

## Risk factors associated with tuberculosis infection among health care workers in Inner Mongolia, China

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### SUMMARY

**SETTING:** Health care workers (HCWs) are at increased risk for tuberculosis (TB) infection. In China, surveys examining TB infection among HCWs have not studied general health care facilities, compared tuberculin tests conducted using local protocols against an internationally accepted test or characterised risk factors.

**OBJECTIVE:** To measure the prevalence of and risk factors for TB infection among HCWs in Inner Mongolia, China.

**DESIGN:** Between April and August 2010, we administered QuantiFERON®-TB Gold In-Tube (QFT-GIT) tests, skin tests using Chinese tuberculin (TST) and surveys among HCWs at an infectious diseases hospital and a general medical hospital. We assessed whether demographic characteristics, personal exposure and work exposure were associated with QFT-GIT and TST positivity, and assessed agreement between test results.

**RESULTS:** Of 999 HCWs, 683 (68%) were QFT-GIT-positive, which was associated with greater age, longer HCW career, TB disease in a co-worker and greater daily patient exposure using multivariable analysis. TST reactions  $\geq 5$  mm occurred in 69% of the HCWs; agreement between test results was low ( $\kappa$  0.22).

**CONCLUSIONS:** The prevalence of TB infection among HCWs in Inner Mongolia is high; infection was associated with occupational exposure. Results from locally conducted TST are difficult to interpret. In China, TB infection control in health care facilities should be strengthened.

**KEY WORDS:** QuantiFERON; tuberculin; infection control; prevalence

HEALTH CARE FACILITIES are a high-risk environment for acquiring tuberculosis (TB), a pathogen with obligate airborne transmission.<sup>1</sup> TB patients often present to health care facilities with non-specific respiratory symptoms and may spend prolonged periods around health care workers (HCWs) and other patients before they are diagnosed, treated and rendered non-infectious.<sup>2</sup> Studies conducted in multiple different settings have found that TB infection and disease occur frequently in HCWs.<sup>1</sup> Transmission of drug-resistant TB is particularly feared. Combined improvements in administrative, environmental, and personal protective controls can reduce the rate of TB infection among HCWs.<sup>3</sup>

In 2010, China had an estimated 1.3 million new TB disease cases annually, the second highest case-load in the world.<sup>4</sup> In 2000, a nationwide prevalence

survey found that 45% of Chinese citizens had TB infection, and 4.5 million had active pulmonary TB disease.<sup>5</sup> China also has more than 100 000 incident multidrug-resistant TB (MDR-TB) cases annually, the highest in the world.<sup>4,6</sup> TB transmission is frequent in hospitals; however, the magnitude of the problem and risk factors for infection are not well characterised. Several surveys of TB infection among HCWs have been performed in China, but these enrolled small numbers of people, focused on HCWs in TB specialty hospitals or relied entirely on the tuberculin skin test (TST).<sup>7–9</sup>

As China has the largest population and second highest number of new TB cases per year in the world, it is important to understand how locally made tuberculin and protocols compare with an internationally validated test for TB infection. In China, tuberculin purified protein derivative (PPD) is derived from *Mycobacterium bovis* bacille Calmette-Guérin (BCG);

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Article submitted 8 March 2012. Final version accepted 10 May 2012.

this is the only tuberculin available in China and it is used to diagnose TB infection.<sup>10</sup> National guidelines support using a  $\geq 5$  mm cut-off for TST positivity.<sup>11</sup> Interferon-gamma release assays (IGRAs), including QuantiFERON®-TB Gold In-Tube (QFT-GIT, Cellestis, Carnegie, VIC, Australia), have been shown to be effective in several high-incidence countries,<sup>12–14</sup> produce results that are not affected by previous BCG vaccination and provide standardised numeric scores that are not prone to reader bias.<sup>15</sup> No large studies evaluating IGRAs, particularly among HCWs, have previously been published in China.

We conducted a cross-sectional study of HCWs in China's Inner Mongolia Autonomous Region. We sought to measure TB infection prevalence using QFT-GIT, determine risk factors for infection and assess the usefulness of Chinese tuberculin for HCW screening.

