The Impact of the COVID-19 Pandemic on Tuberculosis Treatment for Migrant Workers in Shanghai

by

Yuqing Cui

Duke Global Health Institute
Duke University

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Approved:

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Shenglan Tang, Supervisor

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Jennifer Headley

_____
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Thesis submitted in partial fulfillment of
the requirements for the degree of
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ABSTRACT

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Abstract

Background: Tuberculosis (TB) is one of the world's top infectious killers, particularly affecting poor and vulnerable populations. COVID-19, another severe acute respiratory syndrome, is raging worldwide and has a relatively negative impact on TB care and patients. Thus, investigating the impact of COVID-19 on migrant TB patients is crucial.

Objectives: The primary aim is to investigate and compare TB patients' health service conditions of migrant workers and residents before and during COVID-19. Besides, the study also investigates health system responses and constraints in TB control in the context of the COVID-19 pandemic in China and further develops evidence-based recommendations to tackle TB healthcare challenges facing the vulnerable group and to improve TB healthcare equality in China and beyond.

Methods: This mixed-methods study applied quantitative analysis and qualitative analysis. The quantitative analysis used the TB registry data from 2018 to 2020 in Shanghai to study changes in the diagnosis delay, diagnosis results, treatment outcomes, and treatment periods by conducting descriptive statistics and regression analysis. The qualitative study conducted key informant interviews and focus group discussions on understanding TB-related policies, practices, and patient experience during the COVID-19 pandemic, especially for migrant TB patients.

Results: Migrant patients have a longer diagnosis delay than local patients (95% CI: 1.62, 2.76), and there is a relatively short diagnosis delay for patients registered during the recovery period (95% CI: -2.15, -0.77). There is no significant difference between local and migrant patients or patients registered at different periods on test results (p-values >

0.05). The migrant patients are more likely to receive a successful or complete treatment during pre-COVID and the outbreak period than local patients, while the recovery period affects migrant patients' success treatment odds ratio and turns it down from 1.57 to 0.83. Migrant patients have a longer treatment period than local patients (95% CI: 5.94, 13.18), while registration time has no impact on the length of treatment. Qualitative results showed that Shanghai has a well-established policy structure on TB care and rapidly emerged new coping strategies during COVID-19. The pandemic positively impacted the TB diagnosis but negatively affected the TB treatment provision and access and patients' financial burden. Conclusion: Shanghai's mature policy and management system and its rapid response during the COVID-19 outbreak have resulted in no significant differences in TB diagnosis, treatment, and management between local and migrant patients. Also, the COVID-19 somehow positively affects the case detection but causes a certain degree of delay in treatment. The current reimbursement mechanism does not provide sufficient protection and support for migrant patients in terms of financial burden. However, more evidence is needed to test and elucidate this relationship.

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1. Introduction

Tuberculosis (TB) is one of the world's top infectious killers, a contagious, airborne disease caused by bacteria and most often affects the lungs. Though TB is curable and preventable, it still prevails (WHO). According to the Global TB Report in 2021, TB ranked 13th cause of death worldwide and the top cause from a single infectious agent (WHO, 2021b). The United Nations listed END TB by 2030 as one of the 17 Sustainable Development Goals in response to such disease(UN, 2021). Although the world has made some progress and the number of people newly diagnosed with TB fell from 7.1 million in 2019 to 5.8 million in 2020, global TB targets are still unmet(WHO, 2021a). Moreover, most countries with a high burden of TB are low- and middle-income countries (LMICs). In 2020, two-thirds of the incident TB cases can be found in the eight countries: India (26%), China (8.5%), Indonesia (8.4%), the Philippines (6.0%), Pakistan (5.8%), Nigeria (4.6%), Bangladesh (3.6%) and South Africa (3.3%)(WHO, 2021b).

TB particularly affects poor and vulnerable populations (Stop & Stop, 2005). Especially in the LMICs, where TB has already prevailed widely with poor working and living environments and weak healthcare systems, migrants there are more likely to become a high-risk population. Migrants are a vast population who are moving or have moved across the national border or within a nation but away from the original place of residence (IOM, 2019). It now becomes a social determinant of TB-related health issues. Because of a series of complex reasons, including but not limited to their legal status, living environment,

economic status, and higher possibility of co-infection with other diseases, migrants may pose a more significant disease burden to countries (IOM, 2014).

The existing literature on TB in LMICs mainly discusses migrants across national borders, and internal migrants are rarely mentioned. Internal migrants refers to a group that moves between usual residences within national states. (Rees, 2001) They generally move for work or educational opportunities and a better living environment. This group is especially ubiquitous in China, a country with a vast area, dense population, and a tremendous regional development gap. "In China, massive rural-to-urban population shifts over the past 15 years have coincided with significant increases of the disease in cities." (Warren, 2019) This increment is typically attributed to migrants from rural regions where the TB infection is more severe than in urban areas (Warren, 2019). For this large population with a higher risk of TB infection, the government has issued Guidelines for the Management of Tuberculosis Patients in the Migrant Population, which advocates the localized and digitalized management of the migrant patients (CATA, 2021). However, there are still barriers for migrant TB patients to access TB care. The free treatment policy only covers a small fraction of migrant patients' total costs, causing financial burden for migrant patients (X. Wei et al., 2009). Also, the complicated referral and diagnostic procedure at different locations accounted for delayed TB treatment initiation and diagnosis for non-resident TB patients (Wang et al., 2007).

Today, the COVID-19, another severe acute respiratory syndrome, is raging worldwide and has become a global concern. As of January 6, 2022, there were 297,867,623 confirmed cases and 5,465,542 total deaths worldwide (CSSE). The most direct impact of this raging

epidemic on TB is a sharp declination in TB cases notification and reports during an increment in TB deaths (WHO, 2021a). Except for it, the diversion of resources and the inevitable shift of health system focus for confronting the COVID-19 may strain the TB control program, and both the quality and outcome of TB care may be affected (Togun et al., 2020). The resources reallocated to COVID-19 caused spending deduction for essential TB services, and the decline in investment partially resulted in the slow progress of TB-related research and innovation(WHO, 2021a). However, the co-infection of COVID and TB can worsen health outcomes (Song et al., 2021). Due to TB patients' common comorbidities or lung damages, they may have a higher exposure to more severe COVID-19 (X. Wei et al., 2009). In a systematic review, TB was concluded to be a risk factor for COVID-19 in terms of severity and mortality (Tamuzi et al., 2020). Aside from the deteriorating health conditions brought by the co-infection, the overlapping symptoms of TB and COVID-19 can also lead to diagnosis confusion, diagnosis and treatment delay, and even worsen the stigmatization (X. Wei et al., 2009) (Can Sarınoğlu et al., 2020).

According to existing literature, migrant TB patients have a higher risk of infection and have certain obstacles in obtaining TB care. At the same time, the COVID-19 also has a relatively negative impact on TB care and TB patients. However, very little literature discusses the impact of the COVID-19 on migrant TB patients. This mixed-method study aims to investigate and compare TB patients' health service conditions of migrant workers and residents before and during the COVID-19 pandemic in China, specifically in Shanghai. The study also investigates health system responses and constraints in TB control in the context of the COVID-19 pandemic in China and further develops evidence-based recommendations to tackle TB healthcare challenges facing the vulnerable group and to

improve TB healthcare equality in China and beyond. Our more specific research question is how the COVID-19 pandemic affects the migrant TB patients' health service use and financial burden compared to residents in Shanghai, China.

2. Methods

2.1. Study Design

We applied mixed methods, including quantitative analysis and qualitative analysis, to this study. We gathered TB registry data from 2018 to 2020 in Shanghai to study changes in the diagnosis delay, diagnosis results, treatment outcomes, and treatment periods before and during the COVID-19 pandemic and conducted a comparative analysis between the conditions of residents and migrant patients. We also conducted key informant interviews and focus group discussions to understand TB-related policies, practices, and patient experience during the COVID-19 pandemic, especially for migrant TB patients. The quantitative data help study the TB health services condition, and the qualitative data help supplement and interpret the results perceived from quantitative analysis. We used each type of data to validate and help interpret the other and build a solid response to our research question.

