Risk of Tuberculosis in Correctional Healthcare Workers

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Objective: *The objective of this study was to determine the prevalence, incidence, and risk factors for occupational infection with tuberculosis among healthcare workers employed in correctional facilities.* ***Methods:*** *The authors conducted a self-administered survey, clinical interview, and tuberculin skin testing.* ***Results:*** *The overall tuberculin skin test point prevalence rate was 17.7%, the reactivity rate was 2.2%, and the annual incidence was 1.3%. At the multivariate level, after controlling for bacille Calmette-Guérin vaccination, only origin of birth remained significantly associated with prevalence of tuberculosis infection.* ***Conclusions:*** *Although the prevalence of tuberculin reactivity was high in this population, the risk factors were predominantly demographic rather than occupational. Nevertheless, continued vigilance to control occupational exposure to this and other respiratory pathogens is warranted, given the potential for future outbreaks of tuberculosis, as well as other known and emerging airborne pathogens.* (J Occup Environ Med. *2005;47:580–586*)

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The risk of tuberculosis (TB) exposure and infection has been well documented in workers employed across a range of healthcare settings, including correctional healthcare facilities.[1–4] Although data are sparse, correctional healthcare workers (CHCWs) may be particularly at risk because the prevalence of TB among inmate populations is high,[5–7] with a significant portion of persons with TB in the country passing through the correctional system.[8] The risk may be further increased by the inherent difficulties in the delivery of health care within prisons, which may result in suboptimal infection control measures, including inadequate case identification and follow up of cases.[6,9] Although risk assessment information on prison workers is scarce, available data suggest that they may be at increased risk. For example, studies of tuberculin skin testing (TST) in correctional officers showed relatively high reactivity rates, ranging from 2.7% to 4.9%,[10] and the Institute of Medicine recently estimated an annual risk of infection among CHCWs as high as 6.6% per year among exposed workers.[11] Given that the population of CHCWs at potential risk is large, with an estimated 100,000 CHCWs providing care to over two million incarcerated inmates, the potential magnitude of the problem is considerable.[12,13] To help minimize this risk, the Centers for Disease Control and Prevention (CDC) published guidelines aimed at risk reduction of infectious disease spread within prisons,[14] and in 1997, the Occupational Safety and Health Administration

(OSHA) proposed TB regulations, although these proposed rules were withdrawn in 2003.[15,16] Studies on the adoption of published guidelines and the degree to which they help to reduce risk for CHCWs, although extremely limited, indicate that infection control practices in prisons may be suboptimal.[17,18]

To assess the risk of TB infection among CHCWs, we conducted a risk assessment survey and performed TST using purified protein derivative of tuberculin (PPD) among CHCWs employed in correctional facilities representing a broad range of facility types, inmate populations, infectious disease rates, and geographic mixes.

Materials and Methods

Study Population

This study was performed among current full-time employees of adult correctional facilities operated by the Departments of Corrections in Rhode Island (RI), Maryland (MD), and Texas (TX) between 1999 and 2000. To facilitate recruitment, specific regional healthcare facilities within each prison system were designated as "test sites." In collaboration with each of the prison systems, medical directors, and infection control leadership, all of the CHCWs employed within a particular region were invited, by mail, to participate in the study on the days that the study team would be at their nearest test site. The sample frame consisted of only those employees who would normally be expected to be on duty during the time of the testing. CHCWs were defined as noninmate employees of a prison healthcare department. All procedures involving human subjects were reviewed and approved by the Johns Hopkins Institutional Review Board, the Columbia University Institutional Review Board, the Centers for Disease Control/National Institute for Occupational Safety and Health Institutional Review Board, and each state's correctional system's Institutional Review Board. All participants provided signed informed consent. Participation in the study involved completion of a 267-item, 14-page questionnaire, clinical interview by a nurse clinician, and TST for eligible participants. Previous TST results were verified, when possible, through record review.