## STUDY POPULATION AND METHODS

We examined HCWs at a large infectious diseases hospital and a large general hospital in China's Inner Mongolia Autonomous Region from April to August 2010. Inner Mongolia was chosen for the study because both TB (49 cases/100 000 persons) and MDR-TB (7% in new patients) rates are high in the region, while the prevalence of human immunodeficiency virus infection is among the lowest in China.<sup>16</sup> The infectious diseases hospital has specialised TB wards; the general hospital admits TB patients if the case is severe or has complications. Any person working in these two hospitals—paid or unpaid, full or part time—was considered a HCW and was eligible for enrolment.

Study personnel visited each hospital to conduct the survey. On designated days, HCWs were encouraged by department supervisors to visit study nurses to complete a written questionnaire, have blood drawn for QFT-GIT and undergo a TST. The questionnaire collected information on basic demographic characteristics, and personal and work exposure potentially associated with TB infection and disease.

All HCWs provided written informed consent before participating. This research project was approved by the Chinese Ethical Committee for Tuberculosis Operational Research and the Chinese Center for Disease Control and Prevention.

### TST and QFT-GIT

We performed a single-step TST using 5 international units (IU; 0.1 ml) of tuberculin. The only domestic source for tuberculin in China is the Chengdu Institute of Biological Products (Chengdu, China), which produces tuberculin from *M. bovis* BCG. TST was administered using the Mantoux method by an experienced nurse, and participants returned 48–72 h after TST placement for reading by two independent clinicians; readings were averaged. As TB infection is

not routinely treated in China, TST-positive participants were advised to have close follow-up for development of any active TB symptoms.

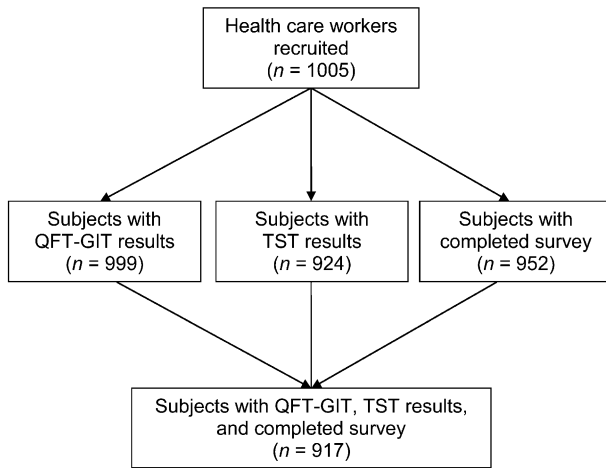
Blood samples were collected and sent to the laboratory in each hospital every morning and afternoon for QFT-GIT testing. Samples were incubated at 37°C for 24 h within 16 h of collection, centrifuged and stored for up to 28 days before the enzyme-linked immunosorbant assay (ELISA) was conducted. The quantity of interferon-gamma (IFN- $\gamma$ ) elaborated in response to TB antigens minus the control was measured in IU/ml, and a positive result was defined as  $\geq 0.35$  IU/ml and  $>25\%$  of the negative control. Results were indeterminate if the response to TB antigens was  $<0.5$  IU/ml or the negative control was  $>8$  IU/ml. Samples with indeterminate results were tested a second time, and the results of the second test were recorded as the final result. As the QFT-GIT ELISA cannot determine absolute values of IFN- $\gamma$   $> 10$  IU/ml, these results were recorded as  $>10$  IU/ml. Sample collection, testing and interpretation were conducted according to the manufacturer's instructions.<sup>17</sup> Laboratory quality and procedures were overseen by an external laboratory expert trained by Cellestis.

### Statistical analyses

Two small studies in China have found that agreement between the TST and an in-house IGRA is 0.16–0.28.<sup>18,19</sup> Based on a null-hypothesis kappa ( $\kappa$ ) of 0.70 and a power of 80%, we estimated that paired TST and QFT-GIT tests in 1000 HCWs would be powered to detect a  $\kappa$  of  $\geq 0.80$  or  $\leq 0.60$  when TB infection prevalence is  $>10\%$ .<sup>20</sup>

We defined TST positivity as  $\geq 5$  mm based on guidelines issued by the Chinese Ministry of Health, to reflect what is being used for patient diagnosis in China.<sup>11</sup> QFT-GIT results were dichotomised into positive and negative; indeterminate results were excluded from the comparison. We evaluated the agreement between QFT-GIT results and three TST induration cut-offs using Cohen's  $\kappa$  coefficient. As the use of BCG-PPD tuberculin and a 5 mm cut-off are not an international standard, QFT-GIT results and not TST results were used to determine presence of TB infection.

