

# Tuberculosis in South Asians Living in the United States, 1993-2004

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**Background:** Patients with tuberculosis (TB) in the United States are often described in 2 broad categories, US-born and foreign-born, which may mask differences among different immigrant groups. We determined characteristics of patients born in South Asia and diagnosed as having TB in the United States.

**Methods:** All 224 101 TB cases reported to the US National Tuberculosis Surveillance System from the 50 states and the District of Columbia from 1993 to 2004 were included. We used descriptive analysis and logistic regression to explore differences among patients born in South Asia, other foreign-born, and US-born TB patients.

**Results:** Half of the South Asian TB patients (50.5%) in our study were in the 25- to 44-year-old age group, compared with 40.1% of other foreign-born TB patients and 31.8% of US-born TB patients. Compared with other for-

eign-born TB patients, South Asians were more likely to have extrapulmonary disease (odds ratio [OR], 1.7), more likely to be uninfected with human immunodeficiency virus (HIV) (OR, 5.8) but also more likely not to be offered HIV testing (OR, 9.4) or not to accept an HIV test if offered (OR, 11.8), and more likely not to be homeless (OR, 2.9) or not to use drugs or excess alcohol (OR, 2.7).

**Conclusions:** South Asian TB patients in the United States are younger and more commonly develop extrapulmonary TB than other foreign-born patients. New TB control strategies that target younger patients and that encourage HIV testing and inform physicians about high extrapulmonary TB in the absence of common risk factors in South Asians are needed.

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**G**LOBALLY, AN ESTIMATED 8.8 million new cases of tuberculosis (TB) were reported in 2003 (140 per 100 000 population)<sup>1</sup> and nearly 1.75 million people died of TB or TB-related conditions.<sup>2</sup> Although the number of TB cases in the United States in the native-born population has fallen steadily since 1993, the number of cases in foreign-born persons has been relatively unchanged. In 2001, for the first time, foreign-born patients with TB outnumbered US-born patients, and in 2005, 55% of the US total of 14 093 TB cases occurred in foreign-born persons.<sup>3</sup>

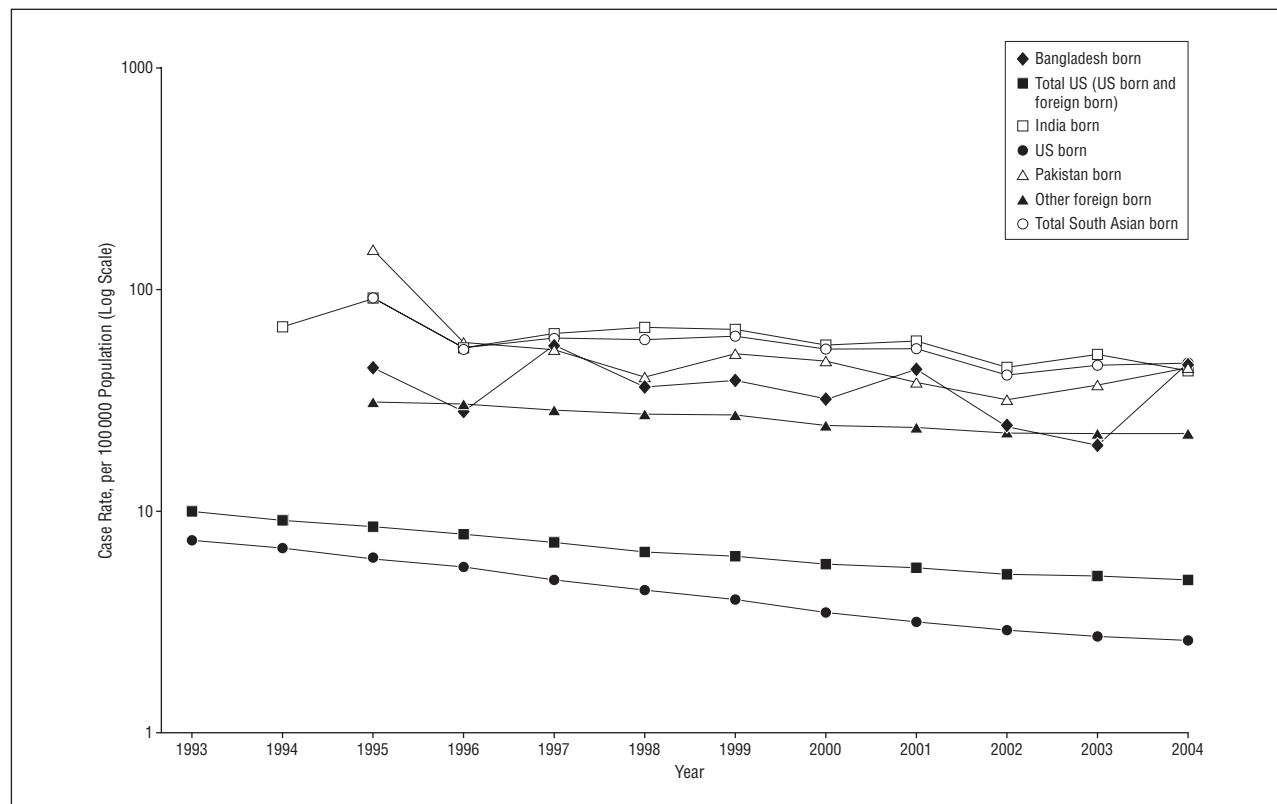
Other authors have described TB in the United States in 2 broad patient categories: US-born and foreign-born. Foreign-born TB patients come from various countries,<sup>4</sup> and combining them into 1 broad category may obscure important disease characteristics and risk factors. In this study, we describe the characteristics and associated risk factors of TB among persons born in South Asia and diagnosed as having TB in the United States and compare them with other foreign-born TB patients and with US-born patients.

