

## ORIGINAL ARTICLE

## Tuberculosis among Healthcare Workers, United States, 1995–2007

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**OBJECTIVE.** We examined surveillance data to describe the epidemiology of tuberculosis (TB) among healthcare workers (HCWs) in the United States during the period 1995–2007.

**DESIGN.** Cross-sectional descriptive analysis of existing surveillance data.

**SETTING AND PARTICIPANTS.** TB cases reported to the Centers for Disease Control and Prevention from the 50 states and the District of Columbia from 1995 through 2007.

**RESULTS.** Of the 200,744 reported TB cases in persons 18 years of age or older, 6,049 (3%) occurred in individuals who were classified as HCWs. HCWs with TB were more likely than other adults with TB to be women (unadjusted odds ratio [95% confidence interval], 4.1 [3.8–4.3]), be foreign born (1.3 [1.3–1.4]), have extrapulmonary TB (1.6 [1.5–1.7]), and complete TB treatment (2.5 [2.3–2.8]).

**CONCLUSIONS.** Healthcare institutions may benefit from intensifying TB screening of HCWs upon hire, especially persons from countries with a high incidence of TB, and encouraging treatment for latent TB infection among HCWs to prevent progression to TB disease.

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Since the early 1990s, outbreaks of tuberculosis (TB) and multidrug-resistant TB in various medical settings have demonstrated patient-to-healthcare worker (HCW) transmission of *Mycobacterium tuberculosis*,<sup>1–4</sup> and other investigations have suggested that HCWs with untreated latent TB infection (LTBI) can later experience progression to TB disease, which can cause workplace exposure to patients and other HCWs.<sup>5,6</sup> The extent of occupational risk of TB for HCWs varies according to many factors, including prevalence of TB in the patient population, immunocompetency of the HCW, and effectiveness of infection control measures in the healthcare setting.<sup>7</sup>

The objective of this analysis was to examine surveillance data and describe the epidemiology of TB among HCWs in the United States during the period 1995–2007. Additional goals were to compare demographic characteristics and treatment outcomes of reported TB cases among HCWs and other adults and to compare US-born and foreign-born HCWs.

#### METHODS

This study describes new analyses of existing data routinely submitted to the Centers for Disease Control and Prevention through the National Tuberculosis Surveillance System. These data are collected for the purposes of disease surveillance and not human subject research that requires ethical institutional board review. TB cases were reported by the 50 states and the District of Columbia. Data were collected on a standard-

ized form that included demographic, laboratory, clinical, and treatment outcome information.

We calculated the proportion of TB cases reported during 1995–2007 that occurred in persons 18 years of age or older whose occupations were categorized as “healthcare worker.” Data for treatment outcomes were analyzed only through 2005 to provide a 2-year period to complete reporting. To calculate an annual TB incidence rate among HCWs, we used the US Census Bureau Current Population Survey’s estimate for the denominator of HCWs in the United States for 2003–2007.<sup>8</sup> Estimated numbers of HCWs in the United States were not available before 2003.

Persons were considered to be foreign born if the reported country of birth was outside the United States or its jurisdictions in the Pacific and Caribbean. Method of TB treatment was recorded as (i) directly observed therapy (DOT), (ii) self-administered therapy, (iii) a combination of self-administered therapy and DOT, or (iv) unknown. DOT, an adherence-enhancing strategy in which a HCW or other trained person watches a patient swallow each dose of medication, is the standard care for all patients with TB disease and is a preferred option for patients treated for LTBI in the United States, when feasible.<sup>9–11</sup> Persons were classified as having a previous diagnosis of TB if they had verified TB in the past, had completed TB therapy, or were lost to supervision for more than 12 months and had verified TB again. The proportion of human immunodeficiency virus

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(HIV)-infected persons was calculated as a percentage of the total number of persons with test results reported (ie, negative, positive, or indeterminate). The number of persons documented as having refused an HIV test was also reported; others were classified as HIV status unknown (ie, HIV test not offered or result not reported).

Unadjusted odds ratios (uORs) were used to compare characteristics of HCWs who had TB with those of other adults who had TB and to compare characteristics of US-born HCWs who had TB with characteristics of foreign-born HCWs who had TB. Data were analyzed with SAS for Windows, version 9.1 (SAS Institute), and Microsoft Excel 2003 (Microsoft).