We calculated unadjusted odds ratios and 95% confidence intervals (CIs) for characteristics associated with a positive TST or QFT-GIT using bivariate logistic regression. We then regressed factors known to be risk factors for infection from the literature and additional factors with  $P \leq 0.10$  in bivariate analysis on TST and QFT-GIT results using multivariable logistic regression. We selected the most parsimonious model for each outcome (TST and QFT-GIT positivity) after examining several models using risk factor and statistical criteria. Model fit was evaluated using the Hosmer-Lemeshow test. Statistical analyses were conducted using SAS, version 9.3 (SAS Institute, Cary, NC, USA).



**Figure 1** Study participation diagram of health care workers, Inner Mongolia, China, 2010. QFT-GIT = QuantiFERON®-TB Gold In-Tube; TST = tuberculin skin test.

## RESULTS

### Participant description

Of 1578 HCWs at the two hospitals, 1005 were recruited and 999 (63%) completed QFT-GIT testing. Of these 999 HCWs, 917 (92%) also completed the survey and underwent TST (Figure 1). The median age was 41 years (range 18–72); 72% were women, and 47% were physicians and nurses (Table 1). The median duration of time as a HCW was 10 years (range <1–50). Five per cent reported having a previous diagnosis of TB; 21% reported a prior TST, of whom 54% reported testing positive. Twenty-one per cent of participants reported caring for a TB patient in the last year, and 18% reported either living with (9%) or working with (9%) a person previously diagnosed with TB. Most (70%) participants reported not having any formal TB infection control training.

### TST results

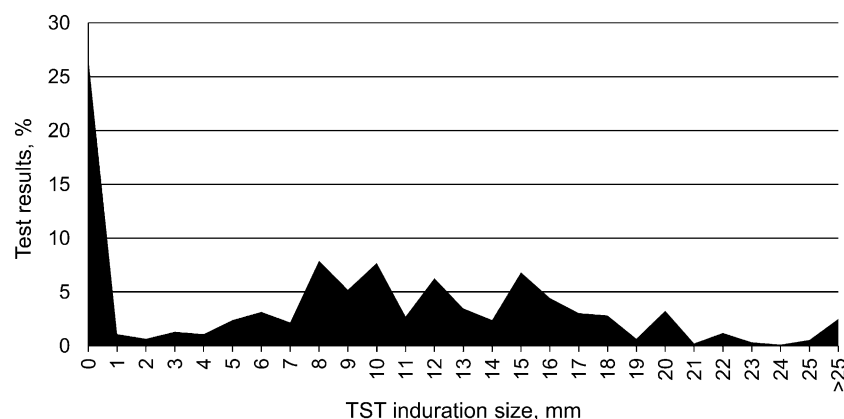
TST results were available for 924 participants (Figure 1): 27% of these had an induration diameter of

**Table 1** Characteristics of health care workers, Inner Mongolia, China, 2010 ( $n = 917$ )

Characteristic	Participants* <i>n</i> (%)
Age, years	
18–29	202 (22)
30–39	213 (23)
40–49	317 (35)
$\geq 50$	185 (20)
Female sex	659 (72)
Education	
High school or below	262 (29)
Some college/technical school	354 (39)
College degree or above	301 (33)
Job category	
Nurse	290 (32)
Administrative/clerk	170 (19)
Service (food/housekeeping)	142 (16)
Physician	139 (15)
Public health	37 (4)
Pharmacy	30 (3)
Laboratory expert	25 (3)
X-ray technician	16 (2)
Other	67 (7)
Previous diagnosis of tuberculosis	47 (5)
Previous TST	195 (21)
Previous positive TST	98 (54)
Self-reported receipt of bacille Calmette-Guérin vaccination	312 (34)
Current or former smoker	180 (20)

\*Categories may not total 917 due to missing data.  
TST = tuberculin skin test.

0 mm (Figure 2). Using cut-offs of  $\geq 5$  mm,  $\geq 10$  mm and  $\geq 15$  mm, the proportions positive were respectively 69%, 54% and 25%. In bivariate analysis of the 917 HCWs with TST, QFT-GIT and survey results, risk factors associated with TST positivity included older age, higher education level, being a physician, a longer career in health care, BCG vaccination, caring for a TB patient, a household TB contact and smoking (Table 2). In multivariable analysis, male sex, caring for a TB patient in the last year, working for >15 years as a HCW and having a household contact with TB were associated with TST positivity (Table 3).



