Professional Title (n=240)		
8	Non	86	35.8
9	Junior	120	50.0
10	Intermediate	31	12.9
11	Deputy senior	3	1.3
12			
13			
14	Number of BPHS programs undertook (n=225)		
15	TB program only	17	7.6
16	2-3	127	56.4
17	≥4	80	36.0
18			
19	Monthly Income (n=242)		
20	<2500	52	21.5
21	2500-3500	89	36.8
22	3500-4500	74	30.6
23	>4500	27	11.2
24			
25			
26	Working satisfaction (n=259)		
27	High satisfaction	58	22.4
28	Middle satisfaction	96	37.1
29	Low satisfaction	105	40.5
30			
31	<b><i>TB patients in questionnaire survey</i></b>		
32	Gender (n=459)		
33	Male	324	70.6
34	Female	135	29.4
35			
36	Age (n=459)		
37	<40	94	20.5
38	40-49	96	20.9
39	50-59	78	17
40	≥60	191	41.6
41			
42	Ethnicity (n=459)		
43	Han	359	78.2
44	Ethnic minority	100	21.8
45			
46	Marital status (n=459)		
47	Single	69	15.0
48	Married	320	69.7
49	Divorced/Widowed	70	15.3
50			
51	Residence (n=459)		
52	Urban	81	17.6
53	Rural	378	82.4
54			
55	Registered information (n=459)		
56	Permanent resident	437	95.2
57	Migrant	22	4.8
58			
59			
60			

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.

## 257 Quantitative results about TTMS delivery status

258 TB patient's survey showed that 76.0% (349) of the patients ever received TTMS from  
 259 HCWs in CHCs during the whole course of treatment (it was 83.7% and 76.7% during their  
 260 intensive and continuation phase respectively). Just around 40.0% ever received TTMS from  
 261 HCWs in THCs/village clinics during their whole course of treatment (it was 45.1% and  
 262 42.3% during intensive and continuation phase respectively). Only 17.0% received standard  
 263 TTMS from HCWs during the whole course of treatment (it was 18.1% and 55.8% for  
 264 intensive and continuation phase respectively). 2.8% were never received TTMS from HCWs  
 265 (it was 3.9 % and 7.2% during intensive and continuation phase respectively). (Table 2)

266 **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.

267 HCWs' survey showed that the average delivery rate of TTMS (involved totally 60 service  
 268 items) in PHC sectors was 88.4 %, and 13 TTMS items reported a lower delivery rate  
 269 (<90%). Notably, the delivery rates of DOT in intensive phase and continuation phase were  
 270 low, with only 54.7% and 53.0% respectively. Besides, less than half (44.9%) of HCWs in  
 271 PHC sectors provided service of collecting patients' sputum samples during the follow-up  
 272 supervision. Less than half of the HCWs provided food or transport assistances for poor TB  
 273 patient (45.2%), provided subsistence allowance or psychological support for migrant patient  
 274 (49.6%), and provided injection treatment for MDR-TB patient (41.0%). Moreover, less than  
 275 60% provided supervision for newly released prison patient (58.9%) and established platform  
 276 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 (%)
<b><i>First time home visit</i></b>	
Patients' peer supervision establish (n=235)	185 (78.7)
<b><i>DOT</i></b>	
Intensive phase DOT (n=236)	129 (54.7)
Continuation phase DOT (n=236)	125 (53.0)
Regular medicine delivery (n=234)	160 (68.4)
<b><i>Follow-up supervision</i></b>	
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

278 **Factors associated with TTMS with lower delivery rate**

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

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**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)
<b>Gender</b>							
Female	Reference			Reference			
Male	0.577 (0.258-1.270)			0.605(0.320-1.147)			
<b>Age</b>							
>50		Reference					
40-50		2.053(0.985-4.279)					
30-39		2.230(0.947-5.248)					
<30		Default					
<b>Professional Title</b>							
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(0.432-2.999)	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(0.131-20.581)	0.809(0.054-12.031)	2.534(0.179-35.887)
<b>Training frequency</b>							
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(0.729-11.466)	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)
<b>Working satisfaction</b>							
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.

293 **Qualitative results about barriers to TTMS delivery**

294 The in-depth interviews disclosed numerous barriers to TTMS delivery from the four core

295 PRISM domains as follows (Table 5):

296 **Table 5** Barriers of TTMS delivery by HCWs in PHC sectors

Core PRISM domains	Results	Quotations
Intervention: TTMS program	<p><b>Patient-centered manner:</b> 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.</p>	<p><i>Got telephone calls during the first 2 months, very few afterwards...I didn't like (DOT). (Mid-20s patient)</i> <i>There is one MDR-TB patient...say it is annoying to call him every day (by us to deliver TTMS program). (HCW)</i> <i>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)</i></p>
Recipients	<p><b>Resources and incentive in PHC sectors:</b> Majority HCWs and leaders stated that PHC sectors, particularly THCs faced insufficient human resource HCWs to deliver TTMS program. HCWs often undertook &gt;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.</p>	<p><i>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)</i> <i>Insufficient and unstable HCWs ...one HCW leave, then we need to train a new one...(CDC leader)</i> <i>HCWs, especially at TCHs, low quality, patients don't trust them. (CDC leader)</i> <i>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)</i> <i>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)</i> <i>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)</i></p>

	<p><b>Training support to HCWs in PHC sectors:</b> 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.</p>	<p><i>2-3 TB trainings each year, from CDC...combined with other (BPHS) trainings...and I think this training is not effective.(HCW)</i></p>
	<p><b>Patient's socio-economy:</b> 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.</p>	<p><i>During treatment in later period, I didn't (take sputum examination), no money, no money for transportation. (Late-50s patient)</i> <i>Because TB itself is a "disease of the poor", most TB patients have financial difficulties with bad lifestyles and poor literacy. (HC leader)</i> <i>Migrant patients are hard to reach...some have no stable work and often change their phone numbers...don't like TTMS. (HCW)</i> <i>I told him/her the dangerousness and seriousness of MDR-TB, he/she still didn't keep treatment, only told me: 'no money'. (HCW)</i></p>
	<p><b>Patient's health literacy:</b> 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.</p>	<p><i>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)</i></p>
External environment	<p><b>Health insurance:</b> 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.</p>	<p><i>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)</i></p>
	<p><b>Cross-sectional coordination:</b> 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.</p>	<p><i>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)</i> <i>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)</i></p>
	<p><b>Social stigma:</b> 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.</p>	<p><i>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)</i> <i>Some TB patients don't like us to go to their home for home-visit... (They are)</i></p>

		<i>worried about how people around would think of them. (HCW)</i>
Implementation and Sustainability infrastructure	<p><b>Performance assessment:</b> 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.</p>	<p><i>(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)</i> <i>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)</i></p>

Note: *TB* refers to tuberculosis, *MDR-TB* refers to multidrug-resistant tuberculosis, *TTMS* refers to tuberculosis treatment management services, *DOT* refers to directly observed therapy, *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.

### 297 **1) Interventions**

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

### 301 **2) Recipients:**

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



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5 310 workload and infection risk of TB. In addition, out-of-pocket expenditure for transportation  
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8 311 and telephone charge for TTMS delivery could further influence HCW's working motivation,  
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10 312 performance, and attrition. Moreover, inadequate qualified training (the content lack of  
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12  
13 313 communicational and professional knowledge for TTMS delivery, and the training approach  
14  
15  
16 314 of TB trainings mixed with other BPHS programs and lacking of high quality TB-specific  
17  
18 315 training for HCWs ) supports for TB HCWs were also reported by interviewers. So current  
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20  
21 316 training could not provide much support in HCWs' capabilities and performance.

22  
23  
24 317 In terms of patient characteristics, the majority of interviewers claimed that TB is a disease of  
25  
26 318 the poor and most TB patients were disadvantaged group (aging, low education, migrant and  
27  
28 319 financial difficulty), who had poor TB-related health literacy and had high risk to reject  
29  
30  
31 320 TTMS. HCWs also mentioned the hardship to deliver TTMS among migrant patients due to  
32  
33  
34 321 hard to reach them.

### 322 **3) External environment:**

323 On the one hand, inadequate health insurance coverage for medicines and tests related to  
324  
325 side-effects accentuated financial burden among poor TB patients and reduced willingness to  
326  
327 receive TTMS. On the other hand, difficulties in cross-sectional coordination to assist TTMS  
328  
329 delivery were reported, especially supports from TB designated hospitals and also other  
330  
331 departments like departments of public security and education. Furthermore, TB-related  
332  
333 social stigma was reported as one of the main barriers to conduct home-visits among urban  
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335 patients who care much privacy and were more likely to refuse to accept home-visits from  
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5 331 **4) Implementation and sustainability infrastructure:**  
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8 332 The performance assessment for TB HCWs might exist irrationality considering their heavy  
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10 333 workload. One leader pointed out that to the purpose of TTMS delivery could become to  
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12 334 complete the targeted indicators, and therefore, lead to substandard TTMS to patients.  
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14 335 Moreover, inappropriate performance assessment also hinder working motivation and  
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16 336 increased working attrition among HCWs to deliver TTMS.  
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21 337 **Discussion**  
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23 338 In China, HCWs in PHC sectors are considered as an important part of the TB integrated  
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25 339 model and taking responsibility for TTMS delivery. This study assessed the delivery of  
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27 340 TTMS program by HCWs in PHC sectors in West China. Though we found that the TTMS  
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29 341 delivery rates in intensive phase and continuation phase were higher than previous study in  
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31 342 West China [14], the standard TTMS (at least 24 times TTMS during their treatment course)  
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33 343 delivery rate is far below the required rate of >90% according to the National TB Control  
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35 344 Plan [5]. Besides, our study showed that TB patients received DOT from HCW in CHCs (in  
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37 345 urban regions) was higher than that from HCW in THCs (in rural regions). This difference  
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39 346 might be explained by our qualitative results as interviewed HCWs reported the challenges to  
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41 347 delivery TTMS to remote rural patients due to patients' poor health literacy which is also  
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43 348 reported in other studies [16, 25], and our study also pointed the far away distance with  
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45 349 insufficient transportation tools for HCWs blocked TTMS delivery. In addition, our study  
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47 350 revealed that less than half of HCWs provided services of collecting patients' sputum  
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49 351 samples during follow-up supervision, which is much lower than the result reports in the  
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5 352 study in Guizhou (96.56%) [25]. Furthermore, we found a low level of working satisfaction  
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8 353 (22.4%) among TB HCWs, while, it is higher than previous study (12.2%) [26]. Our study  
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10 354 results indicated that HCWs with low working satisfaction were more likely to have a low  
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13 355 delivery rate of first-time home visit, DOT, and sputum sample collection services. Efforts  
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16 356 should be made to maintain and promote HCWs' working satisfaction to enhance TTMS  
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18 357 delivery.

21 358 Our study disclosed that the current TTMS delivery was confronted with various barriers,  
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24 359 despite that TB HCWs in PHC sectors carried out TTMS program had made many  
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26 360 achievements in West China. In the organizational level, we found that the TTMS programs  
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29 361 itself existed several barriers for HCWs to delivery services. On the one hand, the national  
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31 362 TB action plans and nationwide TB survey in China [2, 8, 27] mentioned the cross-sectional  
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34 363 coordination for TTMS delivery, however, we found that HCWs in PHC sectors still lack of  
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36 364 well coordination with other departments, such as coordination from department of education  
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39 365 to support students treatment management, help from department of public security to trace  
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42 366 migrant patients' information. Particularly, HCWs from some PHC sectors faced barriers to  
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45 367 access timely connections with TB HCWs from TB designated hospital in addressing TB  
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47 368 patients' side effects and treatment adherence. It is difficult to realize the participation of the  
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50 369 whole society in TB control in China so far [28]. As the call by the Action Plan to Stop TB  
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52 370 (2019 to 2022) in China [2], it is an emergent need to build a multi-sectorial collaboration  
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55 371 mechanism led by the National Health Commission (NHC) in order to coordinate  
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57 372 cross-sectional efforts to support TB prevention and control program [29].  
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5 373 The second barrier emerged at health organizational level is the approaches to delivery  
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8 374 TTMS. We found TTMS were mainly delivered by telephone call, which consistent with  
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11 375 previous studies in West China [14, 28], and the insufficient patient-centered manners could  
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13 376 resulted in patients' rejects to DOT and TTMS by HCWs. Although researches showed that  
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16 377 home-visits and DOT did led to positive treatment outcome [29, 30], our study pointed out  
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18 378 the need to provide TTMS with e-health approach, which was consistent with previous  
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21 379 studies, and previous studies demonstrated the effectiveness of e-health technology for  
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24 380 promoting patients' treatment adherence [31-36]. It is deserved to explore internet-based case  
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27 381 management model, such as digital supported self-management, and with the help of HCWs  
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29 382 in PHC sectors to deliver TTMS to TB patients who live in remote mountain area or against  
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31 383 face-to-face DOT.

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34 384 The third barrier in organizational level is the health human resource for TTMS in PHC  
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37 385 sectors. Other studies reported that PHC sectors especial in rural areas had a limited number  
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40 386 of HCWs to conduct BPHS programs which led to heavy workload and "shortage of hands"  
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42 387 since HCWs often carried out multiple assigned services [37-39]. We consistently found that  
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45 388 PHC sectors, particularly in THCs, faced human resource barriers in terms of insufficient  
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47 389 number and inadequate professional capability to deliver TTMS program. On the one side,  
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50 390 our study showed that heavy workload with multiple BPHS programs could led to hardship to  
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52 391 deliver standard TTMS to TB patients. On the other side, we found that inadequate  
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55 392 professional capability, especially village doctors, could led to patients' distrusts and hence  
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57 393 impeded TTMS delivery. Simultaneously, our study disclosed that PHC sectors lack of  
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5 394 adequate TB training for HCWs, particularly training related to communicational and  
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8 395 professional knowledge for TTMS delivery resulted in substandard TTMS. Other studies  
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11 396 proved the on-the-job training is important to improve professional skills among HCWs [28,  
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13 397 38, 40, 41], especially trainings emphasized both knowledge and practice [42]. Furthermore,  
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16 398 we found that the performance assessment for HCWs in TTMS program may exist  
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18 399 irrationality regarding their heavy workload which led to hardship to deliver standard TTMS  
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21 400 and hindered their working enthusiastic.

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23 401 In addition, our results showed that PHC sectors lack of sufficient funding for TTMS  
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26 402 program, and most HCWs unsatisfied with low salary, allowance or subsidy which was  
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29 403 consistent with other study [25]. Many research also indicated that the diverse issues of  
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31 404 financial incentives combined with heavy workload could influence HCW's motivation and  
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34 405 performance [38, 43-46]. The appropriate use of incentives for HCWs is a means of  
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37 406 promoting health outcomes with a direct impact on the effectiveness and sustainability of a  
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40 407 health program, and also able to improve services delivery through enhancing motivation and  
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42 408 reducing attrition [42]. Notably, we found that HCWs faced out-of-pocket expenditure for  
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45 409 transportations and telephone charges for TTMS delivery which could further impact their  
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47 410 work enthusiastic.

