

Policy Forum



The Current Status and Challenges Regarding Tuberculosis Infection Control in Health Care Facilities in China*

ZHAO Fei^{1,^}, CHENG Jun^{1,^}, CHENG Shi Ming¹, ZHANG Hui¹, ZHAO Yan Lin¹, ZHANG Can You¹, HU Dong Mei¹, FAN Hai Ying¹, HUANG Fei¹, QU Yan^{1,#}, HE Guang Xue^{2,#}, and WANG Li Xia^{1,#}

Health care facilities are a high-risk environment for generating and spreading respiratory infectious diseases such as tuberculosis (TB). The TB prevention and treatment staff in health care facilities are responsible for the identification, diagnosis, treatment, supervision, and management of TB patients^[1]. If infection control measures are not properly taken, TB patients who excrete bacteria may transmit mycobacterium TB (MTB) to the facility staff and other patients, increasing the risk of TB mycobacterium infection and TB disease in the health care facility^[2].

TB infection control is a combination of measures aimed at minimizing the risk of TB transmission within the general population^[3] and plays an important role in preventing the spread of MTB in health care facilities and cross-infection between health care workers and patients. Currently, there is no specific vaccine for TB^[4] and no specific drug therapy for HIV infectors and AIDS patients^[5]. The spread of HIV infection, and the appearance of multidrug-resistant TB (MDR-TB) and extensively multi-drug resistant TB (XDR-TB)^[6] increase the risk of MTB spread, and make curative therapy more difficult. Therefore, reducing the risks of MTB spread to the masses through TB infection control measures is very important, particularly among high-risk populations such as health care workers in endemic areas^[7].

TB infection control methods in China include organizational management and three kinds of control measures. Among them, three kinds of control measures include administrative control, environmental and engineering control, and personal protection. Organizational management primarily includes 1) establishing and improving the managerial organization of TB infection control, 2)

evaluating the level of risk for TB infection, 3) making policies, plans, and developing budgets, 4) strengthening human resources, 5) optimizing the layout of health care facilities, 6) TB infection control education, 7) surveillance and assessment of TB infection control, and 8) conducting implementation research. Administrative control is the first step of TB infection control and prevention and mainly includes 'five earlier measures' for TB cases (earlier detection, earlier diagnosis, earlier isolation, earlier separation, and earlier treatment), the dissemination of proper respiratory hygiene and cough etiquette, the management of outpatients and inpatients with suspected TB symptoms, and decreasing the risk of TB contamination in the laboratory. The purpose of administrative control is to prevent the generation of infectious droplet nuclei and reduce the risk of MTB infection by taking a series of control measures during the diagnosis and treatment of patients with infectious pulmonary TB. Environmental and engineering control mainly refers to appropriate architectural design and manipulation of the environment that has been, or may be polluted, by MTB, to reduce the concentration of inhalable infectious droplet nuclei in the air. At present, environmental and engineering measures in China generally include ventilation and the use of ultraviolet germicidal lamps. Personal protection is the third layer of TB infection control and includes the use of medical protective respirators and personal protective equipment such as goggles, gloves, and isolation clothing.

The aim of this report is to analyze and discuss the current status and challenges regarding TB infection control in China, and to make suggestions for health care workers and facilities regarding TB

doi: 10.3967/bes2015.118

*This work was funded by the China-Gates Foundation TB Control Project (Phase II) (51914).

1. National Center for Tuberculosis Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing 102206, China; 2. Science and Technology Department, Chinese Center for Disease Control and Prevention, Beijing 102206, China

infection control.

CURRENT STATUS OF TB INFECTION CONTROL

Policies and Technical Specifications

In 2009 the World Health Organization (WHO) issued the *WHO Policy on TB Infection Control in Health Care Facilities, Congregate Settings and Households*^[3], which included activities for national and subnational TB infection control and measures for facility-level TB infection control. These activities and measures provided policy references for countries to carry out TB infection control. In recent years, China has completed several basic surveys regarding TB infection control and has carried out a training series. In project areas (National Science and Technology Major Project of the 11th Five-Year Plan^[8], China-US Collaborative Program on Emerging and Re-emerging Infectious Diseases^[9], Damien Foundation TB Control Project, and the China-Gates Foundation TB Control Project^[10]) and some economically developed provinces, TB infection control research has been conducted^[11]. Nonetheless, information on nationwide TB infection control is still lacking.