2.2. Setting

We carried out the study in Shanghai, a provincial-level municipality in China. Shanghai is a developed coastal city with the largest regional GDP and the second-largest per capita GDP in China. With a population of 24.9 million in 2020, 89.3% of the population is urban and 10.5 million of the population are inter-provincial migrants (China, 2021). In response to the massive migrant population, Shanghai has issued the Shanghai Residence Permit Management Measures as a policy for managing the residency registration (*Shanghai Residence Permit Management Measures* 2018). In 2019, Shanghai had the second-lowest reported incidence of tuberculosis in the country (WANG Qian, 2021). However, though

Shanghai has a relatively low TB disease burden, it has a large migrant population and a high proportion of tuberculosis among the migrant population. The Shanghai Municipal Health Commission reported in 2020 that there were 5,921 tuberculosis cases, with about 44% (2,601) of cases coming from the migrant population (MHC, 2021). To properly manage patients, Shanghai has established and implemented a three-in-one network, which consists of the CDC, TB designated hospitals, and community healthcare facilities. Each level of the CDC takes charge of macro-level management and assessment, including but not limited to the epidemiological investigation, organizing the contact tracing for TB patients, etc. Designated hospitals mainly take responsibility for the diagnosis and treatment, while community healthcare facilities focus on managing the patients (CDC, 2017).

On January 20th, 2020, the first import COVID-19 case was confirmed by Shanghai Municipal Health Commission (MHC, 2020b). Shanghai Municipal Health Commission responded quickly and formulated a "Comprehensive Work Plan for the Prevention and Control of COVID-19" on January 21st (MHC, 2020d). Three days later, Shanghai government activated a first-level response mechanism for major public health emergencies, strictly implementing quarantine and observation for 14 days for people entering Shanghai from key areas and strengthening identification and screening of people from key areas who were already in Shanghai (MHC, 2020e). During this period, people entering Shanghai who did not have a residence or a job would be persuaded to return or suspend their entry into Shanghai (MHC, 2020a). Under such strict management measures, COVID-19 was well controlled. On March 23rd, Shanghai Municipal Health Commission

adjusted the response mechanism for major public health emergencies from first-level to second-level, and gradually promoted work and production resumption (MHC, 2020c).

For the qualitative study, we selected three specific districts in both central and peripheral areas of Shanghai: Jingan, Hongkou, and Baoshan. The table below introduces the basic demographic information of the three districts.

Table 1. Demographic Information of Three Study Districts

District	Jingan	Hongkou	Baoshan
Total Population (k)	1057.7	794.0	2044.3
Migrant Population (k)	268.3	154.6	837.8
Area (km^2)	36.88	23.48	270.99
Population Density (per km^2)	28680	33816	7544
GDP (billion dollar)	36.32	16.32	24.51
GDP per capita (dollar)	34328.59	22954.19	12006.32

2.3. Data Collection

2.3.1. Quantitative Data Collection

Registry data of drug-sensitive TB patients notified between January 1st, 2018 and December 31st, 2020 were collected from the Chinese Tuberculosis Information Management System (TBIMS), a system developed by Chinese Center for Disease Control and Prevention (CDC) launched in 2005. The database included TB patients' demographic information such as gender, age, residency type (local or migrant) and job type, diagnostic and treatment information, and the treatment outcome. Drug-resistant TB (DRTB) patients who need at least 18 months of standard treatment in China were not included in the analysis because their records were moved to another management system.

2.3.2. Qualitative Data Collection

2.3.2.1. Data Collection Instruments

Our research team developed three interview guides: one for policymakers and CDC officers, another for community healthcare workers, and a third for migrant TB patients. The interview guides varied according to participants' positions and roles.

The interview guide for policymakers and CDC officers contained five sections: 1) describing current conditions of the area they are responsible for, 2) policies related to TB before and during the COVID, 3) the impact of COVID on the TB patients, especially for migrant patients, 4) the impact brought by those policies, and 5) further suggestions for the TB prevention and control.

The second interview guide was designed for migrant TB patients, mainly focusing on their personal experiences during their TB treatment. The interview guide consisted of five sections: 1) experiences seeking health services, 2) experiences with TB treatment, 3) employment conditions and financial burden, 4) barriers experienced due to COVID, and 5) suggestions on TB-related services and policies.

The third interview guide was designed for community health workers in focus-group discussions. With the main responsibilities of patient management, the health worker interview guide mainly included questions on their primary work, strategies they adopted during COVID-19 to meet patients' needs, how COVID and related policies affected patients' adherence and treatment, financial challenges patients faced, and their suggestions on patient management.

2.3.2.2. Procedure

Key informant interviews were conducted with TB policymakers and CDC official at the national level (n=1), the head of the TB department at the provincial-level-CDC (n=2), and the district-level CDC (n=7), one TB doctor, as well as migrant TB patients (n=6). Of the six migrant patients, three were unemployed due to TB, one was unemployed due to the COVID, one was employed and not affected by either TB or COVID, and one was retired. Among all patients, four had residence permits before being diagnosed with TB, one applied for a permit during the treatment, and another lived in a neighboring province that did not need the permit. Also, one interviewed patient had drug-resistant TB. Two focus group discussions were conducted with community health workers in Baoshan district (n=4) and Jingan district (n=6), respectively.

All key informant interviews and focus group discussions were conducted by an experienced researcher trained in qualitative research. Due to the COVID-19, the key informant interviews were conducted through online meetings. The focus group discussions were conducted in a private room. The key informant interview was one-to-one, while the focus group discussion was one-to-six or eight. Oral consent was obtained before audio-recording. On average, each key informant interview lasted about 30-45 minutes, and each focus group discussion was about 60-90 minutes. All interviews were conducted in Chinese. After interviews and discussions, all recordings were transcribed into text files by trained student workers. After transcription, all recordings were deleted, and analysis was then conducted on the text files. We withheld all identifiable interviewee information.

2.4. Data Analysis

2.4.1. Quantitative Analysis

2.4.1.1. Data Cleaning

For this study, we used the data from January 1st, 2018, to December 31st, 2020, with a total of 19,247 registrations. Due to the focus on comparing migrants to residents, patients with residency in Hong Kong, Macao, and Taiwan regions and foreign countries were excluded (n=41). Because tuberculous pleuritis belongs to extrapulmonary tuberculosis, people diagnosed with tuberculous pleuritis are excluded (n=1051). Because the drug-resistant TB patients are managed in another system, we excluded drug-resistant TB patients (n=528). Patients whose current management hospitals are not in Shanghai are also excluded (n=12). After these exclusions, we included 17,615 registrations in the subsequent analysis. Something noticeable is that a full course treatment generally takes six months to complete. Due to the lack of the latest updated data, two variables, "treatment outcomes" and "treatment length," will remove the patient data whose registration time is after June 2020.

2.4.1.2. Measures

Dependent Variables

In this study, we chose the following variables as dependent variables: diagnostic delay, positive rate, treatment success and completion rate, and treatment period. These variables are vital indicators to evaluate and assess the quality of healthcare services provision and treatment. Detailed descriptions of these variables are provided below.

Diagnostic delay: Early diagnosis and prompt initiation of treatment are essential for TB prevention and control. Thus, evaluating diagnostic delay is essential in assessing the

quality and effectiveness of the TB healthcare provider and management. Diagnostic delay is the interval between the first visit to health facilities for TB diagnosis to the date of diagnosis for TB (Datiko et al., 2020).

Positive rate: Unlike common metrics used by the World Health Organization and others, such as the incidence rate, this study sought to calculate the proportion of all enrolled patients diagnosed as positive for TB by different testing methods. Thus, the study defines positive rate as the proportion of smear-positive, culture-positive, molecular biological test positive, and pathologically positive out of the total registered case number.

Treatment success and completion rate: Treatment success is an indicator of the performance of national TB control programs. It not only benefits the specific patients but also aids in overall TB prevention and control (WHO). This study defined it as the proportion of the number of treatment results shown as successful and completed out of the total registered case numbers.

Treatment period: This study defines it as the total length of TB regimens phases (CDC, 2016) and we calculated it by observing the registration date and the treatment stop time.

Independent Variables

In this study, we chose the following variables as independent variables: gender, age, career, patient categories, patient source, residency, time, and type of districts to which the current management hospitals belong. Gender is a dichotomous variable including female and male. Age was categorized into three tertiles: <30, >=30 and <=59, and >=60. According to different characteristics of occupations, we categorized 20 job types into six large categories: 01. formal employed, 02. housekeeping and unemployed, 03. farmers, shepherds, fisherman, and peasant workers, 04. Retired, 05. children and students, and 06.

Others. Patient types are identified based on whether this is their first time to treat TB; thus, there are two categories: new patient and relapse. The patient source is mainly identified as to why patients seek care and divided into two types: actively seeking as symptomatic and passive detection as other. Residency mainly refers to the residency registration type the patient belongs to and is categorized as migrants and local in this study. The registration time refers to the date patients registered into TBIMS. The whole time range (2018 January to 2020 December) is divided into three main phases according to Shanghai's COVID-19 prevention and control policy: phase 1 - 2018 January to 2020 January (pre-COVID period), phase 2 - 2020 February to 2020 April (the first-level response mechanism for major public health emergencies period), and phase 3 - 2020 May to 2020 December (resumption of work and production period). Last but not least, the type of districts the current management hospitals belong to. With a total of 17 districts in Shanghai, we divided them into three categories based on the map: central (Jingan, Huangpu, Xuhui, Changning, Putuo, Hongkou, Yangpu, and Minhang), peripheral (Baoshan, Chongming, Jinshan, Fengxian, Jiading, Qingpu, and Songjiang), and PudongXinqu.