Questionnaire Development and Administration

A self-administered risk assessment questionnaire was developed, which included information on: 1) community and occupational risk factors for exposure to tuberculosis; 2) self-reported compliance with infection control procedures; 3) TB-related knowledge and respirator use; 4) factors that might affect safe work practices,[19–21] including safety climate,[22] work stress,[23] job satisfaction,[24] and a newly constructed scale measuring job irritations; and 5) demographics. Other questions unrelated to this study addressed bloodborne pathogen risk and history of blood/body fluid exposure. The questionnaire was psychometrically validated before administration.

Tuberculin Skin Testing

All participants were first interviewed by a clinical nurse specialist, who recorded previous self-reported TST status and assessed possible contraindications to TST. Participants with a history of a positive TST ($\geq$10 mm) or active TB were ineligible to receive a TST, although they were still encouraged to complete the study questionnaire.

TSTs were administered following the standard Mantoux protocol using 0.1 mL of PPD containing 5 tuberculin units (Connaught, Tubersol PPD).[25] All positive results were measured using a millimeter ruler; only the diameter of palpable induration was measured. As per CDC guidelines, induration of 10 mm or more was considered positive.[25] TSTs were measured at 48 to 72 hours by a correctional facility nurse trained by the clinical nurse specialist, and results were noted on a coded, preaddressed postcard that had both millimeter calibration as well as sample induration affixed. Postcards were returned to the study office by mail. For practical reasons, two-stage testing was not performed in this protocol.

All participants were mailed a copy of their test results, and individuals with TSTs in excess of 10 mm were also contacted by phone by the study physician and advised to seek medical follow up. All TST results were also reported (with prior signed consent of participants) to each participant's employer as part of routine TB surveillance programs within the prisons.

Analysis

Data were double-entered into a database and analyzed using SPSS version 11.5 (SPSS, Inc., Chicago, IL) and Stata version 8.0 (Stata Corp., College Station, TX). Relative risk and odds ratios were calculated with 95% confidence intervals, and all significant variables at the univariate level were entered into regression models.

Results

Of 588 potentially eligible participants, 408 (69%) agreed to participate in the TB study. Demographic characteristics of the participants are provided in Table 1. The demographic characteristics from each test site were statistically similar to the state's CHCW population as a whole and statistically similar across the three states sampled.

Tuberculin Skin Testing Practices

To better understand how the various state systems were carrying out TB surveillance, CHCWs were asked about their employer's TST testing requirements. One hundred percent of CHCWs from Rhode Island reported that annual testing was required, compared with 93.3% of CHCWs from Maryland and only 42.7% of CHCWs from Texas. Three hundred ninety-six (97.1%) of the 408 CHCWs reported that they had

TABLE 1
Demographic Characteristics of Correctional Healthcare Workers (N = 408)

		Total No. (%)
Age, yr (mean)		44.0 (± 10.6)
Sex		
	Female	305 (75)
	Male	103 (25)
Race	White	261 (64)
	Nonwhite	123 (30)
	Missing	24 (6)
Current job	Nursing	209 (51)
	Medical/dental	56 (14)
	Administrative and/or clerical	92 (22)
	Psychology-related	28 (7)
	Technical	15 (4)
	Other	8 (2)
Years worked in correctional health care (mean)		6.9 (SD, 6.3 range; 0–38 yrs)
Origin of birth	US/Europe	361 (88)
	Other	47 (12)

SD, standard deviation.

previously had at least one TST, and this percentage was similar across all three states (98.9% for MD, 99.3% for TX, and 94.9% for RI). When asked when their last TST was performed, 243 (59.6%) of the CHCWs indicated that it had been within the past 12 months.

Exposure and Bacille Calmette-Guérin Vaccine History

Almost half the respondents (n = 183, 45%) reported a history of contact with a person diagnosed with active TB. Of those reporting a history of contact, almost all (n = 168, 91.8%) said the contact occurred in the workplace, with only a small percentage (n = 14, 7.7%) reporting that the contact involved household, close, or casual contact. Nurses reported the greatest percentage (93.8%) of workplace contacts with an inmate-patient with active TB, followed by medical/dental personnel (92.0%), administrative/clerical staff (91.7%), psychiatric personnel (75.0%), and technical personnel (66.7%).