Based on a 2009 TB infection control survey conducted in Chinese provinces by the Chinese Center for Disease Control and Prevention, experts published the *China TB Infection Control and Prevention Manual* and the *Standard Operating Procedures of TB Infection Control in China* in 2010 and 2012, respectively. These two publications provide operational measures and technical methods for TB infection control for all levels of TB prevention and treatment institutions, TB designated hospitals/special hospitals, and comprehensive medical institutions in China.

Current Status of TB Infection Control in Health Care Facilities in China

A very large population is infected with MTB in China. On the basis of a 44.5% MTB infection rate among the total population in The Fourth National TB Epidemiological Sampling Survey Report in 2000, it was estimated that about 550 million people were infected with MTB in China. The Fifth National TB Epidemiological Sampling Survey Report in 2010 showed that the prevalence rate of active, smear-positive, and bacteria-positive TB among the population > 15 years old in China was 459/100,000 people, 66/100,000 people, and 119/100,000 people,

respectively^[12].

Infection, incidence, and prevalence of MTB in TB prevention and treatment staff

The TB prevention and treatment staff play an important role in TB prevention and treatment. Because of their career, they are at a high risk for MTB infection and disease^[13]. TB infection in the medical staff was surveyed in two hospitals in the Inner Mongolia Autonomous Region in 2010^[8]. Of those surveyed, 999 medical staff completed the QuantiFERON-TB Gold In Tube (QFT-GIT) test, a gamma interferon release test. The results showed an infection rate for MTB of 68%; simultaneously, 924 medical staff completed the tuberculin skin test (TST), and the infection rate was 69% (judgment standard: average diameter of induration ≥ 5 mm). The results suggested that the factors affecting MTB infection in the medical staff included time spent working in the medical institution, the number of colleagues suffering from TB, occupation type, and the type of ventilation in the hospital. Compared to the non-clinical medical staff, the differences in the positive rate and strong positive rate in the medical staff were statistically significant^[14].

A longitudinal cohort study was conducted in the Inner Mongolia Autonomous Region of China between November 2011 and November 2012^[9]. All 880 registered and licensed village doctors from two counties were eligible to participate in the study and were followed up 12 months after the baseline survey. TST and QFT-GIT were performed and interpreted to define the infection status at baseline and 12 months later. Based on the TST results, the incidence of latent TB infection (LTBI) for the 465 previously negative village doctors was 11.4%, using ≥ 10 mm of TST induration as the conversion criteria. Meanwhile, based on QFT-GIT results, the incidence of LTBI for the 361 previously negative village doctors was 19.1%, using a level of 0.35 IU/mL of interferon-gamma (IFN- γ) as the conversion criteria. Working location and duration, length of exposure to potentially infected patients and a visible BCG scar were associated with a positive conversion.

A 2010 survey performed in 5235 medical staff in three provinces of China revealed^[2] that the average annual TB prevalence rate was 664.76/100,000 people, and that the average annual prevalence rate of smear-positive TB was 191.02/100,000 people. Among those surveyed, working in a TB prevention and treatment institution or a special hospital, the absence of a TB infection control system, and close contact with patients with

TB for >15 h/week were the main risk factors affecting the development of disease in medical staff.

The above surveys show that the MTB infection rate, the MTB infection incidence rate, and the TB prevalence rate among the TB prevention and treatment staff were relatively high^[15]. This is clearly related to occupational exposure. Management measures, health-care facility environmental and engineering measures, position of medical staff, number of years employed, the use of personal protection, and knowledge-attitude-belief-practice (KABP) regarding TB infection control affected the TB exposure of the medical staff in health care facilities, increasing the risk of infection and the development of disease among the TB prevention and treatment staff^[16].