**Figure 2** Distribution of TST results among health care workers, Inner Mongolia, China, 2010 ( $n = 924$ ). TST = tuberculin skin test.

**Table 2** Risk factors associated with TST and QFT-GIT positivity among health care workers, bivariate analysis, Inner Mongolia, China, 2010 (*n* = 917)

Characteristic	TST $\geq 5$ mm		QFT-GIT-positive	
	<i>n</i> / <i>N</i> (%)	OR (95%CI)	<i>n</i> / <i>N</i> (%)	OR (95%CI)
Age, years				
18–29	131/202 (65)	Referent	104/202 (51)	Referent
30–39	136/213 (64)	0.96 (0.64–1.43)	137/213 (64)	1.70 (1.15–2.52)
40–49	229/317 (72)	1.41 (0.97–2.06)	240/317 (76)	2.94 (2.01–4.28)
$\geq 50$	136/185 (74)	1.50 (0.97–2.33)	157/185 (85)	5.28 (3.24–8.60)
Sex				
Female	437/659 (67)	Referent	451/659 (68)	Referent
Male	195/258 (76)	1.57 (1.13–2.18)	187/258 (73)	1.21 (0.88–1.67)
Education				
High school or less	148/262 (57)	Referent	194/262 (74)	Referent
Some college or technology school	249/354 (70)	1.83 (1.31–2.55)	250/354 (71)	0.84 (0.59–1.21)
College degree or more	235/301 (78)	2.74 (1.90–3.96)	194/301 (65)	0.64 (0.44–0.91)
Hospital				
General	262/358 (73)	Referent	237/358 (66)	Referent
Infectious diseases	342/511 (67)	0.74 (0.55–1.00)	364/511 (71)	1.26 (0.95–1.69)
Job category				
Administrative/clerk	118/170 (69)	Referent	113/170 (67)	Referent
Physician	110/139 (79)	1.67 (0.99–2.82)	108/139 (78)	1.76 (1.05–2.93)
Nurse	203/290 (70)	1.03 (0.68–1.55)	193/290 (67)	1.00 (0.67–1.50)
Pharmacy	20/30 (67)	0.88 (0.39–2.01)	20/30 (67)	1.01 (0.44–2.30)
Laboratory expert	19/25 (76)	1.40 (0.53–3.70)	16/25 (64)	0.90 (0.37–2.15)
Public health	23/37 (62)	0.72 (0.35–1.52)	28/37 (76)	1.57 (0.69–3.55)
Service (food/housekeeping)	72/142 (51)	0.45 (0.29–0.72)	105/142 (74)	1.43 (0.88–2.34)
X-ray technician	14/16 (88)	3.08 (0.68–14.06)	8/16 (50)	0.50 (0.18–1.41)
Other	52/67 (78)	1.53 (0.79–2.96)	46/67 (69)	1.10 (0.60–2.03)
Years in health care				
<1	71/132 (54)	Referent	85/132 (64)	Referent
1–5	140/224 (63)	1.43 (0.93–2.21)	135/224 (60)	0.84 (0.54–1.31)
6–10	54/85 (64)	1.50 (0.86–2.62)	53/85 (62)	0.92 (0.52–1.61)
11–15	62/90 (69)	1.90 (1.08–3.34)	54/90 (60)	0.83 (0.48–1.44)
>15	301/378 (80)	3.36 (2.20–5.13)	306/378 (81)	2.35 (1.51–3.65)
Self-report having BCG				
Did not have BCG	395/602 (66)	Referent	445/602 (74)	Referent
Had BCG	235/312 (75)	1.60 (1.18–2.18)	192/312 (62)	0.56 (0.42–0.76)
Cared for TB patient in last year				
No	473/720 (66)	Referent	505/720 (70)	Referent
Yes	159/197 (81)	2.18 (1.49–3.21)	133/197 (68)	0.88 (0.63–1.24)
Average daily time in patient room, h				
0	141/211 (67)	Referent	138/211 (65)	Referent
<1	68/94 (72)	1.30 (0.76–2.22)	59/94 (63)	0.89 (0.54–1.48)
1–4	73/104 (70)	1.17 (0.70–1.94)	68/104 (65)	1.00 (0.61–1.64)
>4	350/508 (69)	1.10 (0.78–1.55)	373/508 (73)	1.46 (1.03–2.06)
Ever had co-worker with TB				
No	562/833 (68)	Referent	575/833 (69)	Referent
Yes	70/84 (83)	2.41 (1.33–4.36)	63/84 (75)	1.35 (0.80–2.25)
Household contact with TB				
No	561/831 (68)	Referent	580/831 (70)	Referent
Yes	70/85 (82)	2.25 (1.26–4.00)	58/85 (68)	0.93 (0.58–1.50)
Aware of TB infection control guidelines				
Yes	290/450 (64)	Referent	322/450 (72)	Referent
No	341/465 (73)	1.52 (1.14–2.01)	314/465 (68)	0.83 (0.62–1.1)
Had infection control training ever				
Yes	423/644 (66)	Referent	457/644 (71)	Referent
No	209/273 (77)	1.71 (1.23–2.36)	181/273 (66)	0.81 (0.59–1.09)
Smoking status				
Never smoker	494/737 (67)	Referent	504/737 (68)	Referent
Former/current smoker	138/180 (77)	1.62 (1.11–2.36)	134/180 (74)	1.35 (0.93–1.95)
Density of household*				
<1 (lower density)	81/114 (71)	Referent	80/114 (70)	Referent
1	339/469 (72)	1.06 (0.68–1.67)	325/469 (69)	0.96 (0.61–1.50)
>1 (higher density)	211/333 (63)	0.70 (0.44–1.12)	233/333 (70)	0.99 (0.62–1.58)