Of 39 workers who reported a history of bacille Calmette-Guérin (BCG) vaccination, nearly half (n = 17, 43.6%) had been born in African countries, and over one fourth had been born in the United States (n = 10, 25.6%). Although CHCWs reporting a history of BCG vaccine were still eligible for TST, it should be noted that verification of BCG history or BCG scarification was not part of this study's protocol. Nine workers (2.2%) reported a history of TB disease; of these, 8 (88.9%) were born in the United States and 4 (44.4%) reported close contact with a person with active TB, with all of these contacts reported to be workplace-related.

Knowledge and Perceptions Regarding Tuberculosis

Overall, 50.0% of CHCWs indicated they had participated in workplace training related to occupational transmission of TB within the previous 12 months. The highest rates of training were reported by Maryland workers (61.5%), followed by workers in Rhode Island (44.9%) and Texas (38.7%). Significantly more nurses reported TB-related training in the past year (59.0%) compared with all other employees ($P < 0.001$).

CHCWs' general knowledge regarding the occupational risk of TB was high; 95.8% of respondents were aware that TB transmission to HCWs has occurred, with most (87.3%) also aware that occupational transmission involving multiple-drug-resistant strains of TB (MDR-TB) has also occurred. A high percentage of participants (92.7%) also knew that MDR-TB infections can be fatal.

Knowledge of respiratory infection control practices, however, was mixed. Although most participants (79.8%) were aware that the consistent use of respirators could prevent exposure to TB or MDR-TB, one third (n = 122, 30%) believed that standard surgical masks can effectively prevent inhalation of aerosolized or airborne TB droplets. This belief was more common among administrative and clerical workers (51.3%) and technicians (71.4%) than among nurses (21.3%), physicians and dentists (26.4%), or psychiatric personnel (37.0%).

Behavior and Practice

Almost one third of CHCWs (n = 128, 31.4%) reported wearing high-efficiency particulate air (HEPA)* masks to protect themselves from TB, followed by standard surgical masks (n = 60, 14.7%) and fluid-resistant surgical masks (n = 28, 6.9%). A sizable percentage (n = 75, 18.4%) reported that they *never* wore a mask or a respirator of any type to protect themselves. Although not asked directly about barriers to the

*"HEPA masks" is a term that is no longer used by NIOSH in its certification of disposable particulate respirators: "A respirator is a personal protective device that is worn on the face, covers at least the nose and mouth, and is used to reduce the wearer's risk of inhaling hazardous airborne particles (including dust particles and infectious agents), gases, or vapors. There are many types of respirators available. An N-95 respirator is one of nine types of disposable particulate respirators. Respirators in this family are rated as N, R, or P (to reflect the ability of the material to withstand oils) and 95, 99, or 100 (to reflect the ability of the material to filter contaminants)." www.cdc.gov/niosh/homepage.html.

use of HEPA respirators, CHCWs who participated in annual training on TB were more likely to report positive intentions to wear HEPA respirators (64.2%) than those who did not participate in annual training (35.8%) ($P < 0.001$).

Results of Tuberculosis Testing

Of 408 study participants, TSTs were performed on 279 persons (68.4%). Reasons for not being tested included: 1) a history of TB infection ($n = 9$) or a past reactive TST ($n = 54$), refusal ($n = 43$), deferral for medical reasons ($n = 8$), or declination ($n = 15$) because of recent testing (ie, within the past year).

Among the 279 tested, 6 individuals (2.2%) had a reactive skin test: 3 in MD (3 of 109, 2.8%), 2 in RI (2 of 58, 3.4%), and 1 in TX (1 of 112, 0.9%). To calculate the incidence of reactive TSTs, we analyzed data for the 231 CHCWs with verifiable negative PPDs within the prior 12 months. Within this group with recent negative tests, we identified 3 individuals (all in MD) who were TST-reactive, resulting in an estimated annual incidence rate of 1.3%.