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50 411 Our results also identified barriers in patient level to TTMS delivery included their  
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52 412 susceptible socioeconomic characteristics (aging, low education, migrant, and poor financial  
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55 413 status) and lower literacy related to TB control. Previous nationwide TB epidemiology  
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58 414 survey in China revealed that near half (48.8%) of the TB patients were aged  $\geq 60$ , less  
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5 415 educated, and over 80% of TB patients had household incomes below local levels [16]. Our  
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8 416 results indicated that poor socioeconomic characteristics and low TB-related health literacy  
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10 417 together highly impeded TTMS delivery. As patients with low socioeconomic features were  
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13 418 often found with lower education background, poor health literacy, and more likely to be  
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16 419 have nonadherence, hence, they more likely to refuse to HCWs' supervision, which is  
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19 420 consistent with other studies [16, 47]. In addition, we found that TTMS delivery among  
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21 421 migrant patients was challenging for HCWs due to hard to reach. Other studies also reported  
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24 422 that migrant patients with frequently movement and low socioeconomic status had relatively  
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26 423 poorer TB-related awareness [48-50] which could future hindered TB case management.  
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29 424 Previous studies revealed that West China had a higher proportion of rural mountain areas as  
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32 425 well as domestic migrants compared with other regions in China, and TB-related awareness  
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34 426 among rural, less educated, and migrants was particularly serious [16, 48, 50-52].  
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37 427 Our study also discovered that the health insurance cannot cover all medicines and tests  
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39 428 related to side-effects which accentuated financial burden among poor TB patients and led to  
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42 429 hardship for TTMS delivery. In order to relief barriers from TB patients, on the one hand,  
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45 430 addressing financial burden due to TB treatment among poor patients is crucial.  
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47 431 Notwithstanding, previous national TB epidemiology survey in China reported that over 90%  
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50 432 of TB patients had medical insurance combined with the policy of free TB diagnosis and  
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52 433 treatment, the proportion of out-of-pocket among patients was still around 75.0%-84.2% [16].  
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55 434 Studies and reports mentioned the necessary to increase reimbursement ratio and amount for  
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57 435 TB treatment, to expand the scope of current free TB treatment policy, and to strengthen care  
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5 436 and assistance for TB patients [2, 5, 31]. Particularly need to target DR-TB and impoverished  
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8 437 patients with transportation, accommodation and nutrition allowance during TTMS delivery  
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11 438 to promote TB control outcomes.

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13 439 On the other hand, promoting TB-related health literacy among patients and enhancing  
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16 440 TB-related awareness among the public are urgently necessary. As our study revealed that  
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18 441 not only poor TB health literacy is a barrier from patients, TB-related social stigma also  
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21 442 impeded TTMS delivery especially in urban areas. Previous studies suggested to provide  
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24 443 easily understandable TB health education to particular target population (the aged, less  
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26 444 educated, close contacts, etc.) with certain modes of health education [16, 51]. Other study  
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29 445 indicated that a combination of mass media approaches and interpersonal communications  
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32 446 between patients and HCWs could lead to more effective TB control [52]. Similarly, Chinese  
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34 447 Action Plan to Stop TB called for various publicity activities to raise awareness of TB which  
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36 448 includes traditional media such as television broadcasting and newspaper, and also the use of  
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39 449 new media such as WeChat to promote dissemination of scientific TB knowledge and  
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42 450 eliminate social discrimination [2].

#### 44 451 ***Strengthens and limitations***

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47 452 Our study used a mixed research method combining quantitative research (questionnaire  
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50 453 survey) with qualitative research (semi-structured, open-ended in-depth interviews) to assess  
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53 454 TTMS program delivery by HCWs in PHC sectors. Perspectives from organizations and  
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55 455 patients were both included by using the PRISM model to evaluate specific barriers to TTMS  
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58 456 delivery. Three levels of the local health organization were all involved in our study, which  
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5 457 contained the HCWs as the frontline staffs, the CDC leaders as the managers, and the Health  
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8 458 Commission leaders as the policy makers. However, there are a number of limitations in the  
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11 459 current study. First, the sample size of both questionnaire survey and in-depth interviews  
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13 460 could be further expanded to enhance the representativeness of study. Second, as we only  
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15 461 explore the status of and barriers to TTMS delivery by HCWs in PHC sectors,  
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17 462 well-evidenced implementation strategies that able to solve current problems successfully  
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19 463 were not able to be provided in this study. Further studies are required to provide more  
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21 464 evidence for producing more comprehensive and effective TB control strategies.  
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## 26 465 **Conclusion**

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28 466 All the engagements of HCWs in TTMS program suggests that the government realized the  
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31 467 importance of HCWs in PHC sectors in promoting TB patients treatment adherence and  
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33 468 outcomes and underscored their integration into the TB control model. We identified barriers  
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35 469 operating in organizational level (cross-sectional coordination, patient-centered approach,  
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37 470 resources and incentives, training support, reimbursement issue, and performance  
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39 471 assessment) and patient level (socioeconomic characteristics, health literacy and social  
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41 472 stigma) to TTMS delivery by HCWs in PHC sectors. There is an urgent need to identify  
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43 473 comprehensive measures to effectively overcome barriers to TTMS delivery and further  
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45 474 promote TB control in West China.  
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52 475 **Acknowledgements** We would like to thank the participants who responded our  
53  
54 476 questionnaires. We also thank all leaders and healthcare workers in the PHCs in study places  
55  
56 477 who supported this study by facilitating implementation of the field questionnaire survey and  
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58 478 participated in our interviews.  
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5 479 **Contributions** JZ, JP and YL have designed this survey, JZ, JP, GW, WX, TZ, SL and QW  
6  
7 480 have collected data, JZ, JP, RZ, YC and JL have managed and analyzed data, YL and DH  
8  
9 481 have controlled the quality of data collection and analysis, JZ has drafted the manuscript. YL  
10  
11 482 has edited the manuscript. All authors have interpreted the results, revised the report and  
12  
13 483 completed the final version. The author(s) read and approved the final manuscript.

14  
15 484 **Funding** The study was funded by the National Natural Science Foundation of China  
16  
17 485 (No.81773489), the Chongqing outstanding youth project (No.cstc2020jcyj-jq0035), Social  
18  
19 486 Science and Technology Innovation Subject in Chongqing (No.cstc2015shmszx120070).

20  
21 487 **Disclaimer** The funders had no role in study design, data collection and analysis,  
22  
23 488 interpretation of the data, writing the paper and the decision to submit the paper for  
24  
25 489 publication.

26  
27 490 **Competing interests** Not declared

28  
29 491 **Patient consent** Obtained.

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31 492 **Ethics approval** Ethics approval was obtained from the Institutional Review Board of Army  
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33 493 Medical University (Third Military Medical University), Chongqing, China  
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35 494 (No.AF/SC-08/1.0) before starting the study. This study was conducted in accordance with  
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37 495 the Declaration of Helsinki. A full explanation of the purpose and procedure of the study was  
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39 496 provided to participants prior to obtain their written informed consent. All demographic data  
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41 497 and quotes used in this study were deidentified to maintain the anonymity of participants.

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43 498 **Provenance and peer review** Not commissioned; externally peer reviewed.

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45 499 **Data availability statement** Data are available upon reasonable request.

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47 500 **Supplemental material** This content has been supplied by the author(s). It has not been  
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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)
<b>Gender</b>		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)	
<b>Age</b>		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)	
<b>Education</b>		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)	
<b>Regions</b>		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)	
<b>Primary Health Sector Type</b>		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(69.5)		79(45.9)	
Community health center	44(69.8)		35(55.6)		32(51.6)		31(50.0)		39(63.9)		27(42.2)	
<b>Professional Title</b>		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)	
<b>Times of training received in the past six month</b>		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)	
<b>Working satisfaction</b>		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)	

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

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

3 a rate below 90%, DOT refers to directly observed therapy

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17 **Factors associated with TTMS with lower delivery rate (Continue)**

18 Variable	19 Providing food or transport assistances for poor TB patient (n=230)	20 Providing DOT for migrant TB patient at their convenient time (n=235)	21 Providing subsistence allowance or psychological support for migrant patient (n=236)	22 Providing injection treatment for MDR-TB patient (n=234)	23 Providing supervision for newly released prison patient (n=236)	24 Referring TB patient with mental/psychological problems or alcohol/drug addiction (n=235)	25 Training cured TB patients to provide peer education (n=237)	26 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)	
27 <b>Gender</b>		0.215	0.153	0.313	0.274	0.669	0.431	0.957	0.845
28 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)
29 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)
30 <b>Age</b>		0.174	0.573	0.243	0.561	0.408	0.242	0.016*	0.783
31 <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)
32 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)
33 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)
34 >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)
35 <b>Education</b>		0.847	0.526	0.352	0.198	0.073	0.189	0.136	0.194
36 Technical									
37 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)
38 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)
39 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)
40 <b>Regions</b>		0.277	0.327	0.104	0.613	0.299	0.343	0.048	0.737
41 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)
42 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)
43 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)

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		0.885	0.498	0.613	0.394	0.127	0.528	0.157	0.768
<b>Primary Health Sector Type</b>									
1 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)	
2 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)	
<b>Professional Title</b>		0.438	0.327	0.038*	0.004*	0.043*	0.870	0.683	0.789
3 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)	
4 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)	
5 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)	
6 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)	
<b>Times of training received in the past six month</b>		0.256	0.579	0.497	0.001*	0.022*	0.140	0.788	0.099
7 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)	
8 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)	
9 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)	
10 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)	
11 >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)	
<b>Working satisfaction</b>		0.094	0.027*	0.115	0.263	0.452	0.021*	0.114	0.054
12 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)	
13 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)	
14 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)	
15 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 #
<b>Title and abstract</b>	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
<b>Introduction</b>			
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
<b>Methods</b>			
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
<b>Results</b>			

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	
<b>Discussion</b>			
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
<b>Other information</b>			
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](http://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:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2021-053797.R1
Article Type:	Original research
Date Submitted by the Author:	15-Feb-2022
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<b>Primary Subject Heading</b>:	Health services research
Secondary Subject Heading:	Health services research, Infectious diseases
Keywords:	Tuberculosis < INFECTIOUS DISEASES, PRIMARY CARE, HEALTH SERVICES ADMINISTRATION & MANAGEMENT



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6 1 **Tuberculosis treatment management in primary health**  
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8 2 **care sectors: a mixed-methods study investigating delivery**  
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10 3 **status and barriers from organizational and patient**  
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18 6 Jiani Zhou<sup>1</sup>, Jie Pu<sup>1</sup>, Qingya Wang<sup>2</sup>, Rui Zhang<sup>1</sup>, Shili Liu<sup>1</sup>, Geng Wang<sup>1</sup>, Ting Zhang<sup>2</sup>, Yong  
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## 22 **Abstract**

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

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

32 **Setting** Primary healthcare sectors in Southwest China

33 **Results** Our results showed that TTMS delivery rate by HCWs in PHC sectors was <90%  
34 (88.4%) on average, and the delivery rates of intensive and continuation phase DOT were  
35 only 54.7% and 53.0% respectively. HCWs with high working satisfaction and junior title  
36 were more likely to deliver first-time home visit and DOT services. Our results suggested that  
37 barriers to TTMS delivery at organizational level included limited patient-centered  
38 approaches, inadequate resources and incentives, insufficient trainings, poor cross-sectional  
39 coordination, and strict performance assessment. At patient level, barriers include low  
40 socioeconomic characteristics, poor health literacy, and TB-related social stigma.

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

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5 43 are urgent needed to address those barriers in organizational and patient levels to promote  
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8 44 TB control in Southwest China.  
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10 45 **Key words:** tuberculosis, treatment management, healthcare worker, primary healthcare  
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13 46 **Strengths and limitations of this study**  
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16 47 ● This is a mixed method study on accessing the status of and barriers to tuberculosis  
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18 48 treatment management services (TTMS) delivery by healthcare workers (HCWs) in  
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20 49 primary healthcare sectors (PHC) in Southwest China.  
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23 50 ● This study collected both perspectives from organizations and patients followed by using  
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25 51 the PRISM model to evaluate specific barriers to TTMS delivery.  
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28 52 ● We collected a total of 720 questionnaires with HCWs and patients, and conducted 20  
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30 53 interviews with leaders, HCWs and patients in totally 71 PHC sectors.  
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33 54 ● Further studies are required to provide more evidence for producing more effective TB  
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35 55 control strategies since well-evidenced implementation strategies that able to address  
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37 56 current barriers in TTMS delivery were not able to be provided in this study.  
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## 64 **Introduction**

65 Tuberculosis (TB) is one of the leading causes of death worldwide [1]. According to the  
66 World Health Organization (WHO) global TB report 2021, there was a large global drop in  
67 the number of newly diagnosed TB (fall from 7.1 million in 2019 to 5.8 million in 2020) [1].  
68 However, the most immediate consequence of the large drop is an increase in the number of  
69 deaths from TB in 2020 (raised from an estimated 1.2 million deaths among HIV-negative  
70 people in 2019 to an estimated 1.3 million in 2020) [1]. The Chinese government pays high  
71 attention to addressing the TB epidemic and sets the goal of reducing the incidence of TB to  
72 less than 55/100,000 population by 2022 and maintaining a low mortality rate below  
73 3/100,000 population [2, 3]. Though TB cases notification in China has decreased from  
74 70.6/100,000 population in 2012 to 58/100,000 population in 2019 with a treatment success  
75 rate above 90% [1, 2], China is listed as high-burden countries with TB, HIV-associated  
76 TB, and multidrug/rifampicin-resistant TB (MDR/RR-TB) for 2021-2025 in the WHO global  
77 TB report 2021 [1].

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

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5 85 important role to cure and avoid DR-TB, hence treatment management is essentially  
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8 86 necessary for TB patients to ensure treatment adherence, monitor adverse side-effects from  
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11 87 treatment, and avoid development of DR-TB [4]. Since Chinese National 12th Five-Year TB  
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13 88 Control Plan (2011-2015) came out in 2011, TB control model in China started using the  
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16 89 integrated TB control model in most regions [5]. Under the integrated TB control model, the  
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19 90 Centers of Disease Control (CDCs) are responsible for TB program governance, surveillance,  
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22 91 training and health promotion; the TB designated hospitals are responsible for diagnosis and  
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25 92 treatment; and the Primary Healthcare (PHC) sectors are responsible for referrals, tracing,  
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28 93 health education and TB treatment management services (TTMS) [5]. Later, China's National  
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31 94 13th Five-Year TB Control Plan (2016-2020) combined with the Action Plan to Stop TB  
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34 95 (2019-2022) requested to further strengthen TB prevention and control which emphasized  
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37 96 TTMS and strengthened the implementation of various measures to reduce TB epidemic in  
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40 97 China [2, 6]. TTMS is one of the key BPHS programs for all residents in China (one of the  
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43 98 priorities of the new health reform launched in 2009) which are delivered by TB HCWs in  
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46 99 PHC sectors [6, 7]. The BPHS guideline sets a target to accomplish both standard TTMS rate  
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49 100 and treatment success rate above 90% [6, 7]. TTMS for diagnosed TB patients are delivered  
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52 101 by HCWs in PHC sector under the supervision of CDC with coordination from other  
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55 102 departments, such as assistances from the TB designated hospital to deal with patients  
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58 103 side-effects and supports from department of education to conduct health education to student  
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60 104 population [7].

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

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5 106 treatment outcomes [8]. Study in Wuhan pointed that TTMS was crucial important for  
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8 107 monitoring treatment complications and reducing the development of DR-TB [9, 10]. Other  
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11 108 studies showed that in more developed areas in China, TTMS coverage was highly improved  
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14 109 and produced impressive effects [8, 9, 11-14]. Few studies reported the delivery status to  
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16 110 TTMS delivery in resource-limited and mountain regions with high TB/DR-TB burden in  
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19 111 China. One study found that only 37.1% of TB patients received TTMS by HCWs in West  
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21 112 China [15] and study in Chongqing found that 34.3% of TB patients never received TTMS by  
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24 113 HCWs [16]. However, very few studies focus on the perspective of HCWs to evaluate the  
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26 114 current TTMS program under the integrated TB control model. Therefore, this study not only  
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29 115 aim to assess the delivery status of TTMS program from the perspectives of both  
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31 116 organizations and patients, but also to explore the specific barriers to TTMS delivery faced  
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34 117 by HCWs in PHC sectors to provide evidence for promote TB control and treatment  
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37 118 outcome.