\*Ratio of number of persons living in house to number of rooms.

TST = tuberculin skin testing; QFT-GIT = QuantiFERON®-TB Gold In-Tube; OR = odds ratio; CI = confidence interval; BCG = bacille Calmette-Guérin; TB = tuberculosis.

**Table 3** Risk factors associated with positive TST and QFT-GIT results among health care workers, multivariable analysis, Inner Mongolia, China, 2010 ( $n = 843$ )

Characteristic	TST $\geq 5$ mm	QFT-GIT-positive
	aOR (95%CI)	aOR (95%CI)
Age, years		
18–29	Referent	Referent
30–39	0.85 (0.51–1.42)	1.56 (0.94–2.60)
40–49	1.00 (0.60–1.67)	1.93 (1.15–3.24)
$\geq 50$	1.09 (0.63–1.90)	3.21 (1.77–5.82)
Sex		
Female	Referent	Referent
Male	1.84 (1.25–2.70)	1.18 (0.82–1.71)
Hospital		
General	Referent	Referent
Infectious diseases	1.05 (0.71–2.29)	0.80 (0.54–1.18)
Work type		
Clinical	Referent	Referent
Administrative/clerical	1.19 (0.76–1.85)	0.90 (0.58–1.39)
Years in health care		
$< 1$	Referent	Referent
1–5	1.38 (0.87–2.19)	1.00 (0.62–1.62)
6–10	1.57 (0.85–2.92)	1.08 (0.58–2.02)
11–15	1.85 (0.94–3.64)	0.77 (0.39–1.50)
$> 15$	3.43 (2.08–5.66)	1.94 (1.13–3.32)
Self-report having BCG		
Did not have BCG	Referent	Referent
Had BCG	1.47 (0.99–2.18)	0.61 (0.42–0.88)
Cared for TB patient in last year		
No	Referent	Referent
Yes	1.72 (1.06–2.78)	0.75 (0.48–1.17)
Average daily time in patient room, h		
0	Referent	Referent
$< 1$	1.06 (0.55–2.03)	1.22 (0.66–2.26)
1–4	1.07 (0.57–2.02)	1.25 (0.68–2.28)
$> 4$	1.03 (0.67–1.58)	1.87 (1.21–2.89)
Ever had co-worker with TB		
No	Referent	Referent
Yes	1.55 (0.79–3.05)	1.86 (1.01–3.42)
Household contact with TB		
No	Referent	Referent
Yes	1.92 (1.01–3.65)	0.84 (0.49–1.44)

TST = tuberculin skin testing; QFT-GIT = QuantiFERON®-TB Gold In-Tube; aOR = adjusted odds ratio; CI = confidence interval; BCG = bacille Calmette-Guérin; TB = tuberculosis.