To calculate an overall prevalence rate of TB infection among study participants, we combined those reporting a history of TB disease ($n = 9$), the 6 individuals with reactive TSTs in this study, and those reporting a previously reactive TST ($n = 54$). This yielded a total of 69; however, one person who reported an equivocal history of TB disease also had a current reactive TST, and therefore our total number of prevalent cases is 68 (17.7%) of 385 CHCWs responding to these questions. Maryland had the highest prevalence (22.8%), followed by Texas (14.0%) and Rhode Island (12.8%), but these differences were not significant. Infected CHCWs were significantly more likely to be males, nonwhite, and been born in Central America, Africa, Asia, or other non-U.S. or non-European countries (Table 2). In addition, they were more likely have been vaccinated with BCG and to report contact with someone known to have TB disease (predominately inmate-patients).

TABLE 2
Factors Associated With Tuberculin Skin Testing

Characteristic	Relative Risk	95% Confidence Interval
Age (yr)		
<45	1.00	Ref
46+	1.40	0.90–2.19
Sex		
Female	1.00	Ref
Male	1.96	1.27–3.00*
Race		
White	1.00	Ref
African-American	3.15	1.57–5.16*
Other	2.79	1.38–9.02*
Current job		
Administrative/clerical	1.00	Ref
Nursing	1.91	0.92–3.75
Medical/dental	1.90	0.82–4.41
Psychiatric	1.05	0.31–2.60
Technical	2.70	0.96–7.58
Years worked in correctional health care		
>5	1.00	Ref
≤5	1.39	0.88–2.18
Country of origin		
U.S./Europe	1.00	Ref
Other	4.44	3.04–6.50*
Known contact with someone with active tuberculosis		
No	1.00	Ref
Yes	1.82	1.04–3.19*
History of bacille Calmette-Guérin vaccination		
No	1.00	Ref
Yes	5.75	3.84–8.62*
Annual workplace tuberculosis testing required		
No	1.00	Ref
Yes	1.58	0.75–3.30
Type of respirator used		
All other respirators	1.00	Ref
HEPA respirator	1.69	1.06–2.67*
General safety climate at work		
Low	1.00	Ref
High	1.01	0.65–1.59
Work stress		
Low	1.00	Ref
High	1.52	0.96–2.42
Job satisfaction		
Low	1.00	Ref
High	1.06	0.64–1.57
Irritations at work		
Low	1.53	Ref
High	1.00	0.95–2.47

* Significant at $P < 0.05$.

TB infection status was not related to current job title, tenure in correctional health care, or the practice of annual workplace TB testing. We also examined potential organizational and psychosocial-related risk factors for compliance with respiratory protection such as TB-related training, general safety climate, work

stress, job satisfaction, and job irritations. These variables were not significantly associated with infection, nor was type of respirator reportedly used.

In a multivariate model that included all variables significant at the univariate level (ie, gender, race, place of birth, known contact with someone with active TB) and while controlling for BCG vaccination history, the only significant risk factor for TB infection remaining in the model was place of birth (U.S. and Europe vs. all other) ($P < 0.001$).

Discussion

Nationally, the TB case rate declined from 10.5% in 1992 to 5.2% in 2002.[26] In the three states examined in this study, reported cases of TB disease fell in the past decade from 14.2% in Texas (the third highest rate nationally) to 7.1%; in Maryland from 9% to 5.6%; and in Rhode Island from 5.4% to 4.6%.[26] The relatively low incidence rate (ie, 1.3%) in our study may reflect these trends. Our incidence rate is also similar to rates reported for New York State correctional workers (1991–1992), where conversion rates were 1.4% to 2.6% per year, depending on whether the correctional facility had a record of having an inmate case of TB.[10] Our findings are also similar to those reported in a relatively recent study by Cone et al, which noted a 1% rate of new tuberculosis infection in employees in two California prisons.[27]

The overall point prevalence rate of 17.7% in our sample is high and may reflect both past work- and nonwork-associated exposures, although we did not find occupational associations except at the univariate level. Our prevalence findings are somewhat similar to results from a Canadian study of 102 correctional workers, in which the point prevalence of TST reactivity was 32%.[28] Although the Canadian rates were higher, the factors they found to be associated with reactivity were similar to our risk factors, including previous BCG vaccination.[28]