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## METHODS

We used data on all TB cases in the United States reported to the National Tuberculosis Surveillance System at the Centers for Disease Control and Prevention from the 50 states and the District of Columbia from 1993 through 2004.<sup>4</sup> Reported TB cases are verified according to the TB case definition for public health surveillance.<sup>4</sup> For the purpose of this analysis, we categorized TB patients into mutually exclusive groups. South Asians were those born in Bangladesh, Bhutan, India, the Republic of Maldives, Nepal, Pakistan, or Sri Lanka (the World Bank includes Afghanistan in the South Asia region, but we chose to apply the definition used by the South Asian Association for Regional Cooperation, which excludes Afghanistan); others born outside the United States were grouped as "other foreign-born persons," and US-born persons were those born in the United States or a US jurisdiction, or born in a foreign country but with at least 1 US-born parent.

To calculate TB rates, we used population estimates from the Federated Electronic Research, Review, Extract, and Tabulation Tool (version 1.3.3; DataFerrett free software), and the March supplement estimates from the Current Population Survey for patients born in each South Asian country and residing in the United States.<sup>5</sup> We examined associations between select variables using odds ratios (ORs) and 95%



**Figure.** Tuberculosis (TB) case rates in the United States (per 100 000 population) by country or region of birth, 1993-2004. Total US rates are based on all cases of TB reported in the United States. Total South Asia-born TB rates include persons from Bangladesh, India, and Pakistan (these countries contributed 96% of the South Asia-born cases during the study period). Persons born in Bhutan, Maldives, Nepal, and Sri Lanka are not included in this figure because of lack of population figures for these groups (population figures were also not available for the Pakistan-born and Bangladesh-born before 1995). Other foreign-born rates are based on persons born in countries other than the United States, Bangladesh, India, and Pakistan.

confidence intervals (CIs). To determine the adjusted effects of risk factors for being a TB patient born in South Asia compared with being a TB patient born in any other foreign country, we fitted a logistic regression model that included all variables with known biologic importance (eg, human immunodeficiency virus [HIV] infection) and those at a significance level of  $P < .05$  in bivariate analyses. The final multivariate model was determined using a backward elimination strategy. A variable was left in the model if it was significantly associated with the outcome ( $P < .05$ ) or if it changed the ORs of any statistically significant term by 10% or more. Multicollinearity was assessed using variance inflation factors calculated for each variable; potential interactions were evaluated using the Wald statistic. In the final model, observations with a value of "unknown" for sex, age, disease site, sputum culture, and sputum smear were removed ( $n = 1892$ ) because the unknown category was less than 3% of the total for each variable. For other variables with a higher percentage of unknown data, "unknown" was modeled as a separate category. Multivariate models were run both with and without the 1892 observations with missing data to assess the impact of excluding data.