### QFT-GIT results

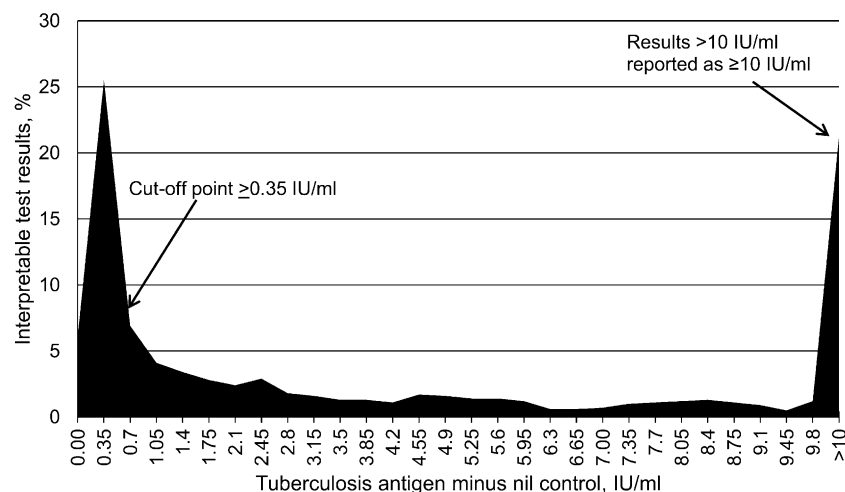
Of the 1005 participants tested, six (0.6%) were indeterminate, and remained indeterminate after retesting. Of the 999 participants with valid results, 68% had a positive QFT-GIT. Peaks in the number of participants with a given IFN- $\gamma$  level occurred at zero (26%) and at  $> 10$  IU/ml (21%; Figure 3). Of 917 HCWs with TST, QFT-GIT and survey results, older age, being a physician, a longer career in health care and greater daily patient contact were associated with greater odds of a positive QFT-GIT, while a college degree or above and prior self-reported BCG vaccination were associated with smaller odds (Table 2). In multivariable analysis, factors associated with QFT-GIT positivity included age  $\geq 40$  years, working for  $> 15$  years as a HCW, spending an average of  $> 4$  h/day in patient rooms and having had a co-worker with TB (Table 2). Self-reported BCG vaccination was associated with smaller odds of a positive QFT-GIT.

### Agreement between TST and QFT-GIT results

Of the 917 participants with valid TST and QFT-GIT results, observed agreement between test results ranged from 45% to 67%, depending on measured induration diameter for the TST (Table 4). As induration size increased, agreement with positive QFT-GIT decreased significantly. For a cut-off of  $\geq 5$  mm,  $\kappa$  was 0.22 (95%CI 0.16–0.29) and for a cut-off of  $\geq 15$  mm,  $\kappa$  was 0.08 (95%CI 0.04–0.12); both indicate poor agreement.

## DISCUSSION

In this large survey in China, we found that nearly 70% of participating HCWs had TB infection as measured using QFT-GIT, and infection was significantly associated with hospital exposures known to be risk factors for infection. Skin testing using Chinese tuberculin had poor agreement with QFT-GIT.



**Figure 3** Distribution of QuantiFERON®-TB Gold In-Tube test results among healthcare workers, Inner Mongolia, China, 2010 ( $n = 999$ ). IU = international unit.

**Table 4** Agreement between TST and QFT-GIT results for 917 health care workers who had both tests performed, Inner Mongolia, China, 2010

Results	TST+ ≥5 mm	TST+ ≥10 mm	TST+ ≥15 mm
TST+/QFT-GIT+*	483	350	181
TST-/QFT-GIT-	130	190	230
TST+/QFT-GIT-	149	89	49
TST-/QFT-GIT+*	155	288	457
Observed agreement, %	66.8	58.9	44.8
Expected agreement, %	57.4	49.2	40.2
κ (95%CI)	0.22 (0.16–0.29)	0.19 (0.13–0.25)	0.08 (0.04–0.12)

\*QFT-GIT+ defined as having results ≥0.35 international units/ml.  
TST = tuberculin skin testing; QFT-GIT = QuantiFERON®-TB Gold In-Tube;  
+ = positive; - = negative; CI = confidence interval.