## 39 119 **Methods**

### 41 120 **Study design**

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44 121 This cross-sectional study utilized mixed research methods [17] to collect data from June to  
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47 122 December 2018. Questionnaire surveys and semi-structured in-depth interviews were  
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50 123 conducted to evaluate the delivery of TTMS in PHC sectors from both health organizational  
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52 124 (HCWs and leaders) and patient's perspectives.

### 53 125 **Study Setting**

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57 126 The prevalence of TB in the western region was significantly higher than the central and  
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5 127 eastern regions in China [18]. Chongqing Municipality is located at the junction of Yangtze  
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8 128 and Jialing rivers and has a population of 32.09 million [19]. This region is a relatively  
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10 129 developed socioeconomic status, with a gross domestic product (GDP) at 2.5 trillion CNY  
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13 130 and a per capita GDP at 55.6 thousand CNY in 2020 [19]. The growing population of  
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16 131 Chongqing depends more on the secondary and tertiary industry as the main economic  
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18 132 activity [19]. The urbanization rate and literacy rate are 69.5% and 98.4% respectively in  
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21 133 2021 [19]. The TB incidence of Chongqing Municipality (2019) is ranking the tenth  
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23 134 (75/100,000) in China [20].

26 135 Guizhou Province is a mountainous province in West China and has a population of 38.6  
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28 136 [21]. 50.9% of its population depends on tertiary industry as a main source of income [21].  
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30 137 The employment rate and literacy rate are 49.0% and 93.3% respectively in 2020 [21]. The  
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32 138 area maintains a relatively less developed socioeconomic status, with a GDP at 1.8 trillion  
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34 139 CNY and a per capita GDP at 46.3 thousand CNY in 2020 [21]. The incidence of TB in  
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36 140 Guizhou Province (2019) is ranking the third (133.5/100,000) following Xinjiang and Tibet  
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39 141 [20].

44 142 A stratified random sampling method was used to select study sites in Chongqing  
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46 143 Municipality and Guizhou Province as follows. First, all counties/districts in Chongqing  
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48 144 municipality and Guizhou province were grouped into three levels according to their  
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50 145 socioeconomic status (GDP) in 2018 [22]: the relatively developed (GDP in the highest  
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52 146 30%), the medium developed (GDP in the middle 40%), and the relatively less developed  
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54 147 (GDP in the lowest 30%). Then, from each group of counties/districts, 4 counties/districts  
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5 148 were randomly selected as study sites. A total of twelve districts/counties were finally  
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8 149 included in this study. All of the PHC sectors (included both CHCs and THCs) in the 12  
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11 150 selected counties/districts, totally 71 PHC sectors were included in this study.  
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### 13 151 **Study participants and data Collection**

#### 14 152 **Quantitative study**

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16 153 All adult pulmonary TB patients who met the following criteria were targeted for recruitment  
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18 154 from the 71 PHC sectors in the 12 selected counties/districts: (1) registered at TB  
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21 155 dispensaries and were diagnosed as drug-sensitive pulmonary TB patients according to  
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24 156 national TB diagnosis standards, (2) completed standard anti-TB drug treatment for at least 4  
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27 157 months which indicated that received TTMS for both intensive (first 2 months) and  
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30 158 continuation phases (following 4 months), (3) aged 15 years and older. Patients who: (1) with  
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33 159 extra-pulmonary TB, (2) could not express themselves clearly (had disturbance of  
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36 160 consciousness or difficulties with speech or hearing), (3) unwilling to participated in the  
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39 161 study were excluded. Patient recruitment was facilitated by local PHC sectors in the study  
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42 162 counties/districts. First, research group members provided a detailed explanation about the  
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45 163 study objectives to all potential participants. Then, those who were willing to participate in  
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48 164 the study were asked to read and sign the informed consent form to assure of confidentiality.

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50 165 The sample size was estimated using the Kish and Leslie formula as follows [23]:

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

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55 167  $n$  is the minimum desired sample size.  $Z_{\alpha}$  is the standard normal deviate, usually set as 1.96,  
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58 168 corresponding to a 5% level of significance.  $P$  is the average rate of TB treatment  
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5 169 management, set at 37.1% based on estimates from the available literature [15].  $d$  is the  
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8 170 degree of accuracy (precision), set at 5% (0.05). Therefore, the calculated minimum sample  
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11 171 size for patient-participants was 359. A total 481 TB patients were recruited to participate in  
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13 172 the survey, and 16 declined. Six TB patients <15 years old were excluded, and finally 459 TB  
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16 173 patients were included in the analysis (response rate were 95.4%).

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18 174 All HCWs who were TB control medical staff in PHC sectors in the selected  
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21 175 counties/districts and were willing to participate in the study were recruited as participants.  
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24 176 TB HCWs who were unwilling to participate in the study were excluded. There were a total  
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26 177 of 261 TB HCWs in the selected counties/districts. Finally, all 261 TB HCWs were recruited  
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29 178 and willing to participate in the survey, and zero declined (response rate was 100.0%).  
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32 179 HCWs recruitment was facilitated by local CDCs in the study districts/counties.

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34 180 Structured questionnaires were conducted to collect data among the participated TB  
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37 181 patients and HCWs. Among TB patients, structured survey involved demographic  
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39 182 information (e.g., gender, age, and residence), and TTMS received from HCWs during  
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42 183 treatment (e.g., intensive phase DOT and continuation phase DOT). Among HCWs, the  
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44 184 questionnaire included demographic and working-related information (e.g., gender, age,  
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47 185 professional title, and working years), working satisfaction, and delivery situation of TTMS  
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50 186 (e.g., the first-time home visit). Questionnaires were designed by our research team based on  
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52 187 the existing literature reports, and then consulted related experts. All questionnaires were  
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55 188 executed by trained investigators from our research group in a meeting room or clinic room at  
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58 189 each PHC sector. HCWs, who were willing to voluntary participated in the study, were asked  
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5 190 to read the informed consent form and then sign the informed consent form. Each completed  
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8 191 questionnaire was checked and examined by trained investigators for quality control.  
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## 10 192 **Qualitative study**

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13 193 In-depth interviews were utilized to explore the current status and identify barriers to the  
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16 194 TTMS delivery from HCWs to TB patients. Purposive sampling method was used to selected  
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19 195 participants with different background, age, and experiences related to TTMS. The integrated  
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21 196 TB control model was established and TTMS provided in all included counties/districts.  
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24 197 Therefore, in-depth interviews were conducted with: HCWs from the PHC sectors of  
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27 198 different socioeconomic levels who had delivered TTMS for at least one year during the  
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29 199 study period; leaders from the local CDC and the Health Commission who were responsible  
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31 200 for TB control program during the study period; and patients from regions of different  
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34 201 socioeconomic levels who had received TTMS and were about to end their TB treatment  
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37 202 during the study, which ensured patients had sufficient experiences related to TTMS. During  
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39 203 recruitment, all HCWs, leaders, and patients were approached and provided with detailed  
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42 204 explanations about the study and its objectives. Those who expressed interest in volunteering  
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45 205 to participate in the in-depth interview were asked to read and sign the informed consent form  
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47 206 as a confirmation of their voluntary participation in the study.  
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49 207 The sample size of the qualitative study was determined by the point of data ‘saturation’  
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52 208 [24]. The recruitment continued until evidence of data saturation was obtained, whereby  
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55 209 adding further participants did not generate new findings. For enhancing the information’s  
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57 210 trustworthiness and credibility of interviews, each interview was conducted face-to-face by at  
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5 211 least two trained interviewers. During each interview, one interviewer performed the  
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8 212 interview according to the semi-structured topic guides, while the other interviewer was  
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11 213 responsible for making notes of key information and may supplement questions to the  
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13 214 interview as necessary. At the end of each interview, interviewers discussed the findings and  
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16 215 key information obtained from the interview to confirm whether a supplementary interview  
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18 216 was required. The information related to TTMS delivery was cross validated between patients  
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21 217 (service receivers) and HCWs (service providers) to increase information trustworthiness.  
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24 218 Documentary sources, such as regulations and standard service procedures, were also utilized  
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26 219 to enhance information credibility. A total of nine purposely selected leaders, seven HCWs  
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29 220 and four patients participated in the in-depth interviews in this study.

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31 221 Semi-structured topic guides with open-ended questions were used for all interviews.  
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34 222 The guiding framework for the topic design was the Practical Robust Implementation and  
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36 223 Sustainability Model (PRISM) [25]. This model considered how the intervention design,  
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39 224 recipients, external environment, and implementation and sustainability infrastructure  
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42 225 influence health program implementation and success, which widely used as theoretical  
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44 226 framework in implementation research [25-27]. With the guide of the PRISM, this study  
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47 227 collected data on barriers on TTMS delivery in the following aspects: (1) intervention design;  
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50 228 (2) recipients; (3) external environment; and (4) implementation and sustainability  
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52 229 infrastructure. The adaptation of PRISM for this study is illustrated in Figure1. All interviews  
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55 230 were conducted in Mandarin or local language (Chongqing dialect and Guizhou dialect) in  
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57 231 meeting rooms in PHC sectors. Only participant and interviewers in the interview location.  
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5 232 Each interview lasted about 40-60 minutes and was audio-recorded with consent of the  
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8 233 participants.

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10 234 **Data analysis**

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13 235 **Quantitative analysis**

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16 236 Data were entered using Epi Data 3.1 and then analyzed using the Statistical Package for the  
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18 237 Social Sciences (SPSS 22.0 (IBM Corporation, Armonk, NY, USA)). Missing data were  
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21 238 excluded during analyze (when analyzing gender, age, medical school education, major,  
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24 239 professional title, number of BPHS programs undertook, monthly Income and working  
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26 240 satisfaction of HCWs etc., only 259, 249, 247, 256, 240, 225, 242 and 259 HCWs  
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29 241 respectively responded those questions in survey, and so we deleted the HCWs who did not  
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31 242 respond this question). A two-tailed probability level of  $p < 0.05$  was chosen as the level of  
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34 243 statistical significance. Missing data were excluded from analysis. Descriptive statistics were  
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37 244 used to describe study participants' demographic characteristics and TTMS delivery rates.  
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39 245 Factors associated with lower delivery rate ( $< 90\%$ ) screened by the Chi-square test ( $p < 0.05$ )  
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42 246 (Appendix A) were entered into multivariate logistic regression models (delivery rate  $< 90\%$   
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44 247 = 1, delivery rate  $> 90\%$  = 0), which were used to examine the effects of those factors on  
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47 248 TTMS delivery.

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49 249 **Qualitative analysis**

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52 250 The framework approach was used to analyze all qualitative data following a five steps  
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55 251 process: (1) familiarization, (2) creating theoretical framework, (3) indexing, (4)  
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57 252 summarizing and (5) data synthesis and interpretation [28-29]. Following that, all interviews  
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5 253 were carefully transcribed into Word Documents, reviewed for accuracy, and then being  
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8 254 coded and classified by our research team members. We identified themes on TTMS delivery  
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10 255 barriers for four domains of the PRISM [25], including: (1) intervention design (PHC sectors  
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13 256 resource and patient-centered manner); (2) the recipients (human resource and incentives,  
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16 257 training support, socio-economy and health literacy); (3) external environment (health  
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19 258 insurance, cross-sectional coordination, and social stigma); and (4) implementation and  
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21 259 sustainability infrastructure (performance assessment). All the names of participants were  
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24 260 removed in quotations of the results to keep anonymity. According to the 13th Five-Year TB  
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26 261 Prevention and Control Plan, the targeted TTMS delivery rate from HCWs to TB patients  
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29 262 is >90% [5]. Therefore, delivery rate below 90% is described as lower delivery rate in this  
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32 263 manuscript.

### 264 **Definitions**

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38 265 Primary healthcare (PHC) sectors in China include the community health centers (CHCs) and  
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41 266 stations in urban areas, township hospital centers (THCs) and village health clinics in rural  
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44 267 areas [4]. Tuberculosis healthcare workers (TB HCWs) include health professionals in PHC  
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47 268 sectors who are responsible for TTMS delivery. Tuberculosis treatment management service  
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49 269 (TTMS) is one of the key basic public health services for all residents in China, which are  
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52 270 delivered by TB HCWs in PHC sectors, including 7 themes: the first-time home visit, health  
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55 271 education, supervising drug intake, follow-up supervision, case closing evaluation, other  
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57 272 services, and services among patient's family members [6, 7]. Both the Chinese National  
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5 273 BPHS guideline and the 13th Five-Year TB Prevention and Control Plan set a target TTMS  
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8 274 rate of >90% [6, 7]. Therefore, in this study, a delivery rate <90% is described as a lower  
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11 275 delivery rate.

## 12 13 276 **Patient and public involvement**

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16 277 There were no patients or public involvement in the design, conduct, reporting and in the  
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18 278 dissemination plans of this research.

## 19 20 21 279 **Results**

### 22 23 280 **Characteristics of participants**

#### 24 25 281 *Participants for the quantitative study*

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28 282 A total of 261 TB HCWs and 459 TB patients were included in the quantitative analysis  
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31 283 (Table 1). Among the HCWs, 66.4% (n=172) were female, 71.5% (n=178) were aged 20-39  
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34 284 years old, 72.4% (n=189) worked at THCs, 50.0% (n=120) and 35.8% (n=86) had junior and  
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37 285 non-professional titles respectively. Near 60% (n=155) of the HCWs had junior college  
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39 286 education and over 80% (n=202) had medical school education background (32.4% majored  
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42 287 in clinical medicine and 30.5% majored in nursing). More than half (56.4%, n=127) of the  
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45 288 HCWs undertook 2-3 BPHS programs in PHC sector, and only 7.6% (n=17) were  
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47 289 dedicatedly in charge of TB program. The majority (67.4%, n=163) had a monthly income of  
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50 290 2500-4500 CNY, and notably, 40.5% (n=105) reported a low working satisfaction.

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52 291 Among the TB patients, the majority of the patients were male (70%, n=324), married  
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55 292 (69.7%, n=320), Han ethnicity (78.2%, n=359), and 41.6% (n=191) were aged  $\geq 60$ . 82.4%  
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58 293 (n=378) of the patients were rural residences and 95.2% (n=437) were permanent residences.

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

296 **Table 1 Characteristics of TB HCW participants surveyed by questionnaires**

Demographic characteristic	Number	Percentage
<b><i>HCWs in questionnaire survey</i></b>		
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)		

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5	TB program only	17	7.6
6	2-3	127	56.4
7	$\geq 4$	80	36.0
8			
9	Monthly Income (CNY) (n=242)		
10	<2500	52	21.5
11	2500-3500	89	36.8
12	3500-4500	74	30.6
13	>4500	27	11.2
14			
15	Working satisfaction (n=259)		
16	High satisfaction	58	22.4
17	Middle satisfaction	96	37.1
18	Low satisfaction	105	40.5
19			
20			
21	<b><i>TB patients in questionnaire survey</i></b>		
22	Gender (n=459)		
23	Male	324	70.6
24	Female	135	29.4
25			
26	Age (n=459)		
27	<40	94	20.5
28	40-49	96	20.9
29	50-59	78	17.0
30	$\geq 60$	191	41.6
31			
32	Ethnicity (n=459)		
33	Han	359	78.2
34	Ethnic minority	100	21.8
35			
36	Marital status (n=459)		
37	Single	69	15.0
38	Married	320	69.7
39	Divorced/Widowed	70	15.3
40			
41	Residence (n=459)		
42	Urban	81	17.6
43	Rural	378	82.4
44			
45	Registered information (n=459)		
46	Permanent resident	437	95.2
47	Migrant	22	4.8
48			
49	Education (n=459)		
50	Primary and below	257	56.0
51	Junior middle school	125	27.2
52	High school and above	77	16.8
53			
54	Occupation (n=459)		
55	Staff/Cadre/Retiree	50	10.9
56	Self-employed	10	2.2
57	Farmer/Migrant worker	315	68.6
58			
59			
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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.