TB infection control knowledge of the TB prevention and treatment staff The level of knowledge regarding TB infection control among the TB prevention and treatment staff directly affects their clinical behavior and attitude, and indirectly affects TB detection and the management of patients with TB. Therefore, it is critical to optimize knowledge of TB infection control for the TB prevention and treatment staff.

A survey regarding the level of knowledge related to TB infection control was conducted among 3,325 medical workers in 22 health care facilities in Beijing, Inner Mongolia Autonomous Region, and Shanghai^[17]. Results showed that 96.5% of medical workers had a correct understanding of isolation and ventilation, but only 30.7% could correctly answer a question about the type of face mask used during contact with suspected or confirmed infectious TB. A questionnaire survey regarding TB infection control knowledge was also administered to 670 rural doctors in two districts and counties in Inner Mongolia. Regarding TB infection control, only 29.9% of rural doctors correctly answered all questions. Studies have shown a low level of knowledge regarding TB infection control in the TB prevention and treatment staff, indicating that education and training in TB infection control needs to be improved.

Implementation status of TB infection control

Implementation of organizational management Organizational management mainly includes establishing and improving the managerial organization of TB infection control, making policies and plans, developing budgets, evaluating the risk of infection, strengthening human

resources, implementing proper architectural design, carrying out health education, implementing monitoring and assessment, and conducting scientific research.

The results of a survey studying TB infection control in 12 medical institutions in the eastern, central, and western regions of China in 2013 showed that eight medical institutions had established managerial organizations for TB infection control or had assigned personnel to be responsible for infection control. The managerial organizations for TB infection control were led by a department vice president, and were implemented by the head of the Infectious Disease Department. Eight institutions had established an infection control system, and had made corresponding written infection control plans, inspection records, and worker training records. Five institutions set up a special fund for TB infection control and established equipment and logistic departments responsible for funding and purchasing UV germicidal lamps, medical protective masks, and other equipment for TB infection control. In terms of monitoring and assessment, of the four institutions surveyed only two institutions evaluated the design of their facilities for TB infection control, and only one institution was carrying out monitoring and assessment for TB infection prevention and control on a regular basis.

Implementation of administrative control Administrative control means that the process of diagnosing and treating patients with infectious TB proceeds through a series of control measures, thereby preventing or reducing the generation of infectious droplet nuclei, and reducing the risk of infection with MTB.

A 2011 survey revealed that four provincial-level TB designated facilities in Inner Mongolia, Chongqing, Jiangsu, and Henan were able to isolate infectious patients diagnosed in outpatient departments, infectious patients diagnosed in hospital wards, multi-drug resistant patients diagnosed in outpatient departments, and multi-drug resistant patients diagnosed in hospital wards. The implementation of proper measures including cough screening, separate waiting areas for patients with suspected TB, priority evaluation by a physician, proper cough etiquette education, and sputum sampling differed greatly between facilities. Only two facilities took measures to separate patients with cough from other patients, and posted educational materials for proper cough etiquette in the corridors. With regard

to shortening the waiting time for patients in the designated facilities, each facility took different measures including priority to register, appointment scheduling, increased usage of service windows, priority to Clinical Check-up and Diagnosis, and having patients return home to wait for a phone call after leaving a sputum sample. In terms of the staff's health management measures, three of four TB designated facilities provided a medical examination for the staff. These three facilities saved the TB records of their organization's staff, while one facility did not maintain TB records of the staff. Based on these health care records, the three facilities had a total of six staff members with TB, including five nurses and one doctor. The six staff members worked 2-18 years in their respective facilities before the onset of TB^[18].

Implementation of environmental and engineering control Environmental and engineering control mainly refers to proper architectural design and the treatment of an environment that has been or may be polluted by MTB, aiming to reduce the concentration of inhalable infectious droplet nuclei in the air.