Surveys of HCWs using IGRAs in other high-burden countries, such as India, Russia and Viet Nam, have also found high TB prevalence rates, ranging from 40% to 47%; one survey in the Republic of Georgia found a prevalence of 60%.<sup>12–14,21</sup> Surveys of HCWs in low- and middle-income countries employing international standard PPD have found TB prevalence ranging from 33% to 79%.<sup>22</sup> Limited data comparing IGRA with TST results in high-burden countries suggest that IGRA testing generally results in similar prevalence estimates.<sup>23</sup> Use of IGRAs among HCWs is limited by high conversion and reversion rates, which are important considerations in serial testing scenarios.<sup>23</sup> Data are sparse on the added value of IGRAs in predicting active TB beyond that of TST.<sup>15</sup>

Despite these limitations, we found that QFT-GIT positivity was independently associated with several known occupational risk factors. TB infection was associated with a greater number of years working in health care<sup>14</sup> after adjusting for age, reflecting cumulative occupational exposure. Greater exposure intensity, measured as >4 h of direct patient care each day, was also associated with infection. In the one other study of HCWs using TST and QFT-GIT in a high-incidence country, HCWs in jobs with greater patient contact time (orderlies) had greater odds of having a positive QFT-GIT.<sup>14</sup> Also similar to the other study in a high-incidence setting, we found that simply caring for TB patients was not a significant risk factor for infection. Together, these results could suggest that in high-incidence settings, occupational exposure to unrecognised TB in the general patient population, and not the diagnosed TB patient population, might be the most important exposure, and that administrative measures that rapidly identify and isolate suspect TB cases are of particular importance. It is to be noted that adherence to infection control measures in Inner Mongolian hospitals have been observed to be poor.<sup>24</sup> As this was a cross-sectional survey, future studies are needed to measure incidence and help identify HCWs or settings at highest risk for TB transmission. At a minimum, our finding of an

increased risk associated with having a co-worker with TB suggests that hospitals should intensify screening of HCWs for TB disease to reduce the possibility of TB transmission to colleagues or patients.

We also found that prior BCG vaccination protected against TB infection. The possibility that BCG vaccination can prevent acquisition of TB infection has previously been reported in one study that evaluated children exposed to TB using an IGRA.<sup>25</sup> The policy implications of this finding for HCWs are unclear. Childhood BCG vaccination coverage in China now approaches 100%; therefore, future generations of HCWs may benefit, if such a protective effect actually exists.

Our study raises important questions about how to monitor HCW TB infection rates in China and prevent TB transmission. We deliberately used Chinese-made tuberculin and a 5 mm cut-off criterion for TST, as a long-term objective of our work is to develop a standard operating procedure for HCW TB surveillance in China. Developing such a protocol requires examining diagnostic reagents available in country (BCG-derived tuberculin is the only source) and nationally endorsed standards. The validity of the non-standard TST protocol, particularly the use of BCG-PPD tuberculin, is problematic, and the study results corroborate these concerns. Although contact with TB patients and length of time as a HCW were associated with TST positivity in the multivariable model, other known risk factors with a dose response, such as age, were not significant. With more stringent TST cut-offs (≥10 mm and ≥15 mm), caring for TB patients was no longer significant in multivariable models (data not shown); in fact, increasing age became inversely associated with TST positivity. We found lower levels of TST and QFT agreement than all previous studies comparing TST and QFT-GIT in high-incidence countries.<sup>23</sup> Agreement decreased with more stringent TST criteria, contrary to the expected increase from fewer false-positive TST results, and contrary to results reported in other studies,<sup>23</sup> leaving further questions about the validity of current TST methods in China. Sustaining surveillance for occupational TB among HCWs in China will require a combination of research, policy evaluation and collaboration between government and private industry to develop, validate and adopt a valid, inexpensive assay for China.

Our study is subject to limitations, the most important of which is selection bias. The 37% of HCWs who elected not to participate could differ in important ways in both outcomes and exposure compared with our participants. The demographic characteristics of non-participating HCWs were not known. In addition, our conclusions are based on two hospitals in Inner Mongolia. We do not know whether these results can be generalised to other facilities in this province or to the rest of China. Finally, we lack reliable data about the expected performance of BCG

tuberculin in a HCW survey; therefore, we were not able to employ more sophisticated analyses of TST reactions, such as Bayesian analyses, which are now recommended.<sup>26</sup>

## CONCLUSIONS

Our study has important implications for public health in China and in other countries around the world. MDR-TB has been identified as an urgent global epidemic, China has the highest number of new MDR-TB cases each year, and hospitals are known to be high-risk settings for MDR-TB transmission. Our study is the first to show that TB infection, as measured using an IGRA, is strongly associated with hospital exposure in China. Both policy and practice in China need to be advanced to promote administrative, environmental and personal protective controls for reducing TB transmission in health care settings.