### 297 ***Participants for the qualitative study***

298 9 leaders, 7 HCWs, and 4 TB patients were interviewed. Most leaders were male (7/9) with  
 299 deputy senior titles (5/9) and worked for 7.6 years on average. The majority of HCWs were  
 300 female (5/7), technical secondary school educated (6/7), majored in clinical medicine (4/5),  
 301 4/5 came from CHCs with had none or junior professional titles. Besides, among the 4  
 302 interviewed patients, drug-sensitive TB (DS-TB) and 2 DR-TB respectively, all of them  
 303 completed anti-TB therapy (6-8 months therapy for DS-TB, and 24 months therapy for  
 304 DR-TB).

### 305 **Quantitative results about TTMS delivery status**

306 TB patient's survey showed that 76.0% (n=349) of the patients ever received TTMS from  
 307 HCWs in CHCs during the whole course of treatment (it was 83.7% and 76.7% during their  
 308 intensive and continuation phase respectively). Just around 40.0% (n=189) ever received  
 309 TTMS from HCWs in THCs/village clinics during their whole course of treatment (it was  
 310 45.1% and 42.3% during intensive and continuation phase respectively). Only 17.0% (n=78)  
 311 received standard TTMS from HCWs during the whole course of treatment (it was 18.1% and  
 312 55.8% for intensive and continuation phase respectively). 2.8% (n=13) were never received  
 313 TTMS from HCWs (it was 3.9 % and 7.2% during intensive and continuation phase  
 314 respectively). (Table 2)

315 **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.

316 HCWs' survey showed that the average delivery rate of TTMS (totally involved 60  
317 service items) in PHC sectors was 88.4 %, and 13 TTMS items reported a lower delivery rate  
318 (<90%). Notably, the delivery rates of DOT in intensive phase and continuation phase were  
319 low, with only 54.7% and 53.0% respectively. Besides, less than half (44.9%) of HCWs in  
320 PHC sectors provided service of collecting patients' sputum samples during the follow-up  
321 supervision. Less than half of the HCWs provided food or transport assistances for poor TB  
322 patient (45.2%), provided subsistence allowance or psychological support for migrant patient  
323 (49.6%), and provided injection treatment for MDR-TB patient (41.0%). Moreover, less than  
324 60% provided supervision for newly released prison patient (58.9%) and established platform

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

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

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

327 **Factors associated with TTMS with lower delivery rate**

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



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335 service (Table 4).

For peer review only

336 **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)
<b>Gender</b>							
Female	Reference			Reference			
Male	0.577 (0.258-1.270)			0.605(0.320-1.147)			
<b>Age</b>							
>50		Reference					
40-50		2.053(0.985-4.279)					
30-39		2.230(0.947-5.248)					
<30		Default					
<b>Professional Title</b>							
Non		Reference	Reference		Reference	Reference	Reference
Junior		0.424(0.215-0.835)*	0.419(0.228-0.771) *		0.458(0.242-0.866) *	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(0.131-20.588)	0.809(0.054-12.031)	2.534(0.179-35.887)
<b>Training frequency</b>							
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(0.165-3.666)	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)
<b>Working satisfaction</b>							
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.

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339 **Qualitative results about barriers to TTMS delivery**

340 The in-depth interviews disclosed numerous barriers to TTMS delivery from the four core

341 PRISM domains as follows (Table 5):

342 **Table 5** Barriers of TTMS delivery by HCWs in PHC sectors

Core PRISM domains	Results	Quotations
Intervention: TTMS program	<p><b>Patient-centered manner:</b> 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.</p>	<p><i>Got telephone calls during the first 2 months, very few afterwards...I didn't like (DOT). (DS-TB patient)</i>  <i>Only received telephone calls from HCW in town, once per month. (MDR-TB patient)</i>  <i>There is one MDR-TB patient...say it is annoying to call him every day (by us to deliver TTMS program). (HCW)</i>  <i>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)</i></p>
Recipients	<p><b>Resources and incentive in PHC sectors:</b> 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.</p> <p><b>Training support to HCWs in PHC sectors:</b> Many HCWs stated that TB trainings lack of adequate professional knowledge and communication skill for TTMS delivery. Both HCWs and leaders mentioned lack of</p>	<p><i>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)</i>  <i>Insufficient and unstable HCWs ...one HCW leave, then we need to train a new one...(CDC leader)</i>  <i>HCWs, especially at TCHs, low quality, patients don't trust them. (CDC leader)</i>  <i>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)</i>  <i>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)</i>  <i>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)</i></p> <p><i>2-3 TB trainings each year, from CDC...combined with other (BPHS) trainings...and I think this training is not effective. (HCW)</i>  <i>It is harder to communicate with MDR-TB patients. Sometimes they seem know more about</i></p>

	<p>TB-specific training for HCWs.</p>	<p><i>treatment than me. Prolonged illness makes a doctor of a patient. (HCW)</i></p>
	<p><b>Patient's socio-economy:</b> 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.</p>	<p><i>During treatment in later period, I didn't (take sputum test), no money, no money for transportation. (DS-TB patient)</i> <i>Cannot bear the financial burden... costs of follow-up examinations, CT, and medicines. (MDR-TB patient)</i> <i>Because TB itself is a "disease of the poor", most TB patients have financial difficulties with bad lifestyles and poor literacy. (HC leader)</i> <i>Migrant patients are hard to reach...some have no stable work and often change their phone numbers...don't like TTMS. (HCW)</i> <i>I told him/her the dangerousness and seriousness of MDR-TB, he/she still didn't keep treatment, only told me: 'no money'. (HCW)</i></p>
	<p><b>Patient's health literacy:</b> 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.</p>	<p><i>I stopped treatment because I felt good about myself. (MDR-TB patient)</i> <i>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)</i></p>
External environment	<p><b>Health insurance:</b> 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.</p>	<p><i>(After reimbursement,) medicines would cost hundreds, and the costs of CT scans can't be reimbursed. (MDR-TB patient)</i> <i>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)</i></p>
	<p><b>Cross-sectional coordination:</b> 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.</p>	<p><i>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)</i> <i>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)</i></p>
	<p><b>Social stigma:</b> 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.</p>	<p><i>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)</i> <i>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)</i></p>
Implementation and Sustainability	<p><b>Performance assessment:</b> All HCWs and some of the leaders stated that the performance assessment for TTMS may exist</p>	<p><i>(Performance) assessment is unreasonable, more works you do, more mistakes you make, and this is unfair. There are no rewards when you perform</i></p>

infrastructure	irrationality considering heavy workload. And leaders pointed out that this could lead to substandard TTMS, and also hinder HCW's working enthusiastic.	<i>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)</i>
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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.

### 343 **1) Interventions**

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

### 347 **2) Recipients:**

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

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5 360 approach of TB trainings mixed with other BPHS programs and lacking of high quality  
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8 361 TB-specific training for HCWs ) supports for TB HCWs were also reported by interviewers.  
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11 362 So current training could not provide much support in HCWs' capabilities and performance.  
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13 363 In terms of patient characteristics, the majority of interviewers claimed that TB is a  
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15 364 disease of the poor and most TB patients were disadvantaged group (aging, low education,  
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17 365 migrant and financial difficulty), particular MDR-TB patients with longer treatment period,  
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19 366 who had poor TB-related health literacy and had high risk to reject TTMS. HCWs also  
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21 367 mentioned the hardship to deliver TTMS among migrant patients due to hard to reach them.  
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26 368 **3) External environment:**  
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29 369 On the one hand, inadequate health insurance coverage for medicines and tests related to  
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31 370 side-effects accentuated financial burden among poor DS-TB patients and the health  
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33 371 coverage was more inadequate for MDR-TB patients with longer treatment period, which  
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35 372 reduced willingness to receive TTMS. On the other hand, difficulties in cross-sectional  
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37 373 coordination to assist TTMS delivery were reported, especially supports from TB designated  
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39 374 hospitals and also other departments like departments of public security and education.  
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42 375 Furthermore, TB-related social stigma was reported as one of the main barriers to conduct  
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44 376 home-visits among urban and young patients who care much privacy and were more likely to  
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46 377 refuse to accept home-visits from HCWs.  
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52 378 **4) Implementation and sustainability infrastructure:**  
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55 379 The performance assessment for TB HCWs might exist irrationality considering their heavy  
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57 380 workload. One leader pointed out that to the purpose of TTMS delivery could become to  
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5 381 complete the targeted indicators, and therefore, lead to substandard TTMS to patients.  
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8 382 Moreover, inappropriate performance assessment also hinder working motivation and  
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10 383 increased working attrition among HCWs to deliver TTMS.  
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### 13 384 **Discussion**

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16 385 In China, HCWs in PHC sectors are considered as an important part of the TB integrated  
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18 386 model and taking responsibility for TTMS delivery. This study assessed the delivery of  
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20 387 TTMS program by HCWs in PHC sectors in West China. Though we found that the TTMS  
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22 388 delivery rates in intensive phase and continuation phase were higher than previous study in  
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24 389 West China [15], the standard TTMS (at least 24 times TTMS during their treatment course)  
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26 390 delivery rate is far below the required rate of >90% according to the National TB Control  
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28 391 Plan [6]. Besides, our study showed that TB patients received DOT from HCW in CHCs (in  
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30 392 urban regions) was higher than that from HCW in THCs (in rural regions). This difference  
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32 393 might be explained by our qualitative results as interviewed HCWs reported the challenges to  
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34 394 delivery TTMS to remote rural patients due to patients' poor health literacy which is also  
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36 395 reported in other studies [18, 30], and our study also pointed the far away distance with  
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38 396 insufficient transportation tools for HCWs blocked TTMS delivery. In addition, our study  
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40 397 revealed that less than half of HCWs provided services of collecting patients' sputum  
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42 398 samples during follow-up supervision, which is much lower than the result reports in the  
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44 399 study in Guizhou (96.56%) [30]. Furthermore, we found a low level of working satisfaction  
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46 400 (22.4%) among TB HCWs, while, it is higher than previous study (12.2%) [31]. Our study  
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48 401 results indicated that HCWs with low working satisfaction were more likely to have a low  
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5 402 delivery rate of first-time home visit, DOT, and sputum sample collection services. Efforts  
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8 403 should be made to maintain and promote HCWs' working satisfaction to enhance TTMS  
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11 404 delivery.

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13 405 Our study disclosed that the current TTMS delivery was confronted with various  
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16 406 barriers, despite that TB HCWs in PHC sectors carried out TTMS program had made many  
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19 407 achievements in West China. In the organizational level, we found that the TTMS programs  
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22 408 itself existed several barriers for HCWs to delivery services. On the one hand, the national  
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24 409 TB action plans and nationwide TB survey in China [2, 9, 32] mentioned the cross-sectional  
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26 410 coordination for TTMS delivery, however, we found that HCWs in PHC sectors still lack of  
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29 411 well coordination with other departments, such as coordination from department of education  
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32 412 to support students treatment management, help from department of public security to trace  
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34 413 migrant patients' information. Particularly, HCWs from some PHC sectors faced barriers to  
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37 414 access timely connections with TB HCWs from TB designated hospital in addressing TB  
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40 415 patients' side effects and treatment adherence. It is difficult to realize the participation of the  
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42 416 whole society in TB control in China so far [33]. As the call by the Action Plan to Stop TB  
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44 417 (2019 to 2022) in China [2], it is an emergent need to build a multi-sectorial collaboration  
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47 418 mechanism led by the National Health Commission (NHC) in order to coordinate  
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50 419 cross-sectional efforts to support TB prevention and control program [29].

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52 420 The second barrier emerged at health organizational level is the approaches to delivery  
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55 421 TTMS. We found TTMS were mainly delivered by telephone call, which consistent with  
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58 422 previous studies in West China [15, 33], and the insufficient patient-centered manners could  
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5 423 result in patients' rejects to DOT and TTMS by HCWs. Previous study in Indonesia also  
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8 424 reported that insufficient patient-centered care was the main treatment barriers for TB  
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11 425 patients in high-burden TB settings [34]. Although research showed that home-visits and  
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13 426 DOT did lead to positive treatment outcome [35, 36], our study pointed out the need to  
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16 427 provide TTMS with e-health approach, which was consistent with previous studies, and  
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18 428 previous studies demonstrated the effectiveness of e-health technology for promoting  
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21 429 patients' treatment adherence [37-42]. It is deserved to explore internet-based case  
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24 430 management model, such as digital supported self-management, and with the help of HCWs  
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26 431 in PHC sectors to deliver TTMS to TB patients who live in remote mountain area or against  
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29 432 face-to-face DOT.

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31 433 The third barrier at organizational level is the health human resource for TTMS in PHC  
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34 434 sectors. Other studies reported that PHC sectors especial in rural areas had a limited number  
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37 435 of HCWs to conduct BPHS programs which led to heavy workload and "shortage of hands"  
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39 436 since HCWs often carried out multiple assigned services [43-45]. We consistently found that  
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42 437 PHC sectors, particularly in THCs, faced human resource barriers in terms of insufficient  
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45 438 number and inadequate professional capability to deliver TTMS program. On the one side,  
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47 439 our study showed that heavy workload with multiple BPHS programs could led to hardship to  
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50 440 deliver standard TTMS to TB patients. On the other side, we found that inadequate  
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53 441 professional capability, especially village doctors, could led to patients' distrusts and hence  
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55 442 impeded TTMS delivery. Simultaneously, our study disclosed that PHC sectors lack of  
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58 443 adequate TB training for HCWs, particularly training related to communicational and  
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5 444 professional knowledge for TTMS delivery resulted in substandard TTMS. Other studies  
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8 445 proved the on-the-job training is important to improve professional skills among HCWs [33,  
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11 446 44, 46, 47], especially trainings emphasized both knowledge and practice [48]. Furthermore,  
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13 447 we found that the performance assessment for HCWs in TTMS program may exist  
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16 448 irrationality regarding their heavy workload which led to hardship to deliver standard TTMS  
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18 449 and hindered their working enthusiastic.

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21 450 In addition, our results showed that PHC sectors lack of sufficient funding for TTMS  
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24 451 program, and most HCWs unsatisfied with low salary, allowance or subsidy which was  
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26 452 consistent with other study [30]. Many research also indicated that the diverse issues of  
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29 453 financial incentives combined with heavy workload could influence HCW's motivation and  
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31 454 performance [44, 49-52]. The appropriate use of incentives for HCWs is a means of  
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34 455 promoting health outcomes with a direct impact on the effectiveness and sustainability of a  
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36 456 health program, and also able to improve services delivery through enhancing motivation and  
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39 457 reducing attrition [48]. Notably, we found that HCWs faced out-of-pocket expenditure for  
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42 458 transportations and telephone charges for TTMS delivery which could further impact their  
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45 459 work enthusiastic.

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47 460 Our results also identified barriers at patient level to TTMS delivery included their  
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50 461 susceptible socioeconomic characteristics (aging, low education, migrant, and poor financial  
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52 462 status) and lower literacy related to TB control. Previous nationwide TB epidemiology  
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55 463 survey in China revealed that near half (48.8%) of the TB patients were aged  $\geq 60$ , less  
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57 464 educated, and over 80% of TB patients had household incomes below local levels [18]. Our  
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5 465 results indicated that poor socioeconomic characteristics and low TB-related health literacy  
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8 466 together highly impeded TTMS delivery. As patients with low socioeconomic features were  
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11 467 often found with lower education background, poor health literacy, and more likely to be  
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13 468 have nonadherence, hence, they were more likely to refuse to HCWs' supervision, which is  
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16 469 consistent with other studies [18, 53, 54]. In addition, we found that TTMS delivery among  
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18 470 migrant patients was challenging for HCWs due to hard to reach. Other studies also reported  
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21 471 that migrant patients with frequently movement and low socioeconomic status had relatively  
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24 472 poorer TB-related awareness [55-57] which could future hindered TB case management.  
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26 473 Previous studies revealed that West China had a higher proportion of rural mountain areas as  
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29 474 well as domestic migrants compared with other regions in China, and TB-related awareness  
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32 475 among rural, less educated, and migrants was particularly serious [18, 55, 57-59].