A new variable of substance abuse was created from 3 existing variables. A TB case was coded as substance abuse related if the patient had self-reported injection or noninjection drug use or excess alcohol use in the year prior to diagnosis. To investigate the possibility that extrapulmonary TB in South Asians was associated with infection with *Mycobacterium bovis*, we classified patient isolates as either having resistance to only pyrazinamide ("pyrazinamide mono-resistance") compared with any other drug-susceptibility pattern. The presence of pyrazinamide mono-resistance as a marker for *M bovis* infection has been reported to have a sensitivity of 81.8% and a specificity of 99.4%.<sup>6</sup>

## RESULTS

From 1993 through 2004, a total of 224 101 TB cases were reported in the United States, of which 7624 (3.4%) were in persons born in 1 of the 7 South Asian countries. The TB rates among South Asians were generally higher than those among other foreign-born persons, but the rate of decline for the 2 groups was similar (**Figure**). The TB rates among South Asians were substantially higher than rates among US-born persons and declined more gradually during this time period.

**Table 1** shows patient and clinical characteristics of TB cases in the United States. Compared with foreign-born as well as with US-born TB patients, South Asian TB patients were more often in the group aged 15 to 44 years and less often in both the group aged younger than 15 years as well as the group aged older than 44 years. In all, 66.3% of South Asians were 15 to 44 years old, compared with 54.1% of the other foreign-born and 36.6% of the US-born TB patients. South Asians were coinfectd with HIV less commonly (1.1%) than other foreign-born patients (5.4%) and US-born patients (13.2%), but 62.7% of South Asians and 64.3% of other foreign-born patients were not tested for HIV infection or had unknown or unreported test results. Other risk factors commonly associated with TB among US-born persons (homelessness, drug use, excess alcohol consumption, and unemployment) were less frequently reported among other foreign-born patients

**Table 1. Patient and Clinical Characteristics of Patients With TB Born in South Asia Compared With Other Foreign-Born and US-Born Patients, 1993-2004<sup>a</sup>**

Characteristic	Patients			
	South Asians	Other Foreign-Born	US-Born	Total
Patients, No.	7624	85 171	131 306	224 101
Sex				
Male	4277 (56.1)	50 743 (59.6)	85 991 (65.5)	141 011
Female	3345 (43.9)	34 422 (40.4)	45 303 (34.5)	83 070
Unknown	2 (0.0)	6 (0.0)	12 (0.0)	20
Age, y				
0-4	52 (0.7)	1237 (1.4)	7057 (5.4)	8346
5-14	121 (1.6)	2182 (2.6)	3553 (2.7)	5856
15-24	1205 (15.8)	11 911 (14.0)	6396 (4.9)	19 512
25-44	3853 (50.5)	34 154 (40.1)	41 707 (31.8)	79 714
45-64	1549 (20.3)	20 370 (23.9)	38 492 (29.3)	60 411
≥65	842 (11.0)	15 303 (18.0)	34 067 (25.9)	50 212
Unknown or missing	2 (0.0)	14 (0.0)	34 (0.0)	50
Years in the United States				
<1	1556 (20.4)	16 566 (19.4)	NA	18 122
1-4	2163 (28.4)	16 175 (19.0)	NA	18 338
5-14	1664 (21.8)	18 370 (21.6)	NA	20 034
≥15	2241 (29.4)	34 060 (40.0)	NA	36 301
HIV status				
Uninfected	2757 (36.2)	25 720 (30.2)	43 667 (33.3)	72 144
Infected	88 (1.1)	4614 (5.4)	17 294 (13.2)	21 996
Refused	745 (9.8)	3788 (4.5)	6890 (5.2)	11 423
Not offered	1444 (18.9)	9324 (10.9)	21 024 (16.0)	31 792
Unknown/indeterminate <sup>b</sup>	2590 (34.0)	41 725 (49.0)	42 431 (32.3)	86 746
Homeless				
Yes	45 (0.6)	2390 (2.8)	10 954 (8.3)	13 389
No	7275 (95.4)	78 075 (91.7)	110 662 (84.3)	196 012
Unknown or missing	304 (4.0)	4706 (5.5)	9690 (7.4)	14 700
Injection drug use				
Yes	5 (0.1)	603 (0.7)	5387 (4.1)	5995
No	7008 (91.9)	75 486 (88.6)	104 187 (79.3)	186 681
Unknown or missing	611 (8.0)	9082 (10.7)	21 732 (16.6)	31 425
Noninjection drug use				
Yes	31 (0.4)	1970 (2.3)	12 505 (9.5)	14 506
No	6957 (91.3)	73 604 (86.4)	96 046 (73.2)	176 607
Unknown or missing	636 (8.3)	9597 (11.3)	22 755 (17.3)	32 988
Excess alcohol use				
Yes	149 (1.9)	5554 (6.5)	24 866 (18.9)	30 569
No	6847 (89.9)	70 425 (82.7)	84 797 (64.6)	162 069
Unknown or missing	628 (8.2)	9192 (10.8)	21 643 (16.5)	31 463
Occupation				
Unemployed	2900 (38.0)	38 059 (44.7)	74 993 (57.1)	115 952
Health care worker	476 (6.3)	2259 (2.6)	2925 (2.2)	5660
Other	3522 (46.2)	34 894 (41.0)	33 068 (25.2)	71 484
Unknown	726 (9.5)	9959 (11.7)	20 320 (15.5)	31 005
Health care provider				
Health department	3063 (40.2)	43 384 (50.9)	51 655 (39.3)	98 102
Private or other	2534 (33.2)	19 050 (22.4)	35 244 (26.8)	56 828
Both	1345 (17.6)	15 983 (18.8)	34 871 (26.6)	52 199
Unknown	682 (9.0)	6754 (7.9)	9536 (7.3)	16 972
Drug susceptibility				
Tested for any drug susceptibility	5906 (77.5)	66 698 (78.3)	96 999 (73.9)	169 603
Tested for isoniazid and rifampin susceptibility	5879 (99.5)	66 369 (99.5)	96 456 (99.4)	168 704
Multidrug-resistant TB	118 (2.0)	1344 (2.0)	1211 (1.3)	2673
Tested for pyrazinamide susceptibility	4540 (76.9)	48 969 (73.4)	54 326 (56.0)	107 835
Pyrazinamide monoresistance	45 (1.0)	785 (1.6)	578 (1.1)	107 835
History of TB				
Yes	252 (3.3)	4634 (5.4)	6879 (5.2)	11 765
No	7267 (95.3)	79 717 (93.6)	123 287 (93.9)	210 271
Unknown	105 (1.4)	820 (1.0)	1140 (0.9)	2065