## RESULTS

During the period 1995–2007, of the 200,744 TB cases involving patients 18 years of age or older, 6,049 (3%) were classified as HCWs (mean of 429 HCWs with TB per year). Using the US Census Bureau population estimates for HCWs for 2003–2007 (ie, an annual average of 1.8 million male and 7.0 million female US-born HCWs and 400,000 male and 1.1 million female foreign-born HCWs),<sup>8</sup> the estimated overall annual incidence of TB for HCWs was 4.2 cases per 100,000 population (range, 3.8–4.6), similar to the overall national TB case rate of 4.4–5.1 cases per 100,000 population during the same time period.<sup>12</sup> However, the estimated annual incidence of TB among foreign-born HCWs was approximately 10 times higher than the incidence among US-born HCWs. Among male HCWs, the TB incidence rate was 2.3 cases per 100,000 US-born persons and 21.4 cases per 100,000 foreign-born persons; among female HCWs, the TB incidence rate was 1.6 cases per 100,000 US-born persons and 16.6 cases per 100,000 foreign-born persons. Nationally, the TB case rate ranged between 20.7 cases and 23.5 cases per 100,000 foreign-born persons during 2003–2007.<sup>12</sup>

### HCWs Who Had TB Compared with Other Adults Who Had TB

Characteristics of persons with TB according to HCW status are summarized in Table 1. Compared with other adults, HCWs were more likely to be women (uOR, 4.1 [95% confidence interval (CI), 3.8–4.3]), be foreign born (uOR, 1.3 [95% CI, 1.3–1.4]), have extrapulmonary TB (uOR, 1.6 [95% CI, 1.5–1.7]), complete TB treatment (uOR, 2.5 [95% CI, 2.3–2.8]), and have a reported HIV test result (uOR, 1.2 [95% CI, 1.1–1.2]). Among cases with reported HIV test results, fewer HCWs (13%) than other adults (20%) were HIV infected.

Clinical features of TB were similar among HCWs and other adults who had TB. Of those with reported initial drug-susceptibility results, HCWs had slightly higher percentages of isoniazid mono-resistant TB (10% compared with 8% of other adults) and multidrug-resistant TB (2% compared with 1%); these differences were not statistically significant. Fewer

HCWs (34%) were reported to have received all doses of TB medication by DOT, compared with 47% of other adults with TB (Table 1).

### Foreign-Born HCWs Who Had TB Compared with US-Born HCWs Who Had TB

Of the 6,049 HCWs reported to have TB during those 13 years, 3,302 (55%) were foreign born. Of those, 67% were women, and 56% were Asian (Tables 1 and 2). From 1995 through 2007, the proportion of foreign-born HCWs with TB increased from 42% to 71%. Meanwhile, among all TB cases, the proportion of cases among foreign-born persons increased annually from 35% to 58%.<sup>12</sup>

Compared with US-born HCWs who had TB, foreign-born HCWs who had TB were more likely to have isoniazid mono-resistant TB (uOR, 2.1 [95% CI, 1.7–2.7]), have extrapulmonary TB (uOR, 1.5 [95% CI, 1.3–1.7]), and complete TB treatment (uOR, 1.3 [95% CI, 1.1–1.6]; Table 2).

The top 3 countries of birth for foreign-born HCWs with TB in the United States were Philippines (32%), India (15%), and Haiti (6%), which represented 53% of all foreign-born HCWs with TB (Figure 1), whereas only 21% of other foreign-born adults with TB were from those 3 countries combined. In contrast, during this time period, the top countries of birth for all foreign-born persons with TB in the United States were Mexico (24%), Philippines (11%), and Vietnam (10%).<sup>12</sup> The median number of years that foreign-born HCWs had resided in the United States was 7 (range, 0–64). Approximately 7% of foreign-born HCWs received a diagnosis of TB within 6 months of arrival to the United States; 18% received a diagnosis within the first year after arrival, 25% within 2 years after arrival, and 43% within 5 years after arrival. In stratified analysis comparing foreign-born Asian HCWs with other foreign-born HCWs, extrapulmonary TB was reported for 46% of foreign-born Asian HCWs, compared with 23% of other foreign-born HCWs.

## DISCUSSION

Although the rate of TB among HCWs was similar to the national rate, consequences in the workplace can be severe when HCWs have TB because of the vulnerable populations that they serve. These findings enable additional understanding of TB among HCWs in the United States and highlight the importance of maintaining a high index of suspicion for TB disease, especially among foreign-born workers, and of providing interventions to diagnose and treat LTBI among HCWs.