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34 476 Our study also discovered that the health insurance cannot cover all medicines and tests  
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37 477 related to side-effects which accentuated financial burden among poor TB patients and led to  
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40 478 hardship for TTMS delivery. In order to relief barriers from TB patients, on the one hand,  
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43 479 addressing financial burden due to TB treatment among poor patients is crucial.  
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46 480 Notwithstanding, previous national TB epidemiology survey in China reported that over 90%  
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49 481 of TB patients had medical insurance combined with the policy of free TB diagnosis and  
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52 482 treatment, the proportion of out-of-pocket among patients was still around 75.0%-84.2% [18].  
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55 483 Studies and reports mentioned the necessary to increase reimbursement ratio and amount for  
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58 484 TB treatment, to expand the scope of current free TB treatment policy, and to strengthen care  
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60 485 and assistance for TB patients [2, 6, 36, 60]. Particularly need to target DR-TB and

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5 486 impoverished patients with transportation, accommodation and nutrition allowance during  
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8 487 TTMS delivery to promote TB control outcomes.  
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10 488 On the other hand, promoting TB-related health literacy among patients and enhancing  
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13 489 TB-related awareness among the public are urgently necessary. As our study revealed that  
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16 490 not only poor TB health literacy is a barrier from patients, TB-related social stigma also  
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19 491 impeded TTMS delivery especially in urban areas. Previous studies suggested to provide  
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21 492 easily understandable TB health education to particular target population (the aged, less  
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24 493 educated, close contacts, etc.) with certain modes of health education [18, 58]. Other study  
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26 494 indicated that a combination of mass media approaches and interpersonal communications  
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29 495 between patients and HCWs could lead to more effective TB control [59]. Similarly, Chinese  
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31 496 Action Plan to Stop TB called for various publicity activities to raise awareness of TB which  
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34 497 includes traditional media such as television broadcasting and newspaper, and also the use of  
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37 498 new media such as WeChat applet to promote dissemination of scientific TB knowledge and  
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39 499 eliminate social discrimination [2].  
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#### 41 ***Strengthens and limitations*** 42

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44 501 Our study used a mixed research method combining quantitative research (questionnaire  
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47 502 survey) with qualitative research (semi-structured, open-ended in-depth interviews) to assess  
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50 503 TTMS program delivery by HCWs in PHC sectors. Perspectives from organizations and  
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52 504 patients were both included by using the PRISM model to evaluate specific barriers to TTMS  
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55 505 delivery. Three levels of the local health organization were all involved in our study, which  
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57 506 contained the HCWs as the frontline staffs, the CDC leaders as the managers, and the Health  
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5 507 Commission leaders as the policy makers. However, there are a number of limitations in the  
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8 508 current study. First, the sample size of both questionnaire survey and in-depth interviews  
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11 509 could be further expanded to enhance the representativeness of study. Second, as we only  
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13 510 explore the status of and barriers to TTMS delivery by HCWs in PHC sectors,  
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16 511 well-evidenced implementation strategies that able to solve current problems successfully  
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18 512 were not able to be provided in this study. Further studies are required to provide more  
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21 513 evidence for producing more comprehensive and effective TB control strategies.  
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## 23 514 **Conclusion**

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26 515 All the engagements of HCWs in TTMS program suggests that the government realized the  
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29 516 importance of HCWs in PHC sectors in promoting TB patients treatment adherence and  
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32 517 outcomes and underscored their integration into the TB control model. We identified barriers  
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34 518 operating in organizational level (cross-sectional coordination, patient-centered approach,  
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37 519 resources and incentives, training support, reimbursement issue, and performance  
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39 520 assessment) and patient level (socioeconomic characteristics, health literacy and social  
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42 521 stigma) to TTMS delivery by HCWs in PHC sectors. There is an urgent need to identify  
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45 522 comprehensive measures to effectively overcome barriers to TTMS delivery and further  
46  
47 523 promote TB control in Southwest China.  
48

49 524 **Acknowledgements** We would like to thank the participants who responded our  
50  
51 525 questionnaires. We also thank all leaders and healthcare workers in the PHCs in study places  
52  
53 526 who supported this study by facilitating implementation of the field questionnaire survey and  
54  
55 527 participated in our interviews.  
56

57 528 **Contributions** JZ, JP and YL have designed this survey, JZ, JP, GW, WX, TZ, SL and QW  
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5 529 have collected data, JZ, JP, RZ, YC and JL have managed and analyzed data, YL and DH  
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7 530 have controlled the quality of data collection and analysis, JZ has drafted the manuscript. YL  
8  
9 531 has edited the manuscript. All authors have interpreted the results, revised the report and  
10  
11 532 completed the final version. The author(s) read and approved the final manuscript.

12  
13 533 **Funding** The study was funded by the National Natural Science Foundation of China  
14  
15 534 (No.81773489), the Chongqing outstanding youth project (No.cstc2020jcyj-jq0035), Social  
16  
17 535 Science and Technology Innovation Subject in Chongqing (No.cstc2015shmszx120070).

18  
19 536 **Disclaimer** The funders had no role in study design, data collection and analysis,  
20  
21 537 interpretation of the data, writing the paper and the decision to submit the paper for  
22  
23 538 publication.

24  
25 539 **Competing interests** Not declared

26  
27 540 **Patient consent** Obtained.

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29 541 **Ethics approval** Ethics approval was obtained from the Institutional Review Board of Army  
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31 542 Medical University (Third Military Medical University), Chongqing, China  
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33 543 (No.AF/SC-08/1.0) before starting the study. This study was conducted in accordance with  
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35 544 the Declaration of Helsinki. A full explanation of the purpose and procedure of the study was  
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37 545 provided to participants prior to obtain their written informed consent. All demographic data  
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39 546 and quotes used in this study were deidentified to maintain the anonymity of participants.

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41 547 **Provenance and peer review** Not commissioned; externally peer reviewed.

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43 548 **Data availability statement** Data are available upon reasonable request.

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45 549 **Supplemental material** This content has been supplied by the author(s). It has not been  
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## 722 **Figure legends**

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

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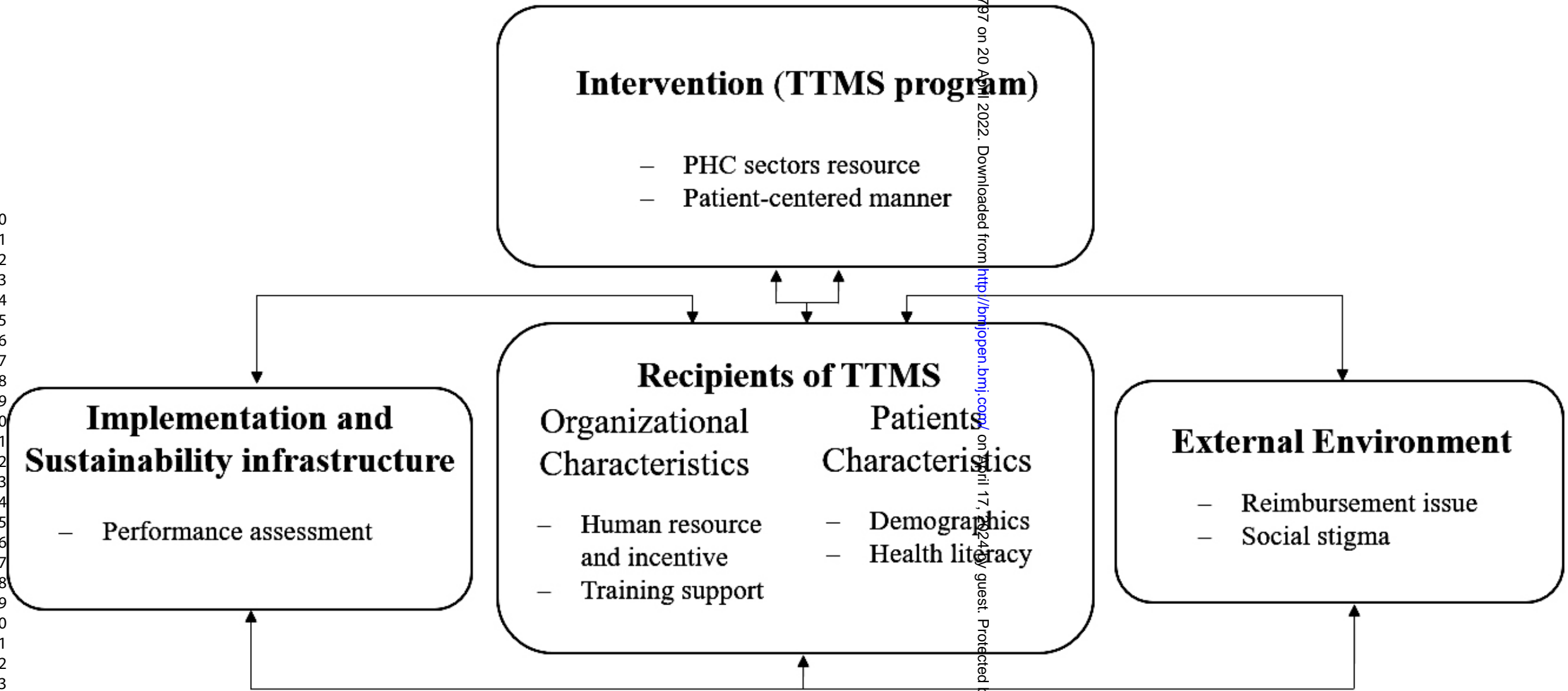
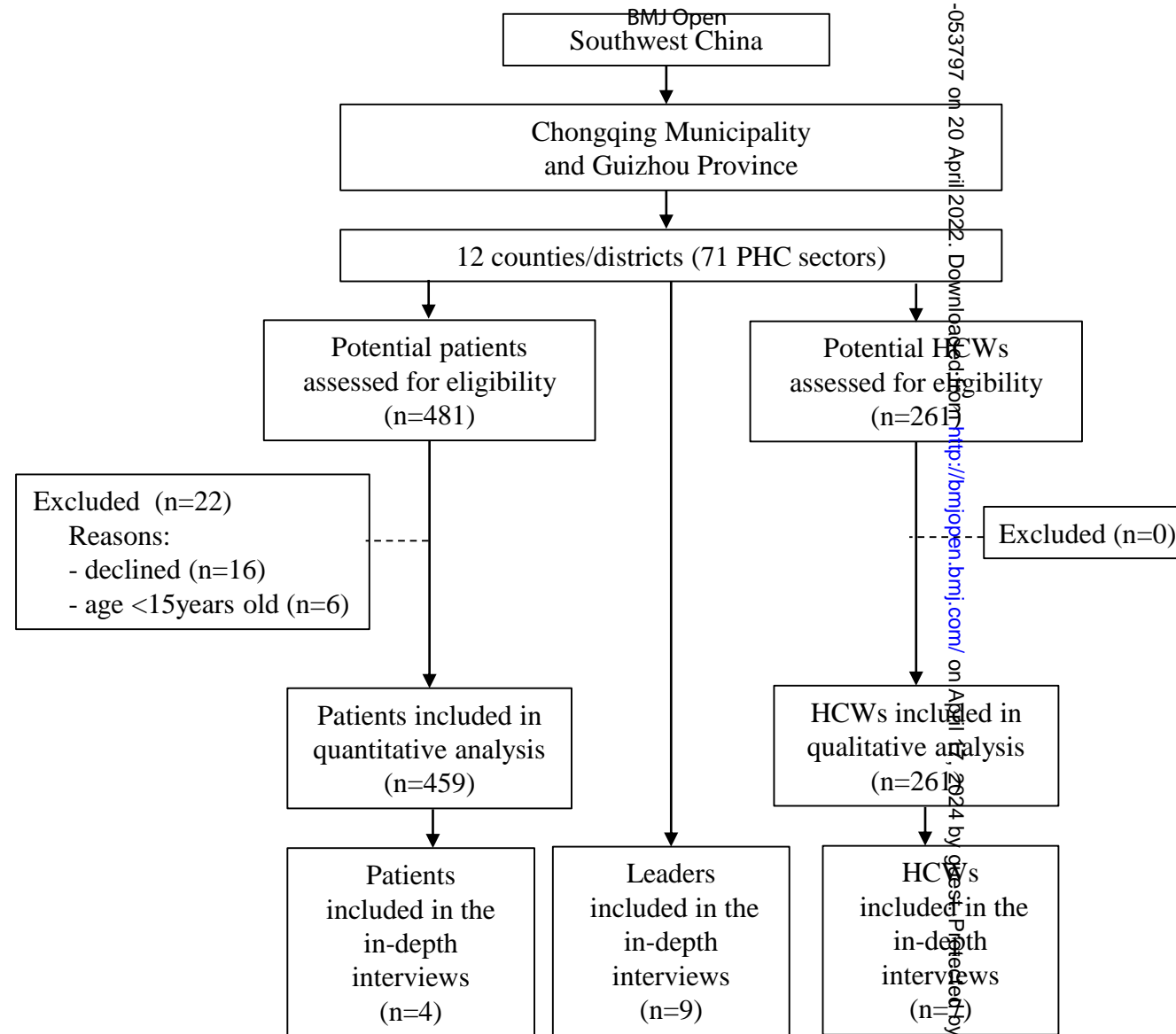


Figure 1: Adapted PRISM for barriers on TTMS delivery in PHC sectors



**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)
<b>Gender</b>		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)	
<b>Age</b>		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)	
<b>Education</b>		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)	
<b>Regions</b>		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)	
<b>Primary Health Sector Type</b>		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(69.5)		79(45.9)	
Community health center	44(69.8)		35(55.6)		32(51.6)		31(50.0)		39(63.9)		27(42.2)	
<b>Professional Title</b>		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)	
<b>Times of training received in the past six month</b>		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)	
<b>Working satisfaction</b>		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)	

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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)
<b>Gender</b>		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)	
<b>Age</b>		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)	
<b>Education</b>		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)	
<b>Regions</b>		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)	

		0.885	0.498	0.613	0.394	0.127	0.528	0.157	0.768
<b>Primary Health Sector Type</b>									
2 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)	
3 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)	
<b>Professional Title</b>		0.438	0.327	0.038*	0.004*	0.043*	0.870	0.683	0.789
6 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)	
7 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)	
8 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)	
9 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)	
<b>Times of training received in the past six month</b>		0.256	0.579	0.497	0.001*	0.022*	0.140	0.788	0.099
13 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)	
14 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)	
15 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)	
16 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)	
17 >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)	
<b>Working satisfaction</b>		0.094	0.027*	0.115	0.263	0.452	0.021*	0.114	0.054
20 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)	
21 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)	
22 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)	
23 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)	

24 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

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

Section/Topic	Item #	Recommendation	Reported on page #
<b>Title and abstract</b>	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
<b>Introduction</b>			
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
<b>Methods</b>			
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
<b>Results</b>			

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 (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	11,12
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (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	
<b>Discussion</b>			
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
<b>Other information</b>			
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](http://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:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2021-053797.R2
Article Type:	Original research
Date Submitted by the Author:	28-Mar-2022
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<b>Primary Subject Heading</b>:	Health services research
Secondary Subject Heading:	Health services research, Infectious diseases
Keywords:	Tuberculosis < INFECTIOUS DISEASES, PRIMARY CARE, HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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6 1 **Tuberculosis treatment management in primary health care sectors: a mixed-methods**  
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8 2 **study investigating delivery status and barriers from organizational and patient**  
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10 3 **perspectives**

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13 4 Jiani Zhou<sup>1</sup>, Jie Pu<sup>1</sup>, Qingya Wang<sup>2</sup>, Rui Zhang<sup>1</sup>, Shili Liu<sup>1</sup>, Geng Wang<sup>1</sup>, Ting Zhang<sup>2</sup>, Yong  
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## 22 ABSTRACT

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

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

32 **Setting** Primary healthcare sectors in Southwest China.