Although positive tuberculin reactions were associated at the univariate level with well-characterized community and individual risk factors such as foreign birth and age, there was no significant difference in TST reactivity rates between employees providing direct clinical care and those in administrative positions. By contrast, Miller et al compared similar employee categories in a large inner-city hospital in the Southwest and found that conversion was associated with degree of patient contact.[29] In other reports, however, outbreaks of TB in correctional facilities noted that length of time spent in certain common areas was an important risk factor for TB transmission.[30] Although we did not specifically explore this, it is possible that the occupational risk of TB transmission in correctional institutions may be less directly related to job type than to environmental factors such as ventilation or infection control practices. Although ventilation assessments were not part of this study, this is an important consideration because prisons may have suboptimal ventilation systems, especially compared with acute-care hospital systems, where patients with TB are more likely to be isolated in specially vented negative pressure rooms. Additionally, the lack of adherence to certain infection control practices, (eg, case identification, isolation procedures, and so on) may also lead to increased risk for both professional and administrative staff.

We attempted to determine whether compliance with standard precautions and use of appropriate respiratory protection reduced the chances of infection. There was no significant association between overall compliance with standard (universal) precautions or with HEPA-type respirator use and TB infection. Again, this is probably because most of the risk of infection was associated with nonwork factors such as origin of birth compared with occupational factors.

One limitation of our study is possible misclassification with respect to the likely cause of tuberculin reaction. The fact that there was such a strong association among country of origin, BCG vaccination status, and tuberculin reactivity strongly suggests that many of these workers became tuberculin-reactive outside of the workplace. It is possible that recall bias resulted in an overestimation of the actual frequency of workplace infection, particularly because exposure records were not available for all participants. Although we could not measure this effect, we used the most conservative assumptions possible by classifying cases as those individuals who definitely attributed exposure to the workplace. Several participants with a history of reactive TSTs did not indicate where their exposure was most likely to have occurred. There was also some inconsistency in reporting. In particular, seven individuals who reported on the questionnaire that their previous TST was negative indicated to the nurse that they had previously had a positive TST. These seven individuals were therefore included in the initial cohort of TST-reactive subjects in the analysis. Similarly, misclassification of BCG vaccinees could have occurred because we did not confirm self-reported BCG history through either examination or review of records, which is preferred.[31] However, there is no reason to suspect a systematic bias in BCG reporting.

Current guidelines for the prevention and control of tuberculosis in correctional employees include TSTs at hire using a two-step Mantoux skin test, followed by annual screening of all correctional employees.[30] For logistical reasons, we used only a single step, and for this reason, our estimate should be considered a min-

imum estimate of the prevalence of reactors within this population.

Previous reports have noted the importance of weak safety culture and climate within healthcare facilities as a risk factor for exposure to bloodborne pathogens through needlesticks, other sharps injuries, and splashes.[17,20–22] By contrast, in this study, we found that safety climate was not significantly associated with TB infection. This may be because nonwork-related factors for TST were most strongly associated with reactivity, thus precluding association with safety climate. This does not diminish the importance of safety culture and climate, because there is clearly a need for sufficient resources to design, operate, and maintain a physical plant and safety program in a way that protects workers (as well as inmates) from TB infection and other aerosol-borne pathogens. This is especially important given the increased risk posed by emerging pathogens such as SARS.[32] Accreditation standards for healthcare facilities in prisons have been proposed to address this issue[33] and, at the very least, these facilities should be operated and maintained in a manner that protects the health of the workers and inmates within the facility using CDC guidelines and OSHA compliance documents to help direct this effort. Although we did not identify specific occupational risk factors for TB infection in this work population, continued assessment of health risks for CHCWs are warranted, given that CHCWs may be at risk of exposure to a variety of infectious agents, and given that their work setting may present challenges to infection control compliance. Continued research, therefore, into occupational exposure and control for this understudied population of HCWs is strongly recommended.

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