(continued)

**Table 1. Patient and Clinical Characteristics of Patients With TB Born in South Asia Compared With Other Foreign-Born and US-Born Patients, 1993-2004<sup>a</sup> (cont)**

Characteristic	Patients			
	South Asians	Other Foreign-Born	US-Born	Total
Sputum culture finding				
Positive	3039 (39.9)	49 407 (58.0)	76 415 (58.2)	<b>128 861</b>
Negative	1619 (21.2)	17 387 (20.4)	20 112 (15.3)	<b>39 118</b>
Not performed	2787 (36.6)	16 947 (19.9)	31 681 (24.1)	<b>51 415</b>
Unknown	179 (2.3)	1430 (1.7)	3098 (2.4)	<b>4707</b>
Sputum smear for acid-fast bacilli finding				
Positive	1846 (24.2)	29 584 (34.7)	49 686 (37.8)	<b>81 116</b>
Negative	2921 (38.3)	38 002 (44.6)	46 996 (35.8)	<b>87 919</b>
Not performed	2757 (36.2)	16 847 (19.8)	32 159 (24.5)	<b>51 763</b>
Unknown	100 (1.3)	738 (0.9)	2465 (1.9)	<b>3303</b>
Findings from chest radiography				
Normal	2067 (27.1)	11 470 (13.5)	12 668 (9.6)	<b>26 205</b>
Abnormal	5217 (68.4)	71 705 (84.2)	113 172 (86.2)	<b>190 094</b>
Unknown or not performed	340 (4.5)	1996 (2.3)	5466 (4.2)	<b>7802</b>
Type of disease found on chest radiography				
Cavitary disease	1113 (14.6)	16 269 (19.1)	28 060 (21.4)	<b>45 442</b>
Noncavitary, consistent with TB	3660 (48.0)	51 412 (60.3)	75 375 (57.4)	<b>130 447</b>
Noncavitary, not consistent with TB	341 (4.5)	2270 (2.7)	5073 (3.9)	<b>7684</b>
Unknown	2510 (32.9)	15 220 (17.9)	22 798 (17.3)	<b>40 528</b>
Disease site				
Pulmonary	3925 (51.5)	61 656 (72.4)	100 529 (76.6)	<b>166 110</b>
Extrapulmonary	3108 (40.8)	17 311 (20.3)	20 650 (15.7)	<b>41 069</b>
Both	586 (7.7)	6192 (7.3)	10 075 (7.7)	<b>16 853</b>
Unknown or missing	5 (0.1)	12 (0.0)	52 (0.0)	<b>69</b>

Abbreviations: HIV, human immunodeficiency virus; NA, not applicable; TB, tuberculosis.