33 **Results** Our results showed that TTMS delivery rate by HCWs in PHC sectors was <90%  
34 (88.4%) on average, and the delivery rates of intensive and continuation phase DOT (directly  
35 observed therapy) were only 54.7% and 53.0%, respectively. HCWs with high work  
36 satisfaction and junior titles were more likely to deliver first-time home visits and DOT services.  
37 Our results suggest that barriers to TTMS delivery at the organizational level include limited  
38 patient-centered approaches, inadequate resources and incentives, insufficient training, poor  
39 cross-sectional coordination, and strict performance assessment. At the patient level, barriers  
40 include low socioeconomic status, poor health literacy, and TB-related social stigma.

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

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5 43 are urgently needed to address these barriers at the organizational and patient levels to  
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8 44 promote TB control in southwest China.  
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10 45 **Key words:** tuberculosis, treatment management, healthcare worker, primary healthcare  
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13 46 **Strengths and limitations of this study**  
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16 47 ● This is a mixed method study on accessing the status of and barriers to tuberculosis  
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18 48 treatment management service (TTMS) delivery by healthcare workers (HCWs) in the  
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20 49 primary healthcare sectors (PHC) of Southwest China.  
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23 50 ● This study collected perspectives from organizations and patients and used the PRISM  
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25 51 model to evaluate specific barriers to TTMS delivery.  
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28 52 ● We collected 720 questionnaires from HCWs and patients and conducted 20 interviews  
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30 53 with leaders, HCWs, and patients in a total of 71 PHC sectors.  
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33 54 ● Further studies are required to provide more evidence for producing more effective TB  
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35 55 control strategies, as well-evidenced implementation strategies that can address current  
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37 56 barriers in TTMS delivery could not be provided in this study.  
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## 64 INTRODUCTION

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

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

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5 85 treatment adherence, monitor adverse side effects from treatment, and avoid the development  
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8 86 of DR-TB.<sup>4</sup> Since the Chinese National 12th Five-Year TB Control Plan (2011–2015) came  
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10  
11 87 out in 2011, the TB control model in China has started using the integrated TB control model  
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13  
14 88 in most regions.<sup>5</sup> Under the integrated TB control model, the Centers of Disease Control (CDCs)  
15  
16 89 are responsible for TB program governance, surveillance, training, and health promotion; TB-  
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18  
19 90 designated hospitals are responsible for diagnosis and treatment; and primary healthcare (PHC)  
20  
21  
22 91 sectors are responsible for referrals, tracing, health education, and TB treatment management  
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24  
25 92 services (TTMS).<sup>5</sup> Later, China's National 13th Five-Year TB Control Plan (2016–2020)  
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27  
28 93 combined with the Action Plan to Stop TB (2019–2022) requested further strengthening of TB  
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30  
31 94 prevention and control, which emphasized TTMSs and strengthened the implementation of  
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33  
34 95 various measures to reduce the TB epidemic in China.<sup>2, 6</sup> TTMSs are one of the key BPHS  
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36  
37 96 (basic public health services) programs available to all residents in China (one of the priorities  
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39  
40 97 of the new health reform launched in 2009) and is delivered by TB HCWs in the PHC sector.<sup>6</sup>  
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42  
43 98 <sup>7</sup> The BPHS guidelines aimed to raise standard TTMS rates and treatment success rates to  
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45  
46 99 above 90%.<sup>6, 7</sup> The TTMSs for diagnosed TB patients is delivered by HCWs in the PHC sector,  
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48  
49 100 under the supervision of the CDC, with coordination from other departments, such as assistance  
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52 101 from the TB-designated hospital to deal with patient side effects and support from the  
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55 102 Department of Education to conduct health education in the student population.<sup>7</sup>

52 103 A study in Jiangxi indicated that TTMS under an integrated TB control model improved  
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55 104 treatment outcomes.<sup>8</sup> A study in Wuhan indicated that TTMSs are crucial for monitoring  
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58 105 treatment complications and reducing the development of DR-TB.<sup>9, 10</sup> Other studies have  
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5 106 shown that, in more developed areas in China, TTMS coverage was highly improved and  
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8 107 produced impressive effects.<sup>8, 9, 11-14</sup> Few studies have reported the status of TTMS delivery in  
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11 108 resource-limited and mountainous regions with a high TB/DR-TB burden in China. One study  
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13 109 found that only 37.1% of TB patients received TTMSs from HCWs in West China,<sup>15</sup> and study  
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16 110 in Chongqing found that 34.3% of TB patients never received TTMSs from HCWs.<sup>16</sup> However,  
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18 111 few studies have focused on the perspective of HCWs to evaluate the current TTMS program  
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21 112 under the integrated TB control model. Therefore, this study not only aimed to assess the  
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24 113 delivery status of the TTMS program from the perspectives of both organizations and patients,  
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26 114 but also to explore the specific barriers to TTMS delivery faced by HCWs in PHC sectors in  
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29 115 order to provide evidence for promoting TB control and treatment outcomes.

## 31 116 **METHODS**

### 34 117 **Study design**

36 118 This cross-sectional study used mixed research methods<sup>17</sup> to collect data from June to  
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39 119 December 2018. Questionnaire surveys and semi-structured in-depth interviews were  
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42 120 conducted to evaluate the delivery of TTMSs in the PHC sector from both health organizations  
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45 121 (HCWs and leaders) and patients' perspectives.

### 47 122 **Study Setting**

49 123 The prevalence of TB in the western region is significantly higher than that in the central and  
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52 124 eastern regions of China.<sup>18</sup> Chongqing Municipality is located at the junction of the Yangtze  
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55 125 and Jialing rivers, and it has a population of 32.09 million.<sup>19</sup> This region has a relatively  
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58 126 developed socioeconomic status, with a gross domestic product (GDP) of 2.5 trillion CNY and  
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5 127 a per capita GDP of 55.6 thousand CNY in 2020.<sup>19</sup> Chongqing's growing population depends  
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8 128 more on secondary and tertiary industries as the main economic activity.<sup>19</sup> Its urbanization rate  
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11 129 and literacy rates were 69.5% and 98.4% respectively in 2021.<sup>19</sup> The TB incidence in  
12  
13 130 Chongqing Municipality (2019) ranks tenth (75/100,000) in China.<sup>20</sup>  
14  
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16 131 Guizhou Province is a mountainous province in West China with a population of 38.6  
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18 132 million.<sup>21</sup> A total of 50.9% of its population depends on tertiary industries as the main source  
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20  
21 133 of income.<sup>21</sup> The employment rate and literacy rates were 49.0% and 93.3% respectively in  
22  
23  
24 134 2020.<sup>21</sup> The area maintains a relatively less developed socioeconomic status, with a GDP of  
25  
26 135 1.8 trillion CNY and a per capita GDP of 46.3 thousand CNY in 2020.<sup>21</sup> The incidence of TB  
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28  
29 136 in Guizhou Province (2019) was ranked third (133.5/100,000) in Xinjiang and Tibet.<sup>20</sup>  
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31 137 A stratified random sampling method was used to select the study sites in Chongqing  
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33  
34 138 Municipality and Guizhou Province. All counties/districts in Chongqing Municipality and  
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37 139 Guizhou Province were grouped into three levels according to their socioeconomic status (GDP)  
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40 140 in 2018<sup>22</sup>: the relatively developed (GDP in the highest 30%), the medium developed (GDP in  
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42 141 the middle 40%), and the relatively less developed (DGP in the lowest 30%). From each group  
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45 142 of counties/districts, four counties/districts were randomly selected as study sites. Twelve  
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47 143 districts/counties were included in this study. All of the PHC sectors (including both CHCs and  
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50 144 THCs) in the 12 selected counties/districts and a total of 71 PHC sectors were included in this  
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52 145 study.  
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## 54 146 **Study participants and data collection**

### 55 147 **Quantitative study**

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5 148 All adult pulmonary TB patients who met the following criteria were recruited from the 71  
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8 149 PHC sectors in the 12 selected counties/districts: (1) registered at TB dispensaries and were  
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10 150 diagnosed with drug-sensitive pulmonary TB according to national TB diagnosis standards; (2)  
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13 151 completed standard anti-TB drug treatment for at least 4 months, which indicated that they  
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16 152 received TTMSs for both intensive (first 2 months) and continuation phases (following 4  
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18 153 months); and (3) aged 15 years and older. Patients who (1) had extra-pulmonary TB, (2) could  
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21 154 not express themselves clearly (had disturbance of consciousness or difficulties with speech or  
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24 155 hearing), and (3) were unwilling to participate in the study were excluded. Patient recruitment  
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26 156 was facilitated by the local PHC sectors in the study counties/districts. First, the research group  
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29 157 members provided a detailed explanation of the study objectives to all the potential participants.  
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31 158 Those who were willing to participate in the study were asked to read and sign the informed  
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34 159 consent form to ensure confidentiality.

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36 160 The sample size was estimated using the Kish and Leslie formula <sup>23</sup>:

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

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42 162 Where,  $n$  is the minimum desired sample size.  $Z_{\alpha}$  is the standard normal deviate, usually set as  
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44 163 1.96, corresponding to a 5% level of significance.  $P$  is the average rate of TB treatment  
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46 164 management, set at 37.1% based on estimates from the available literature,<sup>15</sup> and  $d$  is the degree  
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49 165 of accuracy (precision) set at 5% (0.05). Therefore, the calculated minimum sample size for  
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52 166 patient participants was 359. A total of 481 patients with TB were recruited to participate in  
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55 167 the survey, of whom 16 declined. Six TB patients <15 years old were excluded, and finally,  
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57 168 459 TB patients were included in the analysis (response rate: 95.4%).  
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5 169 All HCWs who were TB control medical staff in the PHC sectors in the selected  
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8 170 counties/districts and who were willing to participate in the study were recruited as participants.  
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11 171 TB HCWs unwilling to participate in the study were excluded. There were 261 TB HCWs in  
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13 172 the selected counties/districts. Finally, all 261 TB HCWs were recruited and willing to  
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15  
16 173 participate in the survey, and zero declined (response rate: 100.0%). Local CDCs in the study  
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18 174 districts/counties facilitated HCW recruitment.

21 175 Structured questionnaires were administered to collect data from participating TB patients  
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23  
24 176 and HCWs. Among TB patients, the structured survey that was administered asked the  
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26 177 participants about their demographic information (e.g., gender, age, and residence) and TTMSs  
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29 178 received from HCWs during their treatment (e.g., intensive phase DOT (directly observed  
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31 179 therapy) and continuation phase DOT). Among HCWs, the questionnaire included  
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34 180 demographic and work-related information (e.g., gender, age, professional title, and working  
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36 181 years), work satisfaction, and delivery situation of TTMSs (e.g., first-time home visit).  
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39 182 Questionnaires were designed by our research team based on existing literature reports and  
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42 183 then we consulted with related experts.

44 184 In the reliability evaluation, Cronbach's  $\alpha$  was calculated to determine the reliability of the  
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47 185 questionnaire for TB patients and the HCWs' questionnaire. Cronbach's  $\alpha$  ranges from 0 to 1;  
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49  
50 186 the higher the coefficient value ( $>0.8$ ), the better the reliability and internal consistency. Both  
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52 187 the TB patients (Cronbach's  $\alpha=0.816$ ) and HCWs (Cronbach's  $\alpha=0.910$ ) questionnaires had  
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55 188 good reliability and internal consistency. In the validity evaluation, the face validity coefficient  
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58 189 was calculated through the Pearson correlation coefficient ( $r$ ) to determine the validity of the  
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5 190 questionnaire for TB patients. The questionnaire had  $r>0.4$  and  $P<0.001$ , indicating good face  
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8 191 validity. The questionnaire for the HCWs, which contained 60 TTMS questions, also had good  
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11 192 construct validity ( $I-CVI=0.850-1.000$ ;  $S-CVI=0.960$ ).

13 193 In the reliability evaluation, Cronbach's  $\alpha$  was calculated to determine the reliability of the  
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16 194 questionnaire for TB patients and the HCWs' questionnaire. Cronbach's  $\alpha$  ranges from 0 to 1;  
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19 195 the higher the coefficient value ( $>0.8$ ), the better the reliability and internal consistency. Both  
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21 196 the TB patients (Cronbach's  $\alpha=0.816$ ) and HCWs (Cronbach's  $\alpha=0.910$ ) questionnaires had  
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24 197 good reliability and internal consistency. In the validity evaluation, the face validity coefficient  
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27 198 was calculated through the Pearson correlation coefficient ( $r$ ) to determine the validity of the  
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29 199 questionnaire for TB patients. The questionnaire had  $r>0.4$  and  $P<0.001$ , indicating good face  
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32 200 validity. The questionnaire for the HCWs, which contained 60 TTMS questions, also had good  
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34 201 construct validity ( $I-CVI=0.850-1.000$ ;  $S-CVI=0.960$ ).

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37 202 All questionnaires were administered by trained investigators from our research group in  
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39 203 a meeting or clinic room in each PHC sector. TB patients and HCWs who volunteered to  
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42 204 participate in the study were asked to read the informed consent form and sign it. Each  
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45 205 completed questionnaire was checked and examined for quality control by trained investigators.

#### 206 **Qualitative study**

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49 207 In-depth interviews were conducted to explore the current status and identify the barriers of  
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52 208 TTMS delivery from HCWs to patients with TB. Purposive sampling was used to select  
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55 209 participants with different backgrounds, ages, and experiences related to TTMS. An integrated  
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58 210 TB control model was established, and TTMSs were provided in all included counties/districts.  
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5 211 Therefore, in-depth interviews were conducted with: HCWs from the PHC sectors of different  
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8 212 socioeconomic levels who had delivered TTMSs for at least one year during the study period;  
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10 213 leaders from the local CDC and the Health Commission who were responsible for the TB  
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13 214 control program during the study period; and patients from regions of different socioeconomic  
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16 215 levels who had received TTMSs and were about to end their TB treatment during the study,  
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18 216 which ensured that patients had sufficient experience related to TTMS. During recruitment, all  
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21 217 HCWs, leaders, and patients were approached and provided detailed explanations of the study  
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24 218 and its objectives. Those who expressed an interest in volunteering to participate in the in-  
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26 219 depth interview were asked to read and sign an informed consent form to confirm their  
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29 220 voluntary participation in the study.