2.4.1.3. Data Analysis

We conducted descriptive analysis on demographic information and patients' characteristics. All variables are categorically coded, and we combined some sub-categories of categorical variables to avoid a too-small sample size in individual cells. We also eliminated the extreme value out of three sigmas as well. We calculated the count and percentage and applied the chi-square test to measure the relationship between two categorical independent variables. Besides, we explored the association between the patients' characteristics (gender, age, career, patient type, patient resource, residency,

district types the current management hospital belong to, and registration time) and four outcome variables: diagnostic delay, positive rate, treatment outcome, and treatment period. Because we also aim to test whether the relation between migrants and outcomes variables depends on the COVID-19, we added an interaction term residency*registration time to our models. We applied the linear and logistic regression model to test. The analyses were conducted with STATA/SE 17.0.

2.4.2. Qualitative Analysis

The qualitative portion is based on key informant interviews and focus-group discussion conducted in Baoshan, Hongkou, and Jingan districts in Shanghai. The analysis aims to explore the implications of the COVID-19 pandemic on access to healthcare service and treatment for local and migrant TB patients in Shanghai.

After the interviews were conducted, all information was transcripted into text files according to the recordings. Transcripts were analyzed using the applied thematic analysis approach (Greg Guest, 2012). First, the research team developed a structural codebook based on the research questions, interview guides, and our transcripts. Key topic areas and answers regarding the research question were classified as themes. After listing relevant structural codes, content codes were added based on thorough reading of the transcripts and participant responses. Then, the codebook was applied to the transcripts in two phases. The first phase aimed to ensure the codebook structure matched our research aims, answered the research questions comprehensively, and was applied accurately to the study transcripts. The codebook was modified accordingly. After achieving consensus on the generated themes and codes, I started the second phase of coding under guidance. The second phase ensured the accuracy of coding to a greater extent, and some missing

quotations were also discovered and coded more appropriately. Transcripts were coded by using NVivo 12 (Yuqing Cui uses NVivo (released in March 2020)). The texts were analyzed in Chinese, and the results were translated into English.

I also created data reduction tables in Excel. The table was sorted according to the codes and results and helped me classify and integrate all data led to the same result for perceiving a more comprehensive understanding of the data. This table was categorized by codes, including all sample quotations, information frequencies, and a preliminary summary of the results.

2.5. Ethics Approval

The Protocol of the study design and data collection tools was reviewed and approved by the Institutional Review Board of Duke Kunshan University (IRB Approval Code: FWA00021580).

3. Results

Policies related to TB care

Shanghai has a well-established TB management policy system, consisting of policies in line with the national level and some adjusted to its situation, including but not limited to case detection and diagnosis, treatment, financial aspect, and patient management. With the outbreak of COVID-19 in early 2020, Shanghai has also adopted a series of new policies to ensure TB-related healthcare services for TB patients, especially migrant patients. Our qualitative analysis revealed the following information.

General policies related to TB care in Shanghai

Regarding diagnosis and treatment of TB, an officer from a district-level CDC claimed that there are designated hospitals for TB care in Shanghai, and TB must be diagnosed and treated in those designated hospitals.

Most CDC officers and community healthcare workers mentioned the following financing policies. Regarding medical insurance reimbursement, except for the local one, the medical insurance in some provinces and cities can now also be reimbursed in Shanghai. In addition to medical insurance reimbursement, Shanghai has a specific exemption policy for TB patients as well. This policy only includes local residents and migrant populations with residence permits and their living spouses and children. At the same time, as a community healthcare worker mentioned in the focus group discussion, the fee waiver requires patients to complete the full course of treatment. In addition to clarifying the eligible conditions, many interviewers also mentioned the scope of reimbursement. It now mainly includes first-line and second-line drug fees and inspection fees.

However, there are currently no other official subsidies for people who neither have medical insurance nor have a residence permit; even the assistance of civil affairs will not cover them. Some districts in Shanghai make adjustments. For example, three district-level CDC officers introduced their districts' measures to grant some additional reduction or relax the reimbursement time limit.

Shanghai implemented a consistent management policy for residents and the migrant population because TB patient management in Shanghai is based on the patients' location rather than their residential registration. A prefectural-level-CDC officer introduced the whole process: After a diagnosis is made, the patient information is registered into the management system, and the community healthcare worker will conduct a door-to-door visit within three days. When patients leave Shanghai, such as migrants returning to their hometown, their TB registry records are also transferred back to their registered residency.

Figure 1. Quotations on the General Policies Related to TB Care in Shanghai

Tuberculosis must be treated in designated medical institutions. (KII, district-level CDC, Shanghai)
The medical insurance card from other provinces, like Jiangsu or Zhejiang, can be directly swiped in Shanghai. (KII, district-level CDC, Shanghai)
We have a treatment reduction policy in Shanghai. Whether patients have drug resistance or not, patients can enjoy the treatment reduction policy as long as they have tuberculosis. Those who are local residents or migrant patients who have a residence permit are eligible for the reimbursement. The latest policy includes spouses and children of migrants with residence permits as eligible for a reduced treatment policy. (KII, prefectural-level CDC, Shanghai)
In addition to the conventional first-line drugs, many second-line drugs have been added. Some basic inspections such as smear tests and CT are included as well. (KII, district-level CDC, Shanghai)
Shanghai has a clear division of responsibility; financial assistance needs to rely on the civil affairs department. but if it is a migrant population, even if there is a residence permit, the assistance of the civil affairs will not cover them. (KII, district-level CDC, Shanghai)
We may relax the exemption's time limit and grant the reduction as long as the residence permit is obtained during the treatment process, even if it is the last day. (KII, district-level CDC, Shanghai)
If patients cannot even continue the treatment due to financial burden and communicate with us, we provide a particular policy that provides free drugs at our district's designated hospital and can even reduce the registration fee. (KII, district-level CDC, Shanghai)

We manage migrant patients who live in Shanghai in the same way as the local residents because we manage patients based on locations but not residency registries. Shanghai's patient management is mainly based on community management. To conduct management, if the patient has been diagnosed, our community doctor will conduct a door-to-door visit within 3 or 5 days. Then the patient will be managed according to diagnosed results until the treatment is complete. The whole process includes an initial visit, the assessment of the family environment, assigning administrators, and then the regular follow-up management. In addition to those policies being consistent nationwide, Shanghai added some basic health education. Some may say that they will return to their hometown after a period of treatment in Shanghai; we will help transfer all information to places of their registered residency for continuous management. (KII, prefectural-level CDC, Shanghai)

FGD Focus-group Discussion, *KII* Key Informant Interview, *CHW* Community Healthcare Workers

Policies related to TB care in Shanghai during COVID-19

As a result of COVID, while the general policies are still in place, some new, adapted policies emerged and affected TB patients' healthcare-seeking behavior and health service access. An officer from the National CDC listed three main policies promulgated in the early stage of COVID-19. The first one aims to guarantee free TB drugs for stranded TB patients and is the only added policy specifically targeting migrants. The other two policies related to patient management.

In addition to macro-level policies, changes also occurred in the hospital admission process and community-level case detection and patient management as a result of COVID-19.

First, the hospital admission process changed as a result of COVID. A CDC officer shared that epidemiological investigations and fever checks are carried out when entering the building. If the patient has a fever, they must have a computerized tomography (CT) and antibody test to confirm if the fever is COVID-related.

New regulations at the community level were also implemented. Community healthcare workers elaborated on the changes in their focus group. Community hospitals strictly control the admission screening and keep close contact with designated hospitals to support COVID-19 and TB case detection. In addition to the policy update on the case detection process, the community healthcare workers also express sympathy through visiting and

providing daily necessities and epidemic prevention materials to TB patients in their community.

In addition to the above mentioned, there are no significant changes in other aspects such as travel or work. The measure of working from home was only implemented in the early stage of the outbreak while wages were paid as usual, and the measure was not performed for long and resumed quickly.