Despite the 2005 estimate that only 15% of HCWs in the United States were foreign born,<sup>13</sup> the estimated annual incidence of TB was approximately 10 times higher among foreign-born HCWs during 2003–2007 than among US-born HCWs, and more than half of all TB cases among HCWs during 1995–2007 occurred among foreign-born persons,

TABLE 1. Characteristics of Patients with Tuberculosis (TB), by Healthcare Worker (HCW) Status, among Individuals 18 Years of Age or Older, 1995–2007

Characteristic	Patients with TB (n = 200,744)	
	HCWs (n = 6,049)	Other adults (n = 194,695)
Female sex	4,195 (69)	69,661 (36)
Mean/median age at diagnosis, years	41/40	49/47
Age at diagnosis range, years	18–91	18–112
Age group, years		
18–35	2,322 (38)	54,798 (28)
36–54	2,774 (46)	68,135 (35)
≥55	953 (16)	71,762 (37)
Birth country		
United States	2,736 (45)	101,382 (52)
Other <sup>a</sup>	3,302 (55)	92,491 (48)
Unknown	11 (<1)	822 (<1)
TST result at time of TB diagnosis <sup>b</sup>	4,724 (78)	138,173 (71)
Positive	4,175/4,724 (88)	109,513/138,173 (79)
Negative	549/4,724 (12)	28,660/138,173 (21)
Culture positive for <i>Mycobacterium tuberculosis</i>	4,829 (80)	162,718 (84)
Site of disease		
Pulmonary TB only	3,803 (63)	142,471 (73)
Extrapulmonary TB only	1,766 (29)	36,700 (19)
Both pulmonary and extrapulmonary TB	477 (8)	15,457 (8)
Findings among patients with any pulmonary TB		
Positive acid-fast bacilli sputum smear result	1,698/4,280 (40)	75,135/157,928 (48)
Positive cavitory chest radiograph findings <sup>c</sup>	1,053/4,280 (25)	43,313/157,928 (27)
Drug resistance <sup>d</sup>	4,708 (78)	157,213 (81)
Isoniazid monoresistance	461/4,708 (10)	12,094/157,213 (8)
Multidrug resistance	89/4,708 (2)	1,968/157,213 (1)
HIV test result reported <sup>e</sup>	3,331 (55)	99,621 (51)
HIV positive	430/3,331 (13)	20,392/99,621 (20)
Refused HIV test	479 (8)	11,394 (6)
HIV test not offered, result unknown, or not reported	2,239 (37)	83,680 (43)
No previous diagnosis of TB	5,817 (96)	182,244 (94)
Postmortem diagnosis of TB	52 (<1)	5,893 (3)
Excessive alcohol use	215 (4)	30,461 (16)
Injection or noninjection drug use	131 (2)	17,146 (9)
Incarceration at time of diagnosis	23 (<1)	7,674 (4)
Method of TB treatment <sup>f</sup>		
Directly observed therapy	1,792/5,233 (34)	79,679/170,478 (47)
Self-administered therapy	2,071/5,233 (40)	39,907/170,478 (23)
Both directly observed and self-administered therapy	1,237/5,233 (24)	41,661/170,478 (24)
Unknown	133/5,233 (3)	9,231/170,478 (5)
Treatment outcome <sup>e</sup>		
Completed therapy	4,745/5,233 (91)	135,062/170,478 (79)
Did not complete therapy	488/5,233 (9)	35,416/170,478 (21)
Moved	98/5,233 (2)	5,133/170,478 (3)
Lost to follow-up	62/5,233 (1)	4,225/170,478 (2)
Died	134/5,233 (3)	15,420/170,478 (9)
Uncooperative/refused	44/5,233 (1)	1,114/170,478 (1)
Other/unknown	150/5,233 (3)	9,524/170,478 (6)

NOTE. Data are no. (%) of persons with TB, unless otherwise indicated. Sum of percentages may not equal 100% due to rounding. HIV, human immunodeficiency virus; TST, tuberculin skin test.

<sup>a</sup> Birth outside of the United States.

<sup>b</sup> Analysis was limited to those with a reported TST result.

<sup>c</sup> Analysis was limited to those with an abnormal chest radiograph finding.

<sup>d</sup> Analysis was limited to those with a positive culture result and an isolate that had drug resistance results reported.