I. Outpatient Service A survey in 2013 showed that only two out of 12 institutions had a reasonable overall architectural design for their outpatient department. The TB outpatient services of these two institutions were in separate buildings, and were relatively distant from other outpatient services, especially the AIDS voluntary counseling clinics, diabetes clinics, and the pediatric outpatient departments. Both provided patients with TB and other patients with separate register windows, charge windows, medicine administration windows, waiting areas, sputum sampling rooms, and

consulting rooms. Five institutions had a separate register window for patients with TB or suspected TB and six institutions set up a separate waiting area for patients with TB or suspected TB. Four institutions set up a separate charge area for patients with TB or suspected TB, four institutions had a separate medicine administration area for patients with TB or suspected TB, and in three institutions, the TB outpatient departments were close to the diabetes clinic or the pediatric outpatient department.

Good ventilation [air changes per hour (ACH) ≥ 12 times/hour]^[3] was achieved in the outpatient departments in 10/12 institutions investigated. Proper illumination intensity (illumination intensity $\geq 70 \mu\text{W}/\text{cm}^2$) was found in the outpatient departments of 6/12 institutions investigated (Table 1)^[10].

II. Laboratory Among the 12 institutions investigated, six institutions had appropriate laboratory layouts. In these six institutions, the laboratory had independent specimen transfer windows, physical isolation of the office and test areas, experimental zones rationally divided into clean areas and contaminated areas by the operation content, and physical separation of sputum smear laboratories and sputum culture laboratories with a separate buffer zone. Among the six other institutions, two institutions had no specimen transfer window in the laboratory, two institutions had no dirt outlet and/or channel in the laboratory, one institution had no running water in the sputum smear laboratory to wash the dyed smear in the same laboratory, and three institutions had sealed laboratories without any ventilation or negative pressure device resulting in an ACH of zero times/hour.

Table 1. Number of Medical Institutions in Three Regions in China Where ACH and Illumination Intensity Requirements were met in 2013

| Region | ACH (≥ 12 ACH) | | | Illumination Intensity ($\geq 70 \mu\text{W}/\text{cm}^2$) | | |
|---------|------------------------|------------|------|--|------------|------|
| | Outpatient departments | Laboratory | Ward | Outpatient departments | Laboratory | Ward |
| Eastern | 4/4 | 2/4 | 3/4 | 2/4 | 4/4 | - |
| Central | 4/4 | 2/4 | 4/4 | 2/4 | 0/2 | 0/2 |
| Western | 2/4 | 2/4 | 4/4 | 2/4 | 1/4 | 1/2 |

Note. ACH=air changes per hour. Each numerator represents the number of institutions where ACH and illumination intensity met requirements; each denominator represents the number of investigated institutions. The down lighting ultraviolet germicidal lamp was installed in the laboratories in only 10/12 institutions investigated, including 4 institutions in eastern China, 2 institutions in central China, and 4 institutions in western China. The down lighting ultraviolet germicidal lamp was installed in the wards in only 4/12 institutions investigated, including 2 institutions in central China and 2 institutions in western China.

Good ventilation (ACH ≥ 12 times/hour) was present in the laboratories of 6/12 institutions investigated. A down lighting ultraviolet germicidal lamp was installed in 10/12 of the institutions investigated and the illumination intensity requirement (illumination intensity $\geq 70 \mu\text{W}/\text{cm}^2$) was met in 5/10 institutions (Table 1)^[10].

III. Ward Among the 12 institutions investigated, only three institutions had reasonable ward designs. In these three institutions, clean areas, semi-contaminated areas, contaminated areas, medical staff channels, and patient channels were set up and divided according to the requirements for isolation wards. The buffer room between the 'two channels' and 'three areas' was set up, and the doors on either side of the buffer room could not be opened simultaneously. There was physical isolation between the patient wards, the doctors' offices, and the nurses' stations. In addition, every ward had independent buffer rooms and bathrooms. The other nine institutions had shortcomings in their ward designs. Among these, in three institutions the TB wards were not separated from the doctors' offices and the nurses' stations, while in three other institutions, hospital beds were placed in ward corridors or buffer rooms. Two institutions did not have independent medical staff channel and independent patient channel in the ward, and in one institution the TB ward and psychiatric ward were on the same floor without any isolation or separation.