Figure 2. Quotations on the Policies Related to TB Care in Shanghai during COVID-19

On February 1st, the national CDC issued a notice to the CDCs at the prefectural level, saying that we should provide free anti-TB drugs for TB patients stranded in other places. On February 13th, another notice, "Measures for the Management of TB Patients During the Prevention and Control of COVID-19", was issued. On April 7th, the National Health Commission issued another notice on further strengthening the prevention and control of tuberculosis. (KII, National CDC)
When patients come to the hospital, there is an epidemiological investigation at the entrance, and the temperature is measured. The epidemiological investigation is set at security check now and may ask where you are from, have you had a fever before, and do you have a fever now. If you are found to have a fever, you will go directly to the admission process of the fever clinic. Any other diagnosis and treatment will be suspended; the priority is screening and checking whether the fever is related to COVID-19; if not, check the antibody and the CT. You can proceed to the next step of the diagnosis and treatment process only if all previous checks are all set. (KII, designated hospital)
We measured temperature at the entrance, and patients with fever cannot enter the community hospital. The doctor will call 120 to take the patient away according to his/her symptoms. (FGD, CHW, Shanghai)
We will ask suspect patients to go to a designated hospital. We only provide management after diagnosis. Some patients may not be able to identify their symptoms due to the similarity of TB and COVID symptoms; then, we will send them to designated hospitals to test whether the patient is TB or a COVID-19. (FGD, CHW, Shanghai)
We will distribute masks, sanitizers, and some other necessities timely for expressing sympathy and providing some psychological comfort. (FGD, CHW, Shanghai)
I believe COVID-19 has little impact on us, at least on our district. Traffic control due to the epidemic does not exist at all; we never applied it. (KII, district-level CDC, Shanghai)
The downtime is not long. (KII, district-level CDC, Shanghai)
It seems all working from home are paid as usual. (KII, prefectural-level CDC, Shanghai)

FGD Focus-group Discussion, *KII* Key Informant Interview, *CHW* Community Healthcare Workers

TB Patient Distribution and Characteristic in Shanghai

The quantitative analysis helps us extract key characteristics and distribution information from our 17,615 registrations in the registry. Table 2 summarizes the distribution of local

and migrant TB patients across time and districts in Shanghai. Among all patients, almost half are migrants (43.49%). From 2018 to 2020, both the number of local and migrant patients decreased, but the proportion of migrant patients in total patients significantly varied across three years (p=0.023).

For comparing across districts, while the peripheral districts have the highest proportion of migrant patients (47.60%), the central districts have the lowest proportion of migrant patients (38.40%), and PudongXinqu is in the middle (44.85%). There is a significant difference in migrant patient distribution across districts (p<0.001).

Table 2. Distribution of Local and Migrant TB Patients across Time and District

	Local	Migrant	% Migrant	P-value
Total	9,955	7,660	43.49%	/
By Year				
2018	3,515	2,748	43.88%	0.023
2019	3,447	2,507	42.11%	
2020	2,993	2,405	44.55%	
By District				
Central District	4,108	2,561	38.40%	<0.001
Peripheral Districts	3,620	3,288	47.60%	
PudongXinqu	2,227	1,811	44.85%	

Table 3 shows the characteristics of patients in the Shanghai TB Registry during 2018-2020. Among local residents, more than half (51.62%) are over 60 years old, and the least proportion (12.07%) of them are under 30 years old. On the contrary, 48.05% of migrant patients are under 30 years old, while the smallest age group is older than 60 years (7.68%). Most of the patients are male in both the resident group (69.22%) and the migrant group (63.75%). In terms of career, about half of local patients are retired (48.18%), but the occupations of the migrant population are much more diverse. Something noticeable is that 26.55% of migrant patients have no job reported, shown as "other or unknown." About

59.84% of local patients and 57.30% of migrant patients are diagnosed as positive. Among these positive patients, local patients have a higher smear test rate (34.56%) while migrant residents have a higher culture rate (24.40%). Migrant patients have a higher treatment success rate regarding the treatment outcome (91.87%); more specifically, local (45.41%) and migrant (45.00%) have a similar cured rate, but migrant patients have a much higher complete rate (46.43%). All variables, including age, gender, patient type, job type, patient source, diagnostic type, and treatment outcome, are all statistically significant with p-values < 0.001.

Table 3. Characteristics of Patients

	Local residents		Migrants		P-value
	N	%	N	%	
Age					
<30	1,202	12.07%	3,681	48.05%	
>=30 & <=59	3,614	36.30%	3,391	44.27%	<0.001
>=60	5,139	51.62%	588	7.68%	
Gender					
Female	3,064	30.78%	2,777	36.25%	<0.001
Male	6,891	69.22%	4,883	63.75%	
Patient type					
New	9,061	91.02%	7,247	94.61%	<0.001
Relapse	894	8.98%	413	5.39%	
Job type					
Formal employment	1,205	12.10%	2,271	29.65%	
Children and Student	348	3.50%	467	6.10%	
Housekeeping & Unemployed	1,475	14.82%	2,019	26.36%	
Farmer, Herdsman, Fisherman & peasant worker	365	3.67%	353	4.61%	<0.001
Retired	4,796	48.18%	516	6.74%	
Other or unknown	1,766	17.74%	2,034	26.55%	
Patient Source					
Symptomatic	9,685	97.29%	7,253	94.69%	<0.001
Other	270	2.71%	407	5.31%	

Diagnostic type					
Positive (total)	5,957	59.84%	4,389	57.30%	
Smear positive	3,440	34.56%	2,088	27.26%	
Culture positive	2,028	20.37%	1,869	24.40%	
Molecular biological test positive	429	4.31%	410	5.35%	<0.001
Other	60	0.60%	22	0.29%	
No Etiological Result	475	4.77%	247	3.22%	
Negative	3,523	35.39%	3,024	39.48%	
Treatment Outcome					
All Success Treatment	8,464	85.02%	7,037	91.87%	<0.001
Among the positive					
Cured	2,705	45.41%	1,975	45.00%	
Complete	2,260	37.94%	2,038	46.43%	
Other	742	12.46%	154	3.51%	

Effects in Case Detection and Diagnosis for Migrant Patient During COVID-19

We applied two main measures to measure the case detection and diagnosis: diagnosis delay and test results. Figure 3 shows local and migrant patients' average diagnosis delay monthly. We can observe that migrant patients may have a slightly longer diagnosis delay than local patients, and both groups' diagnosis delays fluctuate slightly over time. Regarding the test results, figure 4 indicates that the overall positive rate remained almost constant across time, and there is no significant difference between the two groups. However, two subfigures indicate that the smear-positive proportion in the local patients is higher than that in the migrant patients, while the other-positive proportions in the migrants are higher than that in the local (figure 5, 6). Nevertheless, data dispersion may be significant due to the vast amount of data, so applying the regression model to conduct the statistical test is necessary.