<sup>a</sup>Data are given as number (percentage) unless indicated otherwise.

<sup>b</sup>Unknown or other category for HIV results includes refused, test not offered, and test performed with an unknown result.

and even less frequently among South Asians. South Asians received their care through private health care providers more often than did other foreign-born patients. The frequency of multidrug-resistant TB (defined as resistance to at least isoniazid and rifampin) was similar for South Asian and other foreign-born patients (2.0%) but higher than in US-born patients (1.3%). Probable infection with *M bovis*, as determined by the finding of pyrazinamide monoresistance, was equally unusual (<1.6%) among all 3 patient groups, but pyrazinamide susceptibility data were reported less commonly than were data on isoniazid and rifampin. South Asians less often had a history of previous TB than did other foreign-born and US-born patients.

Extrapulmonary TB was more commonly reported among South Asians than among other foreign-born or US-born patients. Almost half (48.5%) of South Asians had extrapulmonary disease (either as their only manifestation of TB [40.8%] or in combination with pulmonary TB [7.7%]). In comparison, only 27.6% of other foreign-born patients and 23.4% of US-born patients had extrapulmonary TB. As a consequence of the frequency of extrapulmonary disease among South Asians, their TB diagnosis was confirmed less commonly by a positive finding from a sputum smear for acid-fast bacilli or a positive finding from a sputum culture, and they had a normal chest radiograph more often than did other foreign-born or US-born patients.

There were differences between South Asians and the other 2 groups in the distribution of extrapulmonary dis-

**Table 2. Major Site of Extrapulmonary Disease of Patients With TB in the United States, 1993-2004**

Major Site of Extrapulmonary Disease	Patients, No. (%)		
	South Asians	Other Foreign-Born	US-Born
Pleural	390 (11.7)	2979 (15.4)	5550 (23.1)
Total lymphatic	1857 (55.6)	8322 (43.1)	7076 (29.4)
Cervical	1149 (34.4)	5678 (29.4)	3562 (14.8)
Intrathoracic	176 (5.3)	615 (3.2)	1351 (5.6)
Other	291 (8.7)	1166 (6.0)	1368 (5.7)
Unknown	241 (7.2)	863 (4.5)	795 (3.3)
Bone and joint	377 (11.3)	1958 (10.1)	2565 (10.7)
Genitourinary	106 (3.2)	1363 (7.1)	1424 (5.9)
Miliary	95 (2.8)	1109 (5.7)	1950 (8.1)
Meningeal	103 (3.1)	775 (4.0)	1498 (6.2)
Peritoneal	134 (4.0)	911 (4.7)	1046 (4.3)
Other	273 (8.2)	1889 (9.8)	2890 (12.0)
Not stated	5 (0.1)	12 (0.1)	47 (0.2)
<b>Total</b>	<b>3340</b>	<b>19 318</b>	<b>24 051</b>

Abbreviation: TB, tuberculosis.

ease (**Table 2**). Among the 3340 South Asians with extrapulmonary TB as their major site of disease, more than half (55.6%) had lymphatic TB. South Asians had lymphatic TB of the neck, the thorax, or another lymphatic site more often than did other foreign-born patients, and they had disease at each of the other extrapulmonary sites reported less often than did other foreign-born patients.



**Table 3. South Asian Patients vs Other Foreign-Born Patients in Univariate and Multivariate Analysis, 1993-2004<sup>a</sup>**