## Acknowledgements

The authors thank X Nie, Jenny, H Guo, Y Li and N Ta for their help in project management. They thank J Rothel for his expertise and support in using QFT-GIT and interpreting its results. They also thank the staff at the following participating facilities in Inner Mongolia for project organisation and coordination, and conducting surveys and clinical tests: the Chinese Centers for Disease Control and Prevention (CDC), the infectious disease and tuberculosis hospitals, and the tuberculosis centres and dispensaries at the provincial, prefecture, county and district levels. This project was supported by the China-US Collaborative Program on Emerging and Re-Emerging Infectious Diseases.

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the United States CDC.

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## R É S U M É

**CONTEXTE :** Les travailleurs de soins de santé (HCW) encourent un risque accru d'infection tuberculeuse (TB). En Chine, les enquêtes examinant l'infection TB chez les HCW n'ont pas étudié les services de soins de santé généraux, n'ont pas comparé les tests tuberculiques (TST) pratiqués selon les protocoles locaux par rapport à un test accepté au niveau international et n'ont pas caractérisé les facteurs de risque.

**OBJECTIF :** Mesurer la prévalence de l'infection TB et ses facteurs de risque chez les HCW en Mongolie intérieure, Chine.

**SCHÉMA :** Entre avril et août 2010, nous avons exécuté les tests QuantiFERON®-TB Gold In-Tube (QFT-GIT), les tests cutanés au moyen de la TST chinoise ainsi que des enquêtes chez les HCW provenant d'un hôpital de maladies infectieuses et d'un hôpital médical général. Nous avons évalué dans quelle mesure les caractéristiques démographiques, les expositions personnelles et

les expositions au travail sont en association avec la positivité du QFT-GIT et du TST, et nous avons évalué les concordances entre les résultats de ces tests.

**RÉSULTATS :** Sur 999 HCW, le QFT-GIT a été positif chez 683 (68%) et a été en association avec un âge plus avancé, une carrière plus longue, l'existence d'une maladie TB chez un travailleur proche et une quantité plus grande d'exposition quotidienne aux patients dans l'analyse multivariée. Des réactions TST  $\geq 5$  mm sont survenues chez 69% des HCW ; la concordance entre les résultats des deux tests a été faible ( $\kappa$  0,22).

**CONCLUSIONS :** La prévalence de l'infection TB s'est révélée importante chez les HCW en Mongolie intérieure ; l'infection est en association avec des expositions professionnelles. Les résultats des TST menés localement sont difficiles à interpréter. En Chine, la lutte contre l'infection TB dans les services de soins de santé devrait être renforcé.

## R E S U M E N

**MARCO DE REFERENCIA:** Los profesionales de la salud (HCW) están cada vez más expuestos al riesgo de contraer la infección tuberculosa. En China, no se han realizado estudios sobre la infección tuberculosa en los HCW de los establecimientos generales de atención sanitaria, no se han estudiado las pruebas tuberculínicas realizadas según protocolos locales en comparación con pruebas aceptadas internacionalmente ni se han caracterizado los factores de riesgo de infección.

**OBJETIVO:** Medir la prevalencia de infección tuberculosa y los factores de riesgo asociados en los HCW de Mongolia Interior en China.

**MÉTODO:** Entre abril y agosto del 2010 se practicaron la prueba QuantiFERON®-TB Gold In-Tube (QFT-GIT) y la prueba cutánea con la tuberculina (TST) china y se administraron encuestas a los HCW de un hospital de enfermedades infecciosas y un hospital general. Se evaluó si las características demográficas y la

exposición personal y ocupacional se asociaban con la positividad de la QFT-GIT y la TST y se analizó la concordancia entre los resultados de las pruebas.

**RESULTADOS:** De los 999 HCW, 683 (68%) tuvieron un resultado positivo con QFT-GIT, el cual se asoció en el análisis multifactorial con la ancianidad, una carrera más larga de trabajo sanitario, la presencia de tuberculosis en un colega de trabajo y una mayor exposición diaria a los pacientes. En 69% de los HCW se presentaron reacciones a la TST  $\geq 5$  mm; la concordancia entre las pruebas fue baja (índice  $\kappa$  0,22).

**CONCLUSIÓN:** La prevalencia de infección tuberculosa en los HCW en Mongolia Interior es alta; la infección se asoció con la exposición ocupacional. Los resultados de la TST local son difíciles de interpretar. En China, es preciso fortalecer el control de la infección tuberculosa en los establecimientos de atención sanitaria.