Good ventilation (ACH ≥ 12 times/hour) in the wards was present in 11/12 institutions investigated. A down lighting ultraviolet germicidal lamp was installed in the wards in only 4/12 institutions investigated and only one of these had the required illumination intensity (illumination intensity $\geq 70 \mu\text{W}/\text{cm}^2$) (Table 1)^[10].

Implementation of personal protective measures

Personal protection is the third layer in TB infection control, and is a useful supplement to organizational management measures and environmental and engineering control.

Among the 12 medical institutions investigated, 11 institutions provided medical staff with medical respirators, but the quantity did not meet the requirements of the workplace. The medical staff in only four institutions wore medical respirators during the survey, and the medical staff in these four institutions wore medical respirators in a non-standard manner. The main errors included wearing only one belt, only covering the mouth, and

exposing the nose for breathing. Ten institutions provided medical surgical masks for patients with TB and suspected TB.

MAIN CHALLENGES FOR TB INFECTION CONTROL IN CHINA

There are many challenges for TB infection control in China. As in other countries with a high TB burden, TB infection control in China has a weak foundation. Most regions have never carried out even standard TB infection control measures. The main problems are as follows.

China lacks policy support specific to TB infection control. Although two manuals on TB infection control have been published, as noted above, they both provide technical guidance but they are not legally binding. Therefore, institutions that desire TB infection control do not receive further support due to a lack of TB infection control policies backed by legal enforcement.

Primary health care facilities lack full-time and/or part-time TB infection control personnel in most regions. In general, the lack of a workforce competent in TB infection control is one of the major barriers to developing and implementing TB infection control measures.

Most areas lack the basic funds for TB infection control. Therefore, facilities for the diagnosis and treatment of TB lack effective ventilation systems, sufficient ultraviolet germicidal lamps, and the necessary ongoing maintenance and testing. Most health care facilities have insufficient personal protective equipment and do not provide patients with TB and suspected TB with medical surgical masks.

In addition, the architecture and functional partitions in some health care facilities do not conform to TB infection control standards. Most hospital wards were not initially designed for the treatment of patients with TB.

Moreover, TB prevention and treatment staff lack the knowledge related to TB infection control. Therefore, some staff do not always practice proper cough etiquette and some do not use the correct medical respirator.

SUGGESTIONS FOR THE IMPROVEMENT OF TB INFECTION CONTROL IN CHINA

These problems and challenges should be overcome in a step-by-step manner in order to

improve TB infection control in China. In view of the current status, we need to introduce policies for TB infection control, increase funding for facilities and human resources, and fully implement TB infection control measures to protect the health of TB prevention and treatment staff and the general population from TB infection and disease.

Introduce Policies for TB Infection Control in China as Soon as Possible

At present, TB infection control is poor in China. The National Health Administrative Departments should introduce TB infection control standards and specifications for China's TB health care facilities, and fully implement TB infection control measures nationwide, so as to protect the health of the TB prevention and treatment staff as well as the general population.

Establish and Improve the TB Infection Control Organization

Depending on the institution's size, corresponding infection control departments should be established. In each institution, at least one qualified person should be responsible for TB infection control.

Increase Investment in Infection Control in Health Care Facilities

Regional TB infection control measures are inconsistent in China and there is a large gap in TB infection control between developed regions and undeveloped regions. The implementation of TB infection control measures needs an investment in manpower, equipment, and other resources, especially medical respirators for the medical staff.

Establish a Systematic TB Infection and Disease Screening System of the TB Prevention and Treatment Staff

Knowing the current status of MTB infection and TB in China is extremely important for the TB prevention and treatment staff. China has not improved TB infection and disease screening, protection measures, or supervision of the TB prevention and treatment staff. Thus, we should improve TB infection and disease monitoring systems for the TB prevention and treatment staff in China in order to detect TB cases in a timely fashion.

Strengthen Education and Training Related to TB Infection Control

We should implement public education awareness campaigns regarding TB prevention and control, and mobilize the public to participate in TB infection control, aiming to eventually control this infection and protect the staff in TB prevention and treatment institutions from TB infection.

[^]These authors contributed equally to this paper.