Figure 3. Monthly Average Diagnosis Delay

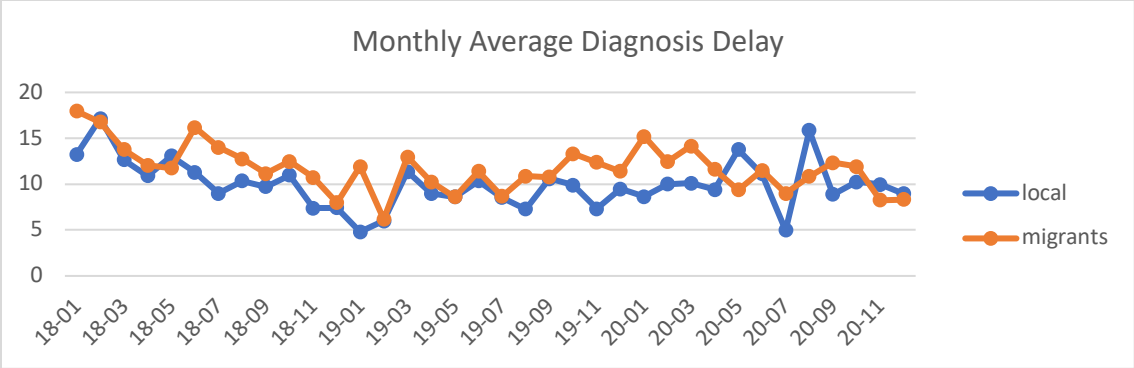

Figure 4. Monthly Overall Positive Rate

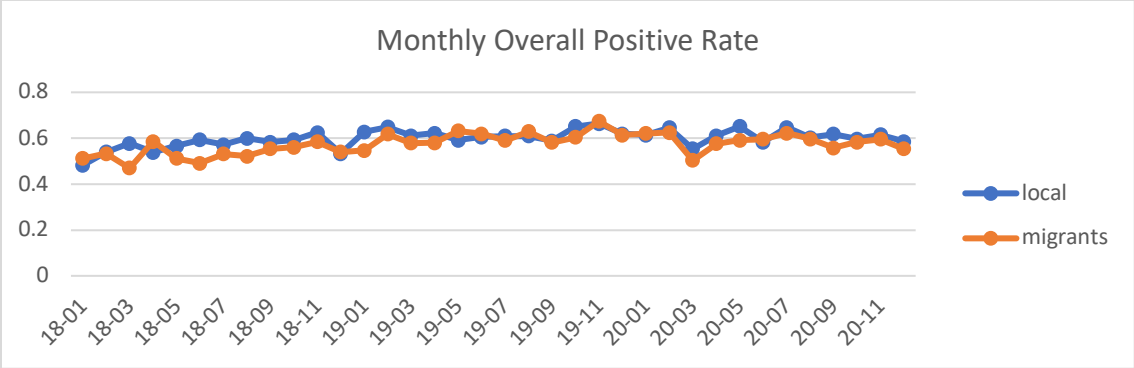

Figure 5. Monthly Smear Positive Rate

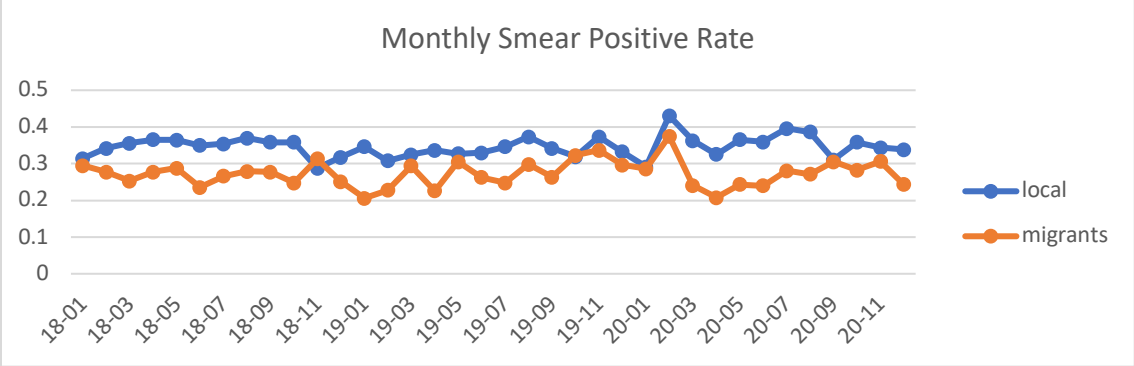

Figure 6. Monthly Other Positive Rate

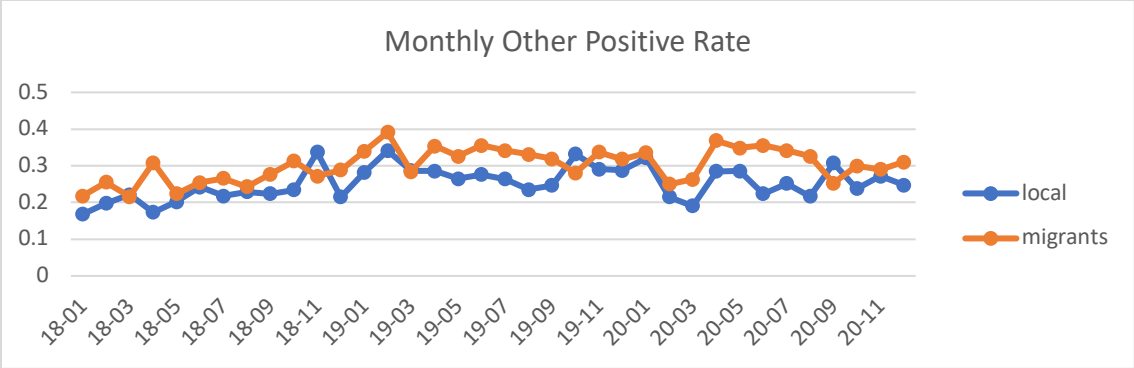

Table 4 indicates the logistic regression results of the association between diagnostic delay with characteristics of patients. Patient resource, career, and residency are the most significant three with p-values < 0.001 among all variables. Regarding patient resources variable, compared to patients seeking health services due to symptoms, patients with passive healthcare-seeking behavior have a significantly longer diagnostic delay. From the perspective of career types, with formal employed selected as the reference level, patients in the following occupations: housekeeping and unemployed, retired, children and students, others or unknown, all present significant differences in diagnostic delay with p-values < 0.001. Residency is another significant predictor of diagnostic delay. Migrants significantly differed from the local patients on diagnostic delay ($p<0.001$) and showed a longer delay than local patients. Besides, gender, patient type, and the registration time are also significant but have relatively less strength of effects. Age and the district type of current management hospital are not statistically significant.

Table 4. Association Between Diagnostic Delay and Characteristics of Patients

Period	Coefficient (95% CI)	Std. Error	P-value
Gender			
Male	Reference		
Female	-0.5161 (-0.9682, -0.0640)	0.2307	0.025

Age			
<30	Reference		
>= 30 & <= 59	0.0273 (-0.5487, 0.6032)	0.2938	0.926
>= 60	0.9493 (-0.0393, 1.9379)	0.5044	0.060
Career			
Formal Employed	Reference		
Housekeeping and Unemployed	-2.9362 (-3.6234, -2.2490)	0.3506	<0.001
Farmer, Herdsman, Fisherman & Peasant Worker	0.5805 (-0.6385, 1.7995)	0.6219	0.351
Retired	-3.5111 (-4.4987, -2.5235)	0.5038	<0.001
Children and Student	-2.1683 (-3.3084, -1.0283)	0.5816	<0.001
Other or Unknown	-6.7985 (-7.4762, -6.1209)	0.3457	<0.001
Patient Type			
Relapse	Reference		
New	1.5071 (0.6945, 2.3196)	0.4145	<0.001
Patient Resource			
Symptomatic	Reference		
No Symptomatic	13.3718 (12.2446, 14.4990)	0.5751	<0.001
Residency			
Local	Reference		
Migrant	2.1895 (1.6176, 2.7613)	0.2918	<0.001
Registration Time			
Jan 2018 – Jan 2020	Reference		
Feb 2020 – Apr 2020	-0.7345 (-1.9969, 0.5278)	0.6440	0.254
May 2020 – Dec 2020	-1.4610 (-2.1529, -0.7690)	0.3530	<0.001
District Type Current Management Hospital Belong to			
Central	Reference		
Peripheral	0.3459 (-0.1457, 0.8374)	0.2508	0.168
PudongXinqu	0.1760 (-0.3878, 0.7398)	0.2876	0.541
Residency * Registration Time			
Time1*migrant	Reference		
Time2*migrant	0.4910 (-1.3762, 2.3582)	0.9526	0.606
Time3*migrant	-0.7122 (-1.7363, 0.3119)	0.5225	0.173

Our qualitative interviews revealed how case detection was affected by COVID-19. A national CDC officer claimed that the impact of COVID-19 in terms of diagnostic delay was somehow positive. Due to the similarity of symptoms of TB and COVID-19 and the

much stricter screening process during COVID-19, including the requirement of CT testing on inpatient admission, TB was easier to detect and treated under this circumstance, reducing diagnosis delay. However, patients' lack of willingness to visit the hospital and frequent quarantine could have delayed diagnosis, especially during the initial period of the COVID-19 outbreak. Some migrant patients reflected that lockdown and quarantine stopped them from going to the hospital. Additionally, in our focus group discussion, several community healthcare workers mentioned patients generally refused or delayed going to the hospital for diagnosis due to concerns about COVID infection. Except for the above, two district-level CDC officers informed that some district-level designated hospitals suspended outpatient services in the early epidemic stage, but it resumed very soon and may not have had much of an impact on timely diagnosis.

Figure 7. Quotations on Effects in Case Detection and Diagnosis During COVID-19

The diagnosis delay seems to be less than before. Many symptoms of TB may be similar to COVID-19. When the patient goes to see a doctor, they may prioritize testing COVID-19, for example, conducting a COVID-19 test, and if COVID-19 is excluded, they may check whether TB is. (KII, National CDC)
The tuberculosis outpatient service of the district-level designated hospital has been suspended, but it has no impact on our whole work because 95% of the patients go to the prefectural-level designated hospital, the pulmonary hospital, which was not affected and work as usual. (KII, district-level CDC, Shanghai)
Some patients, concerning being infected, are reluctant to go to the hospital. (KII, district-level CDC, Shanghai)
If there were an epidemic in Shanghai or Jiangsu, our commuting would be affected; it would be more troublesome for him to go to the doctor when there is an epidemic on both sides. He needs to quarantine after seeing the doctor across the province. (MGTB patient live in Jiangsu and have treatment in Shanghai)
During the particularly prevailed period of COVID-19, patients generally bear for a while and would not go to the hospital for treatment immediately. At that time, the patient would have to be quarantined as long as they go to the hospital, no matter what the situation was. (KII, district-level CDC, Shanghai)

FGD Focus-group Discussion, *KII* Key Informant Interview, *CHW* Community Healthcare Workers, *MGTB* Migrant Tuberculosis

Results of logistic regression of factors associated with test results are shown in Table 5. After adjusting for other demographic and socioeconomic factors, patients working as farmers, herdsmen, fishermen, and peasant workers were 1.6 times more likely to test as TB positive than those who were formally employed (95% CI 1.31– 1.89). Patients elder than 60 years old were more likely to test as positive than patients younger than 30 (95% CI 1.13–1.50). Patients newly admitted were less likely to test as positive than relapsed patients (95% CI 0.64–0.82). Patients with passive healthcare-seeking behavior were less likely to test as positive than those who came to the hospital due to symptoms (95% CI 0.63–0.86). Additionally, gender and district types of current management hospitals are also statistically significant ($p<0.05$) but may have less strength of effects. Residency and registration time are not significant variables in predicting test results. The residency * registration time interaction cannot predict the test results, suggesting that the association between residency and test results has no difference depending on the registration time.