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31 221 The sample size of the qualitative study was determined by the point of data ‘saturation.’<sup>24</sup>  
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34 222 Recruitment continued until evidence of data saturation was obtained and adding further  
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36 223 participants did not generate new findings. Each interview was conducted face-to-face by at  
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39 224 least two trained interviewers to enhance the information’s trustworthiness and credibility.  
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42 225 During each interview, one interviewer performed the interview according to the semi-  
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44 226 structured topic guides, while the other interviewer was responsible for taking notes of the key  
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47 227 information and could supplement questions to the interview as necessary. At the end of each  
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50 228 interview, the interviewers discussed the findings and key information obtained to confirm  
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52 229 whether a supplementary interview was required. Information related to TTMS delivery was  
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55 230 cross-validated between patients (service receivers) and HCWs (service providers) to increase  
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57 231 information trustworthiness. Documentary sources such as regulations and standard service  
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5 232 procedures have also been utilized to enhance information credibility. Nine purposely selected  
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8 233 leaders, 7 HCWs, and 4 patients participated in the in-depth interviews.  
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10 234 Semi-structured topic guides with open-ended questions were used in all interviews. The  
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13 235 guiding framework for topic design was the practical robust implementation and sustainability  
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15  
16 236 model (PRISM).<sup>25</sup> This model considers how the intervention design, recipients, external  
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19 237 environment, and implementation and sustainability infrastructure influence health program  
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22 238 implementation and success, and is widely used as a theoretical framework in implementation  
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24 239 research.<sup>25-27</sup> Using the PRISM guide, this study collected data on the barriers to TTMS  
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26 240 delivery in terms of the following aspects: (1) intervention design, (2) recipients, (3) external  
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29 241 environment, and (4) implementation and sustainability infrastructure. The adaptation of  
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32 242 PRISM in this study is illustrated in figure 1. All interviews were conducted in Mandarin or  
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34 243 the local language in meeting rooms in the PHC sector. Only participants and interviewers were  
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36  
37 244 present at the interview location. Each interview lasted approximately 40–60 minutes and was  
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39 245 audio-recorded with the consent of the participants.  
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#### 41 246 **Data analysis**

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44 247 The data analysis integrated quantitative and qualitative data to assess the status of and barriers  
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47 248 to TTMS program delivery by HCWs in the PHC sectors. For example, patients' demographic  
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50 249 information from questionnaires integrated with the results from in-depth interviews allowed  
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52  
53 250 us to determine how patients' social economy and healthy literacy affected TTMS delivery. In  
54  
55 251 addition, qualitative results regarding patient-centered manners, training support provided to  
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58 252 HCWs, the workload and performance evaluations of HCWs, and so on, clarified the  
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5 253 quantitative results regarding the proportion of TTMSs received and the delivery rate of  
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8 254 TTMSs by HWCs.  
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### 10 255 **Quantitative analysis**

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13 256 Data were entered using Epi Data 3.1 and then analyzed using the Statistical Package for the  
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16 257 Social Sciences (SPSS 22.0 (IBM Corporation, Armonk, NY, USA)). Missing data were  
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19 258 excluded from the analysis—when analyzing gender, age, medical school education, major,  
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21  
22 259 professional title, number of BPHS programs undertaken, monthly income, and work  
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24 260 satisfaction of HCWs, and so on, only 259, 249, 247, 256, 240, 225, 242, and 259 HCWs  
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26  
27 261 responded to the questions in the survey; therefore, we removed the data from the HCWs who  
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29 262 did not respond to these questions. A two-tailed probability level of  $P<0.05$  was chosen as the  
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31  
32 263 level of statistical significance. Descriptive statistics were used to describe the participants'  
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34 264 demographic characteristics and TTMS delivery rates. Factors associated with lower delivery  
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36 265 rates (<90%), as screened by the chi-square test ( $P<0.05$ ) (appendix 1), were entered into  
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39 266 multivariate logistic regression models (delivery rate <90%=1, delivery rate >90%=0), which  
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42 267 were used to examine the effects of these factors on TTMS delivery.  
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### 44 268 **Qualitative analysis**

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47 269 The framework approach was used to analyze all qualitative data following a five-step process:  
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50 270 (1) familiarization, (2) adapting the theoretical framework, (3) indexing, (4) summarizing, and  
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52 271 (5) data synthesis and interpretation.<sup>28-29</sup> Subsequently, all interviews were carefully  
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55 272 transcribed into Word documents, reviewed for accuracy, and coded and classified by our  
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58 273 research team members. We identified themes of the theoretical framework on TTMS delivery  
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5 274 barriers based on the four domains of PRISM,<sup>25</sup> including: (1) intervention design (PHC sector  
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8 275 resource and patient-centered mannerisms); (2) recipients (human resources and incentives,  
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10 276 training support, socio-economy, and health literacy); (3) external environment (health  
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13 277 insurance, cross-sectional coordination, and social stigma); and (4) implementation and  
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16 278 sustainability infrastructure (performance assessment). All the names of the participants were  
17  
18 279 removed from the results to maintain anonymity. According to the 13th Five-Year TB  
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21 280 Prevention and Control Plan, the targeted TTMS delivery rate from HCWs to TB patients  
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24 281 is >90%.<sup>5</sup> Therefore, a delivery rate below 90% was described as a lower delivery rate in this  
25  
26 282 study.

### 283 **Definitions**

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

294 delivery rate.

## 295 **Patient and public involvement**

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

## 298 **RESULTS**

### 299 **Characteristics of participants**

300 Participants for the quantitative study

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

310 Among the TB patients, the majority of the patients were male (70%, n=324), married  
311 (69.7%, n=320), of Han ethnicity (78.2%, n=359), and 41.6% (n=191) were aged  $\geq 60$  years. A  
312 total of 82.4% (n=378) of the patients lived in rural residences, and 95.2% (n=437) lived in  
313 permanent residences. Almost 70% (n=315) of the patients were farmer/migrant workers, and  
314 56.0% (n=257) had only primary education or below.

315

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

Demographic characteristic	Number	Percentage
<i>HCWs in questionnaire survey</i>		
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)		

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

#### 316 Participants for the qualitative study

317 Nine organizational leaders, 7 HCWs, and 4 TB patients with TB were interviewed. Most  
 318 organizational leaders were male (7/9), with deputy senior titles (5/9), and worked for 7.6 years  
 319 an average. The majority of HCWs were female (5/7), technical secondary school educated  
 320 (6/7), majored in clinical medicine (4/5), and 4/5 came from CHCs with no or junior  
 321 professional titles. In addition, among four interviewed patients, which included two drug-  
 322 sensitive TB (DS-TB) and two DR-TB patients, respectively, and all patients completed anti-  
 323 TB therapy (6–8 months therapy for DS-TB, and 24 months therapy for DR-TB).

#### 324 **Quantitative results regarding TTMS delivery status**

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

334 **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.

335 The HCWs survey showed that the average delivery rate of TTMSs (involving 60 service  
336 items in total) in the PHC sector was 88.4%, and 13 TTMS items had a lower delivery rate  
337 (<90%). Notably, the delivery rates of DOT in the intensive phase and continuation phases  
338 were low, with proportions of 54.7% and 53.0%, respectively. In addition, less than half (44.9%)  
339 of HCWs in PHC sectors provided services related to collecting patient sputum samples during  
340 the follow-up supervision phase. Less than half of the HCWs provided food or transport  
341 assistance for poor TB patients (45.2%), provided subsistence allowance or psychological  
342 support for migrant patients (49.6%), and provided injection treatment for MDR-TB patients  
343 (41.0%). Moreover, less than 60% provided supervision for newly released prison patients



344 (58.9%) and established platforms for TB patient communication (57.8%). (table 3)

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

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

346 **Factors associated with TTMSs with lower delivery rates**

347 Multivariate logistic regression analysis showed that HCWs with high work satisfaction were  
 348 less likely to have a lower delivery rate to establish patient peer supervision as needed  
 349 (OR=0.182, 95%CI: 0.059–0.562). Among both intensive and continuation phase DOT, HCWs  
 350 with junior titles (OR=0.424, 95%CI: 0.215–0.835) and high work satisfaction (OR=0.326,  
 351 95%CI: 0.140–0.766) were less likely to have lower delivery rates. Similarly, HCWs with  
 352 junior titles (OR=0.458, 95%CI: 0.242–0.865) and high work satisfaction (OR=0.395, 95%CI:  
 353 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)
<b>Gender</b>							
Female	Reference			Reference			
Male	0.577 (0.258-1.270)			0.605(0.320-1.147)			
<b>Age</b>							
>50		Reference					
40-50		2.053(0.985-4.279)					
30-39		2.230(0.947-5.248)					
<30		Default					
<b>Professional Title</b>							
Non		Reference	Reference		Reference	Reference	Reference
Junior		0.424(0.215-0.835)*	0.419(0.228-0.771) *		0.458(0.242-0.866) *	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(0.131-20.588)	0.809(0.054-12.031)	2.534(0.179-35.887)
<b>Training frequency</b>							
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(0.165-3.666)	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)
<b>Work satisfaction</b>							
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  $p < 0.05$ .

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5 357 **Qualitative results regarding barriers to TTMS delivery**  
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8 358 The in-depth interviews revealed numerous barriers to TTMS delivery from the four core  
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10 359 PRISM domains (table 5).

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13 360 1) Interventions

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16 361 The current TTMS program was mainly delivered via telephone calls and lacked a sufficient  
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18 362 patient-centered approach, which led to patient antipathy to DOT. HCWs suggested that e-  
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21 363 health approaches, including APP, would be good methods for delivering TTMSs.

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24 364 2) Recipients:

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26 365 Most PHC sectors faced insufficient human resources with which to deliver TTMS programs.  
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28 366 Every HCWs often undertook more than two BPHS programs. HCWs with this heavy BPHS  
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30 367 workload had difficulty delivering standard TTMSs. On the other hand, the PHC sectors also  
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33 368 lacked transportation tools with which to facilitate home visits, especially for remote rural TB  
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36 369 patients.

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39 370 HCWs in the PHC sectors also faced inadequate professional capabilities, especially  
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41 371 village doctors, which led to patient distrust and therefore hindered TTMS delivery by HCWs.  
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44 372 On the other hand, the PHC sector also lacked sufficient incentives for HCWs in the TTMS  
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47 373 program, and almost all HCWs were unsatisfied with their low salaries and subsidies due to  
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49 374 their heavy workloads and infection risk of TB. In addition, out-of-pocket expenditures for  
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52 375 transportation and telephone charges related to TTMS delivery could further influence HCW's  
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55 376 working motivation, performance, and attrition. Moreover, inadequate qualified training  
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57 377 (lacked of communication skills and professional knowledge related to TTMS delivery, the  
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5 378 training approach of TB training mixed with other BPHS programs, and lacked of high-quality  
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8 379 TB-specific training for HCWs) support for TB HCWs was also reported by interviewees.  
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10 380 Therefore, the current training methods do not provide much support for HCWs' capabilities  
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13 381 and performance.

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16 382 In terms of patient characteristics, the majority of interviewers claimed that TB is a disease  
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18 383 of the poor and that most TB patients were disadvantaged (of older ages, with low education,  
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20 384 migrant workers, or with financial difficulties), particularly MDR-TB patients with longer  
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23 385 treatment periods, who had poor TB-related health literacy, and had a high risk of rejecting  
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26 386 TTMSs. HCWs also mentioned the difficulty of delivering TTMSs to migrant patients because  
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29 387 it was difficult to reach them.

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31 388 3) External environment:

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34 389 On the one hand, inadequate health insurance coverage for medications and tests related to side  
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36 390 effects accentuated the financial burden among poor DS-TB patients, and the health coverage  
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39 391 was more inadequate for MDR-TB patients with longer treatment periods, which reduced their  
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42 392 willingness to receive TTMSs. On the other hand, difficulties in cross-sectional coordination  
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44 393 to assist TTMS delivery have been reported, especially support from TB-designated hospitals  
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46  
47 394 and other departments, such as departments of public security and education. Furthermore, TB-  
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50 395 related social stigma has been reported as one of the main barriers to conducting home visits  
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53 396 among urban and young patients who cared about privacy, and these patients were therefore  
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55 397 more likely to refuse home visits from HCWs.

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57 398 4) Implementation and sustainability infrastructure:  
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5 399 The performance assessment of TB HCWs might be irrational, considering their heavy  
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8 400 workload. One leader pointed out that the purpose of TTMS delivery could be to complete the  
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11 401 target indicators, and therefore, lead to substandard TTMSs in patients. Moreover,  
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13 402 inappropriate performance assessments also hinder working motivation and increase working  
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16 403 attrition among HCWs when delivering TTMSs.

## 17 18 404 **DISCUSSION**

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21 405 In China, HCWs in the PHC sector are considered an important part of the integrated TB model,  
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23 406 and these workers are responsible for TTMS delivery. This study assessed the delivery of the  
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26 407 TTMS program by HCWs in the PHC sector in West China. Although we found that the TTMS  
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29 408 delivery rates in the intensive and continuation phases were higher than in a previous study in  
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32 409 West China,<sup>15</sup> the standard TTMS (at least 24 times TTMS during their treatment course)  
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34 410 delivery rate was far below the required rate of >90%, according to the National TB Control  
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37 411 Plan.<sup>6</sup> In addition, our study showed that the number of TB patients receiving DOT from HCW  
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40 412 in CHCs (in urban regions) was higher than that from HCW in THCs (in rural regions). This  
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42 413 difference might be explained by our qualitative results, as interviewed HCWs reported  
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44 414 challenges in delivering TTMSs to remote rural patients due to patients' poor health literacy,  
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47 415 which has also been reported in other studies.<sup>18, 30</sup> Our study also indicated that far distances  
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50 416 with insufficient transportation tools for HCWs were preventing TTMS delivery. In addition,  
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53 417 our study revealed that less than half of HCWs provided services related to collecting patient  
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55 418 sputum samples during follow-up supervision, which is much lower than the results reported  
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58 419 in a study in Guizhou (96.56%).<sup>30</sup> Furthermore, we found a low level of work satisfaction  
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5 420 (22.4%) among TB HCWs, although it was higher than in a previous study (12.2%).<sup>31</sup> Our  
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8 421 study results indicated that HCWs with low work satisfaction were more likely to have a low  
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10 422 delivery rate of first-time home visits, DOT, and sputum sample collection services. Efforts  
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13 423 should be made to maintain and promote HCWs' work satisfaction to enhance TTMS delivery.  
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16 424 Our study revealed that the current TTMS delivery was confronted with various barriers,  
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18 425 despite the fact that TB HCWs in PHC sectors who carried out TTMS programs had made  
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20 426 many achievements in West China. At the organizational level, we found that the TTMS  
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22 427 programs themselves had several barriers affecting the delivery of services from HCWs. On  
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24 428 the one hand, the national TB Action Plan and nationwide TB survey in China<sup>2, 9, 32</sup> mentioned  
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26 429 cross-sectional coordination of TTMS delivery; however, we found that HCWs in the PHC  
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28 430 sectors still lacked good coordination with other departments, such as coordination from the  
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30 431 Department of Education to support students' treatment management and help from the  
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32 432 Department of Public Security to trace migrant patients' information. In particular, HCWs from  
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34 433 some PHC sectors faced barriers to accessing timely connections with TB HCWs from TB-  
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36 434 designated hospitals when addressing TB patients' side effects and treatment adherence. It is  
37  
38 435 difficult to realize the participation of the whole society in terms of TB control in China so  
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40 436 far.<sup>33</sup> According to the Action Plan to Stop TB (2019 to 2022) in China,<sup>2</sup> in order to coordinate  
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42 437 cross-sectional efforts to support TB prevention and control programs, there is an urgent need  
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44 438 to build a multi-sectorial collaboration mechanism led by the National Health Commission  
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46 439 (NHC).<sup>29</sup>  
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57 440 The second barrier that emerges at the health organizational level is the approach to TTMS  
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5 441 delivery. We found that TTMSs were mainly delivered via telephone calls, results that are  
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8 442 consistent with previous studies in West China,<sup>15, 33</sup> and insufficient patient-centered  
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10 443 mannerisms could result in patient rejection of DOT and TTMSs by HCWs. A previous study  
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13 444 in Indonesia also reported that insufficient patient-centered care was the main treatment barrier  
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16 445 for TB patients in high-burden settings.<sup>34</sup> Although research has shown that home visits and  
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18 446 DOT led to positive treatment outcomes,<sup>35, 36</sup> our study pointed out the need to provide TTMSs  
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21 447 through an e-health approach, which was consistent with previous studies that demonstrated  
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24 448 the effectiveness of e-health technology for promoting patient treatment adherence.<sup>37-42</sup> It is  
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26 449 necessary to explore internet-based case management models, including digitally supported  
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29 450 self-management, deliver TTMSs to TB patients living in remote mountainous areas with the  
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31 451 help of HCWs in PHC sectors, or provide face-to-face DOT.