<sup>e</sup> Numbers and percentages for HIV status do not include data for California or Vermont cases. California has not reported HIV data for TB cases since 2004 and, in earlier years, only reported cases as HIV infected or unknown; negative HIV test results were not reported. Vermont has not reported HIV data for TB cases since 2006.

<sup>f</sup> Data were analyzed through 2005 to provide a 2-year period to complete reporting.

TABLE 2. Characteristics of Patients with Tuberculosis (TB) among US-Born and Foreign-Born Healthcare Workers (HCWs) 18 Years of Age or Older, 1995–2007

Characteristic	HCWs with TB (n = 6,049)	
	US born (n = 2,736)	Foreign born (n = 3,302)
Female sex	1,969 (72)	2,220 (67)
Mean/median age at diagnosis, years	43/43	39/37
Age at diagnosis range, years	18–91	18–87
Age group, years		
18–35	815 (30)	1,504 (46)
36–54	1,352 (49)	1,417 (43)
≥55	569 (21)	381 (12)
Race/ethnicity		
Black, non-Hispanic	1,318 (48)	815 (25)
White, non-Hispanic	1,060 (39)	194 (6)
Hispanic	243 (9)	418 (13)
Asian	58 (2)	1,836 (56)
American Indian/Alaska Native	29 (1)	3 (<1)
Native Hawaiian/Pacific Islander	14 (<1)	5 (<1)
Unknown or multiple races	14 (<1)	31 (1)
TST result at time of TB diagnosis <sup>a</sup>	2,216 (81)	2,501 (76)
Positive	1,855 (84)	2,315 (93)
Negative	361 (16)	186 (7)
Culture positive for <i>Mycobacterium tuberculosis</i>	2,126 (78)	2,692 (82)
Site of disease		
Pulmonary TB only	1,917 (70)	1,883 (57)
Extrapulmonary TB only	617 (23)	1,143 (35)
Both pulmonary and extrapulmonary TB	200 (7)	276 (8)
Findings among patients with any pulmonary TB		
Positive acid-fast bacilli sputum smear result	861/2,117 (41)	836 (39)
Positive cavity chest radiograph findings <sup>b</sup>	550/2,117 (26)	503 (23)
Drug resistance <sup>c</sup>	2,056 (75)	2,641 (80)
Isoniazid monoresistance	130/2,056 (6)	331/2,641 (13)
Multidrug resistance	35/2,056 (2)	54/2,641 (2)
HIV test result reported <sup>d</sup>	1,678 (67)	1,649 (65)
HIV positive	237/1,678 (14)	193/1,649 (12)
Refused HIV test	208 (8)	268 (8)
HIV test not offered, result unknown, or not reported	850 (31)	1,385 (42)
No previous diagnosis of TB	2,646 (97)	3,162 (96)
Postmortem diagnosis of TB	33 (1)	18 (<1)
Excessive alcohol use	172 (6)	42 (1)
Injection or noninjection drug use	106 (4)	23 (1)
Incarceration at time of diagnosis	19 (1)	4 (<1)
Method of TB treatment <sup>e</sup>		
Directly observed therapy	955/2,457 (39)	835/2,710 (31)
Self-administered therapy	856/2,457 (35)	1,202/2,710 (44)
Both directly observed and self-administered therapy	595/2,457 (25)	642/2,710 (24)
Unknown	51/2,457 (2)	31/2,710 (1)
Treatment outcome <sup>e</sup>		
Completed therapy	2,229/2,457 (91)	2,508/2,710 (93)
Did not complete therapy	228/2,457 (9)	202/2,710 (7)
Moved	27/2,457 (1)	71/2,710 (3)
Lost to follow-up	26/2,457 (1)	36/2,710 (1)
Died	86/2,457 (4)	46/2,710 (2)
Uncooperative/refused	31/2,457 (1)	13/2,710 (<1)
Other/unknown	58/2,457 (2)	36/2,710 (1)

NOTE. Data are no. (%) of persons with TB, unless otherwise indicated. Sum of percentages may not equal 100% due to rounding. HIV, human immunodeficiency virus; TST, tuberculin skin test.

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<sup>b</sup> Analysis was limited to those with an abnormal chest radiograph finding.

<sup>c</sup> Analysis was limited to those with a positive culture result and an isolate that had drug resistance results reported.