Table 5. Logistic Regression Results of Factors Associated with Test Results

Period	Odds Ratio (95% CI)	Std. Error	P-value
Gender			
Male	Reference		
Female	0.8726 (0.8183, 0.9305)	0.0286	<0.001
Age			
<30	Reference		
>= 30 & <= 59	0.9405 (0.8666, 1.0207)	0.0393	0.141
>= 60	1.3008 (1.1274, 1.5009)	0.0950	<0.001
Career			
Formal Employed	Reference		
Housekeeping and Unemployed	1.0718 (0.9718, 1.1820)	0.0535	0.165
Farmer, Herdsman, Fisherman & Peasant Worker	1.5701 (1.3057, 1.8880)	0.1477	<0.001

Retired	0.8496 (0.7368, 0.9798)	0.0618	0.025
Children and Student	0.9975 (0.8479, 1.1735)	0.0827	0.975
Other or Unknown	0.7967 (0.7239, 0.8768)	0.0390	<0.001
Patient Type			
Relapse	Reference		
New	0.7226 (0.6405, 0.8153)	0.0445	<0.001
Patient Resource			
Symptomatic	Reference		
No Symptomatic	0.7383 (0.6311, 0.8636)	0.0590	<0.001
Residency			
Local	Reference		
Migrant	0.9922 (0.9146, 1.0764)	0.0412	0.850
Registration Time			
Jan 2018 – Jan 2020	Reference		
Feb 2020 – Apr 2020	0.9803 (0.8179, 1.1751)	0.0906	0.830
May 2020 – Dec 2020	1.0311 (0.9333, 1.1393)	0.0525	0.547
District Type Current Management Hospital Belong to			
Central	Reference		
Peripheral	1.0046 (0.9365, 1.0777)	0.0360	0.898
PudongXinqu	0.9221 (0.8509, 0.9994)	0.0378	0.048
Residency * Registration Time			
Time 1 * migrant	Reference		
Time 2 * migrant	0.9374 (0.7183, 1.2232)	0.1273	0.634
Time 3 * migrant	0.9681 (0.8360, 1.1210)	0.0725	0.665

Effects in Treatment for Migrant Patient During COVID-19

The study mainly evaluated the treatment from three perspectives: the accessibility to treatment, the treatment outcome, and treatment length of period.

Findings from our qualitative interviews with CDC officers and migrant patients and focus group discussions with community healthcare workers help elaborate the accessibility to treatment. Causes that hinder case discovery and diagnosis are on-going throughout the COVID-19 pandemic, continuing to effect TB treatment. Waiting times to access healthcare facilities and/or medications was long, e.g., an interviewed migrant patient reported that it takes a long time to wait for inpatient beds, and a community healthcare

worker reported a shortage of medicines at a designated hospital. Community healthcare workers also reported that many patients refuse to receive door-to-door visits because of fear of criticism or stigma, so that patient management, an essential part of treatment, is no longer smooth. Also, lockdowns or quarantines were reported as causing delays in picking up medication or seeing a doctor.

Figure 8. Quotations on Effects in Treatment During COVID-19

After the hospitalization order was issued, we waited for an inpatient bed at Ruijin Hospital for a week and another two or three days for the designated pulmonary hospital. (MGTB patient, Shanghai)
Tuberculosis has always been that patients do not want others to know that he is sick, so they do not want community healthcare workers to come to the door. (FGD, CHW, Shanghai)
I also know that the designated pulmonary hospital has experienced a shortage in medicine. (FGD, CHW, Shanghai)
For example, if there is a suspicious case in this community, patients in the community can definitely not come out, then it will result in two-week discontinuation of the drug. (KII, designated hospital)

FGD Focus-group Discussion, *KII* Key Informant Interview, *CHW* Community Healthcare Workers, *MGTB* Migrant Tuberculosis

Our quantitative analysis mainly assesses two other measures: treatment outcome and treatment length of period. Figure 9 shows local and migrant patients' treatment success rate monthly. We can observe that migrant patients have a slightly higher treatment success rate than local patients, and both groups' success rates fluctuate slightly across time. Regarding the treatment period, figure 10 indicates that the treatment period remained almost constant across time, and migrant patients experienced a longer treatment period than local patients. However, data dispersion may be significant due to the vast amount of data, so regression models are applied later to conduct a statistical test.

Figure 9. Monthly Treatment Success Rate

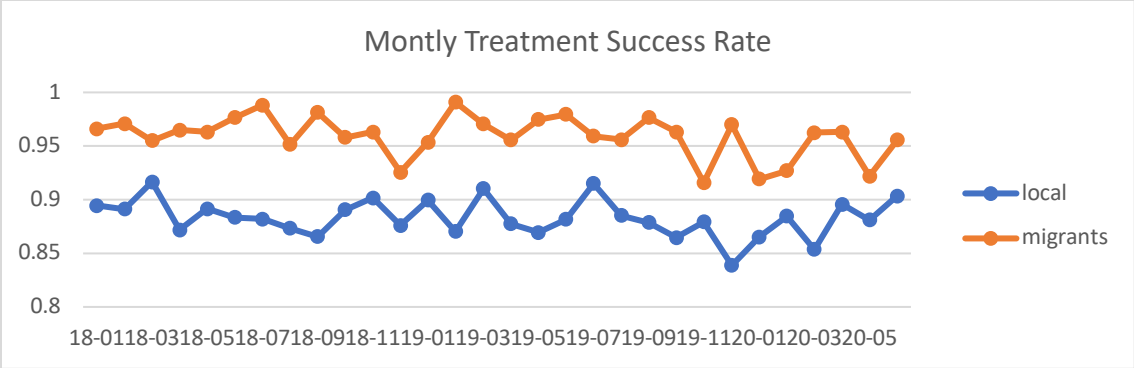

Figure 10. Monthly Average Treatment Period

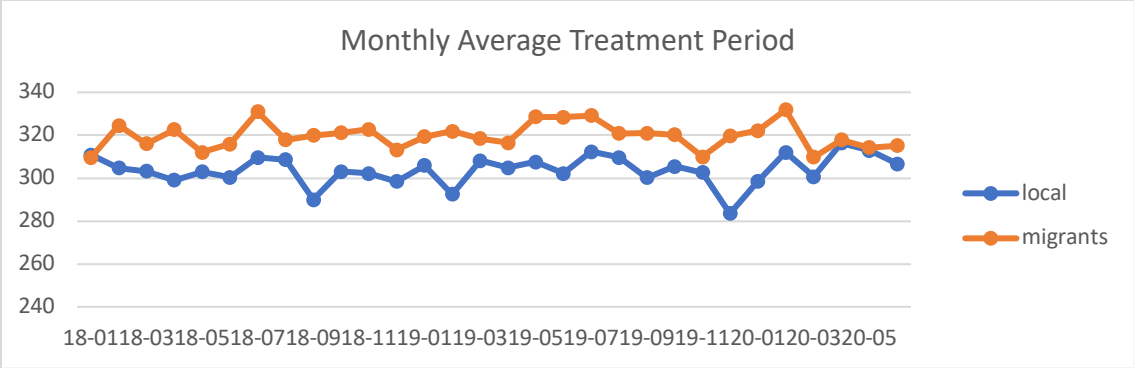

Table 6 concludes the logistic regression results of factors associated with treatment outcomes. Patients between 30 and 60 years old (95% CI 0.37-0.61) are less likely to have a successful or complete treatment outcome than patients younger than 30 years old, while patients older than 60 years old were least likely (95% CI 0.17-0.32) to have a successful or complete treatment outcome. Females were 1.27 times more likely to have an optimal treatment outcome than males (95% CI 1.11-1.46). Patients whose current management hospitals belong to peripheral districts were 1.41 times more likely (95% CI 1.22-1.63) to be successfully or completely treated than patients with management hospitals in central districts. The test result, career type, patient type, and residency are also significant predictors for treatment outcomes. Patient resource and registration time are not

statistically significant in our logistic regression model. The interaction term suggests that time three moderates the association between migrants and treatment outcomes. The migrants are more likely to receive a successful or complete treatment during time one and two than residents, while time three affects its odds ratio and turns it down from 1.57 to 0.83.