[#]Correspondence should be addressed to QU Yan, Tel: 86-10-58900530, E-mail:quyan@chinatb.org; HE Guang Xue, Tel: 86-10-58900237, E-mail: hegx@chinacc.cn; WANG Li Xia, Tel: 86-10-58900517, E-mail:wanglx@chinacc.cn

Biographical notes on the first authors: ZHAO Fei, male, born in 1981, Doctorate Degree, Associate Researcher, majoring in Epidemiology and Health Statistics; CHENG Jun, female, born in 1969, Masters Degree, Associate Researcher, majoring in Epidemiology and Health Statistics.

Received: March 4, 2015;

Accepted: October 29, 2015

REFERENCES

1. Wang LX. Analysis of the current situation of Tuberculosis control and treatment in China. Chinese Journal of Public Health, 2012; 28, 413-4. (In Chinese)
2. He GX, Song YD, YX, et al. Current situation and suggestions on tuberculosis infection control for Chinese health care facilities and tuberculosis health-care workers. Chinese Journal of Anti-tuberculosis, 2014; 36, 641-3. (In Chinese)
3. WHO. WHO policy on TB infection control in Health-care facilities, congregate settings and households. 2009.
4. Dye C, Glaziou P, Floyd K, et al. Prospects for tuberculosis elimination. Annu Rev Public Health, 2013; 34, 271-86.
5. Edelman EJ, Gordon KS, Glover J, et al. The next therapeutic challenge in HIV: polypharmacy. Drugs & aging, 2013; 30, 613-28.
6. Dash M. Drug resistant tuberculosis: a diagnostic challenge. J Postgrad Med, 2013; 59, 196-202.
7. Zhao F, Cheng SM, He GX, et al. Space-Time Clustering Characteristics of Tuberculosis in China, 2005-2011. Plos One, 2013; 8, e83605.
8. Geng MJ, Song YD, Xiong YC, et al. Comparison and analysis of TST and IGRAs for testing tuberculosis infection in health care workers. Chinese Journal of Anti-tuberculosis, 2014; 36, 121-5. (In Chinese)
9. He GX, Li Y, Zhao F, et al. The Prevalence and Incidence of Latent Tuberculosis Infection and Its Associated Factors among Village Doctors in China. Plos One, 2015; 10, e0124097.
10. Zhao F, Wang LX, He GX, et al. Survey on the current situation of tuberculosis (TB) infection control in designated medical

- institutions of tuberculosis in 3 cities. Chinese Journal of Anti-tuberculosis, 2014; 36, 318-22. (In Chinese)
11. He GX, van denHof S, van der Werf MJ, et al. Infection control and the burden of tuberculosis infection and disease in health care workers in china: a cross-sectional study . BMC Infect Dis, 2010; 10, 313.
 12. Wang LX, Zhang H, Ruan Y, et al. Tuberculosis prevalence in China, 1990-2010; a longitudinal analysis of national survey data . Lancet, 2014; 383, 2057-64.
 13. Chai S, Mattingly D, Varma J. Protecting health care workers from tuberculosis in China: a review of policy and practice in China and the United States. Health Policy Plan, 2012; 28, 100-9.
 14. Zhang WM, He GX, Hong F. The status of tuberculosis infection control among health care workers in health-care facilities in China. Chinese Journal of Infection Control, 2011; 10, 248-51. (In Chinese)
 15. Zhang X, Jia H, Liu F, et al. Prevalence and Risk Factors for Latent Tuberculosis Infection among Health Care Workers in China: A Cross-Sectional Study. PLoS One, 2013; 8, e66412.
 16. Hou YY, Xiong YC, He GX, et al. Current situation and influencing factors of TB infection and disease of health care workers. Chinese Journal of Nosocomiology, 2012; 22, 4428-30. (In Chinese)
 17. Tan JB, He GX, Hou YY, et al. Survey of cognitive level of health care workers. China Preventive Medicine, 2012; 5, 397-8. (In Chinese)
 18. Zhang WM, Hong F, Wang HD, et al. The implementation of 'Handbook of Chinese control and prevention of TB infection' in four health-care facilities. Chinese Journal of Anti-tuberculosis, 2011; 33, 475-9. (In Chinese)