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34 452 The third barrier at the organizational level is the human health resources for TTMSs in  
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36 453 the PHC sectors. Other studies reported that PHC sectors, especially those in rural areas, had a  
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39 454 limited number of HCWs with which to conduct BPHS programs, which led to heavy  
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42 455 workloads and a “shortage of hands,” as HCWs often carried out multiple assigned services.<sup>43-</sup>  
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44 456 <sup>45</sup> We consistently found that PHC sectors, particularly THCs, faced human resource barriers  
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47 457 in terms of insufficient and inadequate professional capabilities to deliver the TTMS program.  
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50 458 On the one hand, our study showed that a heavy workload with multiple BPHS programs could  
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52 459 lead to difficulties in delivering standard TTMSs to TB patients. On the other hand, we found  
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55 460 that inadequate professional capabilities, especially village doctors, could lead to patient  
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57 461 distrust and hence impede TTMS delivery. Simultaneously, our study revealed that PHC  
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5 462 sectors lack adequate TB training for HCWs, particularly training related to communication  
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8 463 and professional knowledge related to TTMS delivery, resulting in substandard TTMSs. Other  
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11 464 studies have proved that on-the-job training is important to improve professional skills among  
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13 465 HCWs,<sup>33, 44, 46, 47</sup> especially training emphasizing both knowledge and practice.<sup>48</sup> Furthermore,  
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16 466 we found that the performance assessment of HCWs in the TTMS program may be irrational  
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18 467 considering their heavy workload, and this led to difficulties in delivering standard TTMSs and  
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21 468 hindered their enthusiasm.

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24 469 Our results showed that the PHC sectors lack sufficient funding for the TTMS program,  
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26 470 and most HCWs are unsatisfied with their low salaries, allowances, or subsidies, which is  
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29 471 consistent with other studies.<sup>30</sup> Many studies have also indicated that the diverse issues of  
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31 472 financial incentives combined with heavy workloads could influence HCW's motivation and  
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34 473 performance.<sup>44, 49-52</sup> The appropriate use of incentives for HCWs is a means of promoting health  
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37 474 outcomes with a direct impact on the effectiveness and sustainability of a health program, and  
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39 475 this can also improve service delivery rates by enhancing motivation and reducing attrition.<sup>48</sup>  
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42 476 Notably, we found that HCWs faced out-of-pocket expenditures related to transportation and  
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45 477 telephone charges when delivering TTMSs, which could further impact their work enthusiasm.

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47 478 Our results also identified barriers at the patient level regarding TTMS delivery, including  
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50 479 their susceptible socioeconomic characteristics (older ages, with low education, migrant status,  
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52 480 or poor financial status) and lower literacy regarding TB control. A previous nationwide TB  
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55 481 epidemiology survey in China revealed that nearly half (48.8%) of TB patients were aged  $\geq 60$ ,  
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58 482 less educated, and over 80% of TB patients had household incomes below local levels.<sup>18</sup> Our  
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5 483 results indicate that poor socioeconomic characteristics and low TB-related health literacy  
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8 484 together impede TTMS delivery. As patients with low socioeconomic features were often  
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11 485 found to have a lower educational background, poor health literacy, and were more likely to  
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13 486 be non-adherent, they were more likely to refuse HCWs' supervision, which is consistent with  
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16 487 other studies.<sup>18, 53, 54</sup> In addition, we found that TTMS delivery among migrant patients was  
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18 488 challenging for HCWs because it was difficult to reach them. Other studies also reported that  
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21 489 migrant patients that frequently moved residences and had low socioeconomic status had  
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24 490 relatively poorer TB-related awareness,<sup>55-57</sup> which could hinder their TB case management.  
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26 491 Previous studies revealed that West China had a higher proportion of rural mountain areas as  
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28 492 well as domestic migrants than other regions in China, and TB-related awareness among rural,  
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31 493 less educated, and migrants was particularly serious.<sup>18, 55, 57-59</sup>

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34 494 Our study also discovered that health insurance could not cover all medicines and tests  
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36 495 related to side effects, which accentuates the financial burden among poor TB patients and  
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39 496 leads to barriers to TTMS delivery. To relieve barriers to TB treatment, it is crucial to address  
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42 497 the financial burden of TB treatment among poor patients. Notwithstanding, a previous national  
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44 498 TB epidemiology survey in China reported that although over 90% of TB patients had medical  
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47 499 insurance, in combination with the policy of free TB diagnosis and treatment, the proportion  
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50 500 of patients paying out-of-pocket was still around 75.0%–84.2%.<sup>18</sup> Several studies and reports  
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52 501 mentioned the need to increase the reimbursement ratio and amount provided for TB treatment,  
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55 502 to expand the scope of the currently free TB treatment policy, and to strengthen the care and  
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57 503 assistance provided to TB patients.<sup>2, 6, 36, 60</sup> In particular, there is a need to target DR-TB and  
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5 504 impoverished patients with transportation, accommodation, and nutrition allowances during  
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8 505 TTMS delivery in order to promote TB control outcomes.  
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10 506 Promoting TB-related health literacy among patients and enhancing TB-related awareness  
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13 507 among the public is urgently necessary. As revealed in our study, not only was poor TB health  
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16 508 literacy a barrier to patients, TB-related social stigma also impeded TTMS delivery, especially  
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19 509 in urban areas. Previous studies have suggested providing easily understandable TB health  
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21 510 education to a particular target population (older ages, less educated, close contacts, and others)  
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24 511 with certain modes of health education.<sup>18, 58</sup> Another study indicated that a combination of mass  
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26 512 media approaches and interpersonal communication between patients and HCWs could lead to  
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29 513 more effective TB control.<sup>59</sup> Similarly, the Chinese Action Plan to Stop TB called for various  
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31 514 publicity activities with which to raise awareness of TB, including through traditional media  
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34 515 such as television broadcasts and newspapers, as well as through the use of new media such as  
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37 516 the WeChat app, to promote the dissemination of scientific TB knowledge and eliminate social  
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39 517 discrimination.<sup>2</sup>  
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#### 41 518 **Strengths and limitations**

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44 519 Our study used a mixed research method combining quantitative research (questionnaire  
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47 520 surveys) with qualitative research (semi-structured, open-ended in-depth interviews) to assess  
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50 521 TTMS program delivery by HCWs in the PHC sectors. Perspectives from organizations and  
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52 522 patients were included using the PRISM model to evaluate specific barriers to TTMS delivery.  
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55 523 Three levels of the local health organization were involved in our study, which included HCWs  
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57 524 as frontline staff, CDC leaders as managers, and health commission leaders as policy makers.  
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5 525 However, the current study had several limitations. First, the sample size of both the  
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8 526 questionnaire survey and the in-depth interviews could be further expanded to enhance the  
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11 527 representativeness of the study. Second, as we only explored the status of and barriers to TTMS  
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13 528 delivery by HCWs in PHC sectors, well-evidenced implementation strategies that can solve  
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16 529 the current problems successfully were not provided in this study. Further studies are required  
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19 530 to provide evidence for the development of more comprehensive and effective TB control  
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21 531 strategies.

## 532 **Conclusion**

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

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

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

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5 547 have collected data, JZ, JP, RZ, YC and JL have managed and analyzed data, YL and DH have  
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7 548 controlled the quality of data collection and analysis, JZ has drafted the manuscript. YL has  
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9 549 edited the manuscript. All authors have interpreted the results, revised the report and completed  
10  
11 550 the final version. The author(s) read and approved the final manuscript.

12  
13 551 **Funding** The study was funded by the National Natural Science Foundation of China  
14  
15 552 (No.81773489), the Chongqing outstanding youth project (No.cstc2020jcyj-jq0035), Social  
16  
17 553 Science and Technology Innovation Subject in Chongqing (No.cstc2015shmszx120070).

18  
19 554 **Disclaimer** The funders had no role in study design, data collection and analysis, interpretation  
20  
21 555 of the data, writing the paper and the decision to submit the paper for publication.

22  
23 556 **Competing interests** Not declared

24  
25 557 **Patient consent** Obtained.

26  
27 558 **Ethics approval** Ethics approval was obtained from the Institutional Review Board of Army  
28  
29 559 Medical University (Third Military Medical University), Chongqing, China (No.AF/SC-08/1.0)  
30  
31 560 before starting the study. This study was conducted in accordance with the Declaration of  
32  
33 561 Helsinki. A full explanation of the purpose and procedure of the study was provided to  
34  
35 562 participants prior to obtain their written informed consent. All demographic data and quotes  
36  
37 563 used in this study were deidentified to maintain the anonymity of participants.

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39 564 **Provenance and peer review** Not commissioned; externally peer reviewed.

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41 565 **Data availability statement** Data are available upon reasonable request.

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43 566 **Supplemental material** This content has been supplied by the author(s). It has not been vetted  
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## 736 FIGURE LEGENDS

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

745 **Table 5** Barriers of TTMS delivery by HCWs in PHC sectors

Core PRISM domains	Results	Quotations
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<p>Intervention: TTMS program</p>	<p><b>Patient-centered manner:</b> 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.</p>	<p><i>Got telephone calls during the first 2 months, very few afterwards...I didn't like (DOT). (DS-TB patient)</i> <i>Only received telephone calls from HCW in town, once per month. (MDR-TB patient)</i> <i>There is one MDR-TB patient...say it is annoying to call him every day (by us to deliver TTMS program). (HCW)</i> <i>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)</i></p>
<p>Recipients</p>	<p><b>Resources and incentive in PHC sectors:</b> 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.</p>	<p><i>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)</i> <i>Insufficient and unstable HCWs ...one HCW leave, then we need to train a new one...(CDC leader)</i> <i>HCWs, especially at TCHs, low quality, patients don't trust them. (CDC leader)</i> <i>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)</i> <i>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)</i> <i>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)</i></p>
	<p><b>Training support to HCWs in PHC sectors:</b> 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.</p>	<p><i>2-3 TB trainings each year, from CDC...combined with other (BPHS) trainings...and I think this training is not effective. (HCW)</i> <i>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)</i></p>
	<p><b>Patient's socio-economy:</b> 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.</p>	<p><i>During treatment in later period, I didn't (take sputum test), no money, no money for transportation. (DS-TB patient)</i> <i>Cannot bear the financial burden... costs of follow-up examinations, CT, and medicines. (MDR-TB patient)</i> <i>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</i></p>

		<p><i>work and often change their phone numbers...don't like TTMS. (HCW)</i></p> <p><i>I told him/her the dangerousness and seriousness of MDR-TB, he/she still didn't keep treatment, only told me: 'no money'. (HCW)</i></p>
	<p><b>Patient's health literacy:</b> 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.</p>	<p><i>I stopped treatment because I felt good about myself. (MDR-TB patient)</i></p> <p><i>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)</i></p>
External environment	<p><b>Health insurance:</b> 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.</p>	<p><i>(After reimbursement,) medicines would cost hundreds, and the costs of CT scans can't be reimbursed. (MDR-TB patient)</i></p> <p><i>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)</i></p>
	<p><b>Cross-sectional coordination:</b> 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.</p>	<p><i>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)</i></p> <p><i>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)</i></p>
	<p><b>Social stigma:</b> 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.</p>	<p><i>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)</i></p> <p><i>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)</i></p>
Implementation and Sustainability infrastructure	<p><b>Performance assessment:</b> 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.</p>	<p><i>(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)</i></p> <p><i>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)</i></p>

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.

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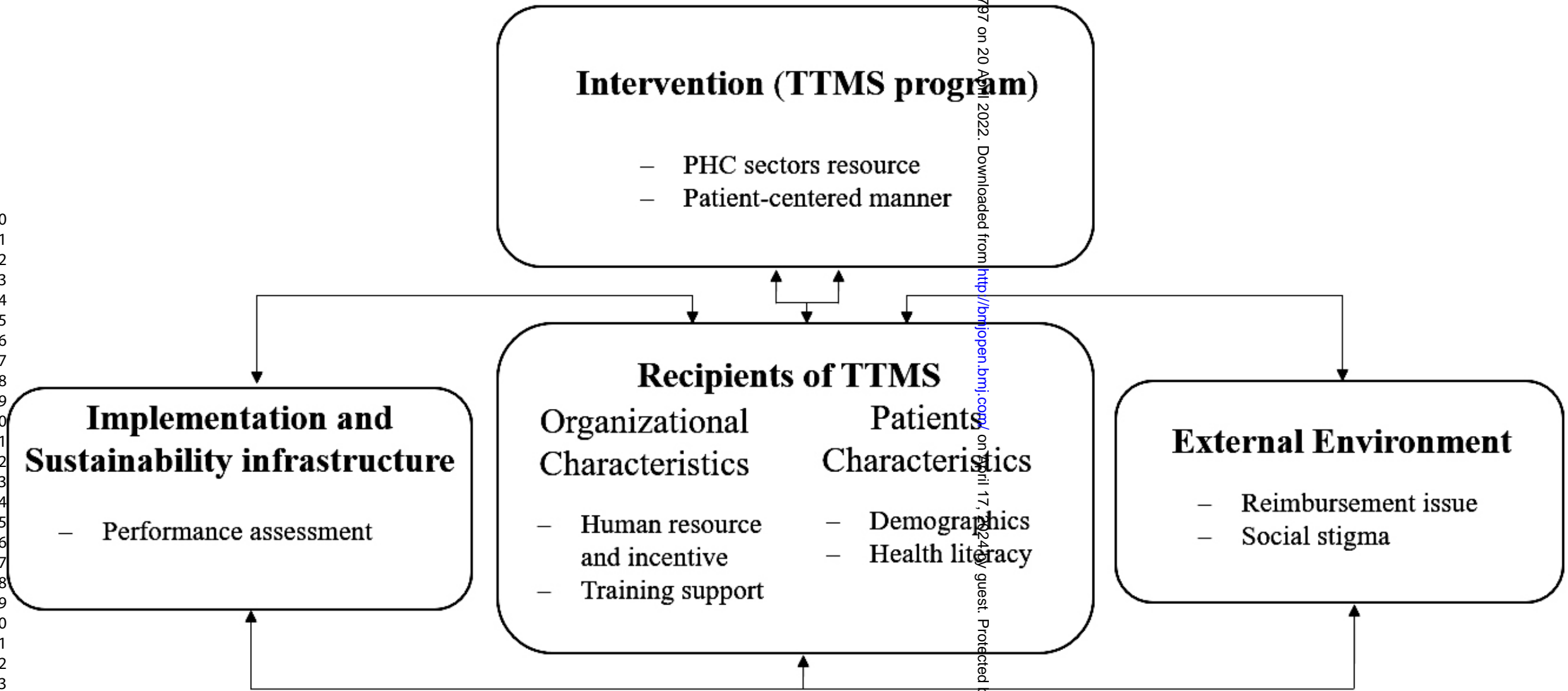


Figure 1: Adapted PRISM for barriers on TTMS delivery in PHC sectors

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)
<b>Gender</b>		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)	
<b>Age</b>		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)	
<b>Education</b>		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)	
<b>Regions</b>		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)	
<b>Primary Health Sector Type</b>		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)	
<b>Professional Title</b>		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)	
<b>Times of training received in the past six month</b>		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)	
<b>Working satisfaction</b>		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)	

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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)
<b>Gender</b>		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)	
<b>Age</b>		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)	
<b>Education</b>		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)	
<b>Regions</b>		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)	

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		0.885	0.498	0.613	0.394	0.127	0.528	0.157	0.768
<b>Primary Health Sector Type</b>									
1 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)	
2 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)	
<b>Professional Title</b>		0.438	0.327	0.038*	0.004*	0.043*	0.870	0.683	0.789
3 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)	
4 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)	
5 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)	
6 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)	
<b>Times of training received in the past six month</b>		0.256	0.579	0.497	0.001*	0.022*	0.140	0.788	0.099
7 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)	
8 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)	
9 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)	
10 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)	
11 >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)	
<b>Working satisfaction</b>		0.094	0.027*	0.115	0.263	0.452	0.021*	0.114	0.054
12 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)	
13 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)	
14 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)	
15 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 #
<b>Title and abstract</b>	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
<b>Introduction</b>			
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
<b>Methods</b>			
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
<b>Results</b>			



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	
<b>Discussion</b>			
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
<b>Other information</b>			
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](http://www.strobe-statement.org).