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<sup>e</sup> Data were analyzed through 2005 to provide a 2-year period to complete reporting.



which reflects the growing number of TB cases among foreign-born persons in the United States.<sup>12,14</sup>

Overall, during this time period, 11%–12% of foreign-born persons with TB were from Philippines. That percentage is in contrast to the 32% of foreign-born Filipino HCWs in this analysis, although consistent with the high proportion of foreign-born HCWs in the United States from Philippines.<sup>15,16</sup> In 2000, almost 40% of internationally trained nurses in the United States were Filipino.<sup>16</sup> In 2005, Philippines reported a TB incidence rate of 291 cases per 100,000 persons.<sup>17</sup>

Findings of our stratified analysis were also consistent with several studies that suggested that, compared with the general population, foreign-born persons, including HCWs, and specifically South Asian HCWs, were more likely to have extrapulmonary TB than pulmonary TB.<sup>18–21</sup>

The findings in this report are subject to a number of limitations. Seven percent of the 1995–2007 TB cases had missing data for occupation, and data were incomplete for other variables; HIV test results and treatment outcomes were missing for 37% and 8% of all HCWs, respectively (Table 1). However, completeness of reported TB data improved throughout the study period. For example, in 1995, 45% of all reported TB cases were missing information on HIV status; in 2007, 23% had missing HIV data. Also, for the years included in this analysis, the National TB Surveillance System did not collect the specific occupation, duration of employment in healthcare, or type of healthcare facility, nor did it collect previous diagnosis or treatment of LTBI.

In 2009, the National TB Surveillance System was modified to include LTBI history and, for foreign-born individuals, immigration status. This additional information could provide a better understanding of which interventions may improve diagnosis and treatment of LTBI among foreign-born HCWs before or soon after entry into the United States. In

general, only individuals entering the United States as immigrants or refugees are subject to a TB screening before entry.<sup>22</sup> Of the foreign-born HCWs in this analysis, 25% received a diagnosis of TB within 2 years after arrival to the United States, which suggests that infection was acquired before entry rather than within the United States, which is a finding consistent with other studies.<sup>23,24</sup>

According to the reported data, HCWs were less likely than other adults with TB to have received all doses of treatment by DOT. DOT has multiple benefits, including maximizing the likelihood of treatment completion, preventing development of drug-resistant disease, and providing an opportunity to identify possible adverse effects of the medication. Providing DOT for HCWs at their work site has been an effective option for ensuring HCWs complete treatment for TB disease and, when possible, for LTBI.<sup>5,10</sup> Identifying and treating LTBI is critical to preventing TB disease in this occupational group, but HCWs appear to be less likely to accept treatment for LTBI.<sup>25–27</sup>

Healthcare institutions, especially those associated with a high risk for TB exposure,<sup>10</sup> may benefit from an intensified approach to TB education and screening of HCWs upon hire, particularly foreign-born workers, and from encouraging completion of treatment for LTBI, if indicated. Such strategies have been associated with cost savings.<sup>28</sup> National guidelines recommend that HCWs who may be exposed to TB at the workplace be screened for TB disease symptoms and receive a tuberculin skin test or an interferon  $\gamma$  release assay blood test for TB infection annually.<sup>10</sup> Strengthening TB prevention and control in healthcare settings will protect HCWs from TB, which will in turn protect patients and the community and further our progress toward the goal of TB elimination in the United States.

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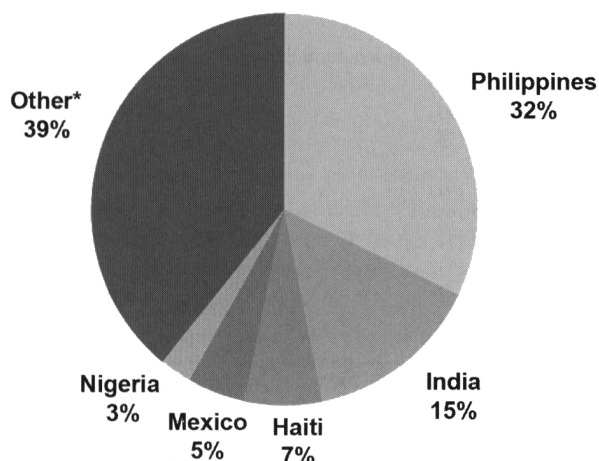


FIGURE 1. Top 10 countries of birth of foreign-born healthcare workers who had tuberculosis in the United States, 1995–2007 ( $n = 3,302$ ). \*"Other" includes Kenya (2%), Vietnam (2%), China (2%), Ethiopia (2%), Peru (2%), and others.

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