Table 6. Logistic Regression Results of Factors Associated with Treatment Outcomes

Period	Odds Ratio (95% CI)	Std. Error	P-value
Gender			
Male	Reference		
Female	1.2724 (1.1077, 1.4616)	0.0900	0.001
Age			
<30	Reference		
>= 30 & <= 59	0.4737 (0.3686, 0.6087)	0.0606	<0.001
>= 60	0.2346 (0.1705, 0.3229)	0.0382	<0.001
Career			
Formal Employed	Reference		
Housekeeping and Unemployed	0.9092 (0.6952, 1.1890)	0.1245	0.487
Farmer, Herdsman, Fisherman & Peasant Worker	0.8232 (0.5635, 1.2026)	0.1592	0.314
Retired	0.6578 (0.4921, 0.8794)	0.0974	0.005
Children and Student	0.6054 (0.3761, 0.9744)	0.1470	0.039
Other or Unknown	0.8101 (0.6348, 1.0338)	0.1008	0.090
Patient Type			
Relapse	Reference		
New	1.2786 (1.0528, 1.5528)	0.1267	0.013
Patient Resource			
Symptomatic	Reference		
No Symptomatic	1.4096 (0.9370, 2.1204)	0.2937	0.099
Residency			
Local	Reference		
Migrant	1.5684 (1.3129, 1.8736)	0.1423	<0.001
Registration Time			
Jan 2018 – Jan 2020	Reference		
Feb 2020 – Apr 2020	0.9669 (0.7323, 1.2766)	0.1371	0.812
May 2020 – Dec 2020	1.1367 (0.8463, 1.5266)	0.1710	0.395

District Type Current Management Hospital Belong to			
Central	Reference		
Peripheral	1.4052 (1.2151, 1.6250)	0.1042	<0.001
PudongXinqu	0.9618 (0.8253, 1.1209)	0.0751	0.618
Residency * Registration Time			
Time 1 * migrant	Reference		
Time 2 * migrant	0.8697 (0.5015, 1.5084)	0.2443	0.619
Time 3 * migrant	0.5289 (0.3163, 0.8846)	0.1388	0.015
Test Result			
Negative or No Result	Reference		
Positive	0.8084 (0.7120, 0.9179)	0.0524	0.001

Table 7 indicates the association between the treatment period and patients' characteristics by using the linear regression model. Patients with passive healthcare-seeking behavior have a significantly shorter treatment period than patients seeking health services due to symptoms, with nearly a month gap (95% CI -37.10 - -22.14). Newly treated patients experienced about 14 days shorter treatment period than relapse patients (95% CI -19.31 - -8.19). Compared to patients younger than 30 years old, patients over 60 experienced a significantly shorter treatment period (95% CI -22.99- -9.57). Besides, residency, district type the current management hospital belongs to, and test results are all statistically significant predictors. Gender and registration time are no significant predictors for the treatment period. The residency * registration time interaction cannot predict the treatment period, suggesting that the association between residency and treatment period has no difference depending on the registration time.

Table 7. Association Between Treatment Period and Characteristics of Patients

Period	Coefficient (95% CI)	Std. Error	P-value
Gender			
Male	Reference		

Female	-2.4215 (-5.5049, -0.6619)	1.5730	0.124
Age			
<30	Reference		
>= 30 & <= 59	0.8086 (-3.0923, 4.7096)	1.9902	0.685
>= 60	-16.2780 (-22.9878, -9.5681)	3.4232	<0.001
Career			
Formal Employed	Reference		
Housekeeping and Unemployed	4.6087 (-0.2677, 9.4851)	2.4878	0.064
Farmer, Herdsman, Fisherman & Peasant Worker	7.8943 (-0.1448, 15.9333)	4.1013	0.054
Retired	6.6585 (-0.0618, 13.3587)	3.4234	0.052
Children and Student	-4.9303 (-12.7028, 2.8421)	3.9653	0.214
Other or Unknown	8.9523 (4.5264, 13.3783)	2.2580	<0.001
Patient Type			
Relapse	Reference		
New	-13.7478 (-19.3093, -8.1862)	2.8373	<0.001
Patient Resource			
Symptomatic	Reference		
No Symptomatic	-29.6195 (-37.0959, -22.1431)	3.8142	<0.001
Residency			
Local	Reference		
Migrant	9.5606 (5.9410, 13.1803)	1.8466	<0.001
Registration Time			
Jan 2018 – Jan 2020	Reference		
Feb 2020 – Apr 2020	7.7701 (-0.0619, 15.6021)	3.9956	0.052
May 2020 – Dec 2020	5.5878 (-2.4284, 13.6041)	4.0897	0.172
District Type Current Management Hospital Belong to			
Central	Reference		
Peripheral	-1.2084 (-4.5618, 2.1451)	1.7108	0.480
PudongXinqu	-6.7836 (-10.6545, -2.9128)	1.9748	0.001
Residency * Registration Time			
Time 1 * migrant	Reference		
Time 2 * migrant	-9.7521 (-21.2864, 1.7823)	5.8845	0.097
Time 3 * migrant	-9.9514 (-21.7090, 1.8062)	5.9984	0.097
Test Result			
Negative or No Result	Reference		
Positive	21.3494 (18.4068, 24.2920)	1.5012	<0.001

Financial Difficulties in Completing TB Healthcare Services

Qualitative interviews revealed that migrants' financial resources and condition affected their ability to complete TB services. Most community health workers introduced the financial condition they observed among their patients in their communities. According to community health workers, though there were very few cases of patients who were impoverished by TB or who discontinued treatment for financial reasons, migrant patients still bore a certain financial burden due to unemployment or an inability to obtain subsidies and reimbursements. Our six migrant patients' interviewees provided some personal experiences. Many migrant patients reported they experienced unemployment due to the physical conditions as a result of having TB or layoffs due to the COVID-19. In addition to losing financial resources, subsidies are also unavailable for some patients. Several community workers explained the reasons and challenges obtaining a residence permit, which was necessary to receive a subsidy. Lastly, community healthcare workers reported that the reimbursement process was complex, and that the reimbursement coverage is not that wide.

Figure 11. Quotations on Financial Difficulties for Migrant Patients to Complete Treatment

But at least we did not hear from the community to tell us which patient had no money to continue the treatment because he lost his job. (KII, district-level CDC, Shanghai)
The migrant is not affected by COVID-19 but mainly by financial conditions. (FGD, CHW, Shanghai)
Some people cannot get a residence permit because their landlords do not want to provide the property ownership certificate. Without the residence permit, there is no reduction or exemption at all. (FGD, CHW, Shanghai)
Reimbursement is hard because the range is small. There is an agreement for reimbursement, and only medicines in the agreement can be reimbursed. TB costs a lot, but the expenses that can be reimbursed are only a small proportion of medicines or examinations. (FGD, district-level CDC, Shanghai)
I was unemployed during COVID-19, and medical insurance was suspended accordingly. I must pay at my own expense. For a total of 40 thousand yuan, I was only reimbursed about 10 thousand and needed to pay for the remaining 20 thousand, which does not even include transportation expenses and meals. (MGTB patient, Shanghai)
The burden is not that heavy and acceptable for me. (MGTB patient, Shanghai)

FGD Focus-group Discussion, *KII* Key Informant Interview, *CHW* Community Healthcare Workers, *MGTB* Migrant Tuberculosis

Coping Strategies

Responses in the qualitative interviews illustrated a series of coping strategies adopted by CDC, designated hospitals, and community health workers in response to challenges and effects COVID-19 brought to TB healthcare. CDC communicated with designated hospitals to perceive all information, including outpatient service provision and inpatient availability, was updated to the public promptly. CDC coordinated the designated hospital volunteers, community health workers, and online drug distribution platforms to work together to ensure the continuity of drug supply for stranded migrant populations and patients in the lockdown. Designated hospitals set up online diagnosis and treatment platforms to provide online services to provide convenience and help patients save time and travel expenses. Community health workers ensured patients' medication and living needs and communicated with patients through phone calls and Wechat instead of door-to-door visits to follow up on treatment-related matters. The community also provided health education to ensure patients were fully aware of the importance of follow-up and timely medication and called on family members to provide relevant support.

Figure 12. Quotations on Adopted Coping Strategies on TB care During COVID-19

We need to quickly grasp the condition of diagnosis and treatment in the designated hospitals. When will the wards open, and when will the outpatient service resume? We will communicate with designated hospitals regarding these questions, and then we will notify patients and update them in time. (KII, prefectural-level CDC, Shanghai)
Under COVID-19, Wuhan Jinyintan Hospital distributes drugs to drug-resistant patients through three-level linkage. (KII, National CDC)
Patients can contact the community COVID-19 prevention and control office regarding their material and medical needs. (KII, district-level CDC, Shanghai)
We have an online platform to conduct diagnosis and treatment. There is no reimbursement because the platform is not qualified for medical insurance. However, even if the patient cannot receive

reimbursement, it is still worthwhile because it saves time and travel costs. After the epidemic was normalized, the platform transformed to a combination of offline and online. (KII, desginated hospital)
The management of medicine usage used to be conducted by door-to-door visits, which is not applicable now. Fortunately, we have made many attempts in Shanghai before, such as mobile apps and phone calls, to keep in touch with patients and prevent the treatment from being interrupted. (KII, prefectural-level CDC, Shanghai)
We told patients the importance of regular medicine usage when we signed the agreement. If you stop the drug easily or repeatedly, it will be easy to relapse in the future, and then it will be easy to develop drug resistance. (FGD, CHW, Shanghai)

FGD Focus-group Discussion, *KII* Key Informant Interview, *CHW* Community Healthcare Workers, *MGTB* Migrant Tuberculosis

4. Discussion

In this study, compared with local patients, migrant patients were younger, a larger percentage of new patients, a more significant percentage were employed, and more treatment-seeking behavior due to passive detection, which is consistent with previous studies' findings (Peng et al., 2010; Shen et al., 2012).

Policies and coping strategies ensure the consistency

Not as generally assumed, overall, the study found no significant difference between the local and migrant patients. We infer that it can attribute to the existing well-established policy and management structure and the rapidly adopted coping strategies during the COVID-19 pandemic in Shanghai. The consistent management system allows migrant patients to enjoy the same comprehensive healthcare process as residents in TB diagnosis and treatment. During the COVID-19 pandemic, the migrant population may encounter problems such as stranding in different places and being unable to return to Shanghai in time for further treatment after returning to their hometowns. However, a series of measures ensured their continuation of treatment to the greatest extent possible. As qualitative results in coping strategies indicated, the online diagnosis and treatment platform guarantees access to off-site diagnosis. In terms of treatment, the core of the transformation of the new measures lies in the realization of remote services, which eliminates the obstacles of geographical location and greatly facilitates the migrant population. The online medicine dispensing platform, the three-level linkage drug supply during the quarantine ensure the continuity of drugs, and the remote patient management and supervision of community volunteers played an important role in guaranteeing and

supervising the continuity of medical treatment and medication. These measures ensured that the diagnosis and treatment of TB in the migrant patients did not differ from the local patients during the COVID-19 outbreak.

Current challenges in accessibility and adherence of migrant patients to TB care

The study found no significant difference in the diagnosis delay between the pre-COVID period and the COVID-19 outbreak period, while the recovery period had a significantly shorter diagnosis delay than the pre-COVID period. Previous studies are inconsistent with our results. Two retrospective cross-sectional studies conducted in Italy and South Korea showed that diagnosis delays have increased due to the COVID-19's impact (Francesco Di et al., 2021; Yang et al., 2021). We infer that this may be because of epidemic transmission conditions and the screening and case detection measures taken by countries, resulting in different effects on TB diagnosis. In our study, although key informants indicated that strict screening for COVID-19 would be beneficial for TB case detection, the statistical insignificance between the COVID-19 outbreak period and pre-COVID period and the significant reduction in recovery period than pre-COVID period may be attributed to the shorter time assigned to the outbreak period in this study, which was only two months. As a result, some changes are not enough to present statistically. At the same time, the decrease in the willingness of patients to seek medical care and the relatively short supply of health services in the early stage of the epidemic are also the reasons related to diagnosis delay.

Our study aligns with the existing studies that diagnosis delay of the migrant population is also significantly higher than that of the local population. The previous study finds that

working hours per day significantly affect medical visitation (Peng et al., 2010). In our study, migrant patients have a larger proportion of employment, while nearly half of local patients are made up of retired elders; we may infer that migrant patients' delay in diagnosis may be contributed to their busy work.

In terms of the treatment, migrant patients have a significantly higher rate of getting successful treatment than residents during the pre-COVID and outbreak period, while this significant association is moderated during the recovery period. At the same time, the treatment period of migrant patients is significantly longer than that of local patients. First, according to previous studies, the finding that migrant patients have higher treatment success rates is consistent(Ge et al., 2018). More specifically, our study indicates that the cure rates of local patients and mobile patients are the same and even slightly higher for local patients, but the treatment completion rate of migrant patients is significantly higher than that of local patients. Our qualitative results help interpret it: generally, migrant patients are younger and more flexible than some local elderly population, they can better realize the importance of timely treatment, and generally have higher adherence. In this case, the migrant patients with a high treatment completion rate may originally have a longer treatment time; in addition, the migrant population's work and their needs to return to their hometown increase the treatment time potentially. These provide explanations for the significantly longer treatment duration of the migrant population. However, during the recovery period of COVID-19, the treatment success rate of the migrant population, which was significantly higher than that of the local population, declined. First, we infer that the

inconvenience of regular follow-up during COVID-19 and the retention of the migrant population was a reason. At the same time, strict case detection and screening and subsequent mandatory treatment during COVID-19 narrowed the gap in patient adherence and compliance. In addition, the incomplete data update may also lead to statistical bias in our analysis.

The financial burden for migrant patients and potential policies to relieve

Our qualitative results show that for migrant patients, the financial burden of TB treatment is still relatively obvious. The current reimbursement policy has relatively strict conditions, and the range and proportion of reimbursement are relatively small. Combined with migrant patients' expenses other than medical treatment (including but not limited to renting, travel, etc.), the current reimbursement mechanism is still insufficient. However, the financial burden has an essential impact on migrant patients' health-seeking behavior and their compliance and persistence of treatment (Peng et al., 2010; Xiaolin Wei et al., 2009).

Based on existing challenges, new policies and measures should be developed. Given that eliminating TB is China's 2030 health goal, and the disease burden brought by the migrant population is heavy, the establishment of a special fund to assist can fill the gap found in our research that has no other subsidies except the current reimbursement policy. Besides, expanding the scope of drugs and tests included in the reimbursement according to the process of tuberculosis treatment and achieving full-process reimbursement coverage as soon as possible. Finally, financial subsidies can be provided as incentives to encourage

patients to adhere to and complete treatment. It can not only relieve the financial burden for patients but also improve the completion rate of treatment.

Limitation

The primary limitation in our study is the unprecise quantitative data. First, the original classification of quantitative data is not precise enough, and the update is not timely. We found missing values in almost every variable during the data cleaning process. Also, a significant proportion of data are listed as "unknown or others," e.g., career. It directly leads to some bias in the statistical analysis also hinders us from digging into the further mechanisms behind the associations between variables.

Another limitation is the lack of quantitative data for the financial burden. Our study only collected qualitative data on the financial burden, an important topic involved in TB treatment, but no quantitative data with a large sample size that can be quantified, so our results are not statistically tested and cannot be presented quantitatively.

Besides, our independent variable "time" is not categorized evenly. In order to fully take into account COVID-19 epidemic and the measures taken during the period, this study divides the time according to the development of the epidemic and Shanghai's response mechanism but results in an uneven: Compared to the pre-COVID period with 25-month data volume, our second phase only includes data of three months, while the recovery period includes eight months of data. This may cause the second and third stages to be too short for the difference to be apparent, resulting in statistical bias.

Last but not least, there are also some limitations in the qualitative data. The sample size for the qualitative interviews is kind of small. Also, most of them are from Baoshan and Jingan, which represent peripheral and central districts; however, Pudongxinqu, the third category of district types, lacks representation. It may lead to some bias in representation and generalizability.

Next Step

In regard to limitations, we may replicate the analysis with updated data and a more extended follow-up period. With the inclusion of the period of normalization of COVID-19, we can more fully observe the changes, conduct analysis, and further analyze the impact of repeated epidemics and newly-issued normalized measures on migrant tuberculosis patients, which will be more practical at this stage. Also, we can expand the study to another study site, maybe a city that is not that well developed but also with a large number of migrants. Under that circumstance, we can observe how COVID-19 affects the TB under the pandemic is not well controlled or TB is not well managed. Finally, we can approach the CDC to perceive the financial-related data, including but not limited to medical insurance conditions, the reimbursement type, and the reimbursement amount. Then, we can develop a more comprehensive and more accurate analysis.

5. Conclusion

There are no significant differences in TB diagnosis, treatment, and management between local and migrant patients in Shanghai, potentially due to mature policy and management system and its rapid response during the COVID-19 outbreak. COVID-19 somehow positively affects the case detection but causes a certain degree of delay in treatment. The current reimbursement mechanism does not provide sufficient protection and support for migrant patients in terms of financial burden. However, more evidence is needed to test and elucidate this relationship.

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