Characteristic	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Sex		
Male	1 [Reference]	1 [Reference]
Female	1.1 (1.1-1.2)	0.9 (0.8-0.9)
Age, y		
0-4	0.4 (0.3-0.5)	0.2 (0.1-0.3)
5-14	0.5 (0.4-0.6)	0.3 (0.3-0.4)
15-24	0.9 (0.8-0.9)	0.8 (0.7-0.8)
25-44	1 [Reference]	1 [Reference]
45-64	0.7 (0.6-0.7)	0.7 (0.7-0.8)
≥65	0.5 (0.4-0.5)	0.5 (0.5-0.6)
Foreign-born patients, years in the US		
<5 y	1 [Reference]	1 [Reference]
≥5 y	0.6 (0.6-0.6)	0.6 (0.5-0.6)
Unknown	0.7 (0.7-0.8)	0.7 (0.7-0.8)
HIV status		
Infected	1 [Reference]	1 [Reference]
Uninfected	5.6 (4.5-6.9)	5.8 (4.7-7.3)
Test refused	10.3 (8.2-12.9)	11.8 (9.4-14.9)
Test not offered	8.1 (6.5-10.1)	9.4 (7.5-11.7)
Unknown	3.2 (2.6-4.0)	4.1 (3.3-5.1)
Homelessness		
Yes	1 [Reference]	1 [Reference]
No	4.9 (3.7-6.7)	2.9 (2.1-3.9)
Unknown or missing	3.4 (2.5-4.8)	2.8 (2.0-3.9)
Any substance abuse		
Yes	1 [Reference]	1 [Reference]
No	3.8 (3.2-4.4)	2.7 (2.3-3.2)
Unknown	2.5 (2.1-3.0)	2.3 (1.9-2.7)
Occupation		
Unemployed	1 [Reference]	1 [Reference]
Health care worker	2.7 (2.4-3.0)	1.8 (1.6-2.1)
Others	1.3 (1.2-1.4)	1.1 (1.0-1.1)
Unknown	0.9 (0.9-1.0)	1.0 (0.9-1.1)
Site of disease		
Pulmonary only	1 [Reference]	1 [Reference]
Extrapulmonary	2.8 (2.7-3.0)	1.7 (1.6-1.9)
Both	1.5 (1.3-1.6)	1.5 (1.4-1.7)
Sputum smear for acid-fast bacillus		
Negative	1 [Reference]	NI
Positive	0.8 (0.8-0.9)	NI
Not performed	2.1 (2.0-2.3)	NI
Findings from chest radiograph		
Normal	1 [Reference]	1 [Reference]
Abnormal, cavitory	0.4 (0.3-0.4)	0.8 (0.8-0.9)
Abnormal, noncavitory consistent with TB	0.4 (0.4-0.4)	0.8 (0.7-0.9)
Abnormal, noncavitory, not consistent with TB	0.8 (0.7-0.9)	1.1 (1.0-1.3)
Unknown	0.7 (0.6-0.7)	0.9 (0.8-1.1)
Sputum culture		
Positive for <i>Mycobacterium tuberculosis</i>	1 [Reference]	1 [Reference]
Negative for <i>M tuberculosis</i>	1.5 (1.4-1.6)	1.1 (1.0-1.2)
Not performed	2.7 (2.5-2.8)	1.6 (1.5-1.8)

Abbreviations: CI, confidence interval; HIV, human immunodeficiency virus; NI, not included; OR, odds ratio; TB, tuberculosis.

<sup>a</sup>Total South Asian patients, 7624; total other foreign-born patients, 85 171.

**Table 3** shows the results of univariate and multivariate analyses in a logistic regression model, which compared South Asians with other foreign-born patients. All

variables listed remained statistically significant except sputum smear for acid-fast bacilli, which was removed from the final model. No evidence of multicollinearity was found, and no interaction terms were significant ( $P < .05$ ). Results and conclusions remained unchanged when the multivariate model was run with all missing data included. South Asian TB patients in the United States were less likely than other foreign-born TB patients to be either younger than 24 years or older than 45 years. South Asians were more likely to be diagnosed as having TB in their first 5 years in the United States and were more likely to be uninfected with HIV (hereinafter, HIV uninfected), but also much more likely to have refused testing for HIV or to have not been offered the test. South Asians were less likely than other foreign-born patients to be homeless, substance abusers, or unemployed. The multivariate analysis confirmed that South Asians were more likely than other foreign-born patients to have extrapulmonary disease.

We explored possible explanations for the high percentage of extrapulmonary TB among South Asians by determining associations between the site of disease and HIV infection status, young age, pyrazinamide monoresistance, and differences in how the diagnosis of TB was made in South Asians compared with other foreign-born patients. Because 62.7% of South Asians had an unknown HIV status, we conducted a sensitivity analysis by HIV status to determine if different combinations of HIV results affected the odds of having extrapulmonary disease. Additional models were restricted to (1) only patients whose HIV status was known, (2) all unknown HIV status considered as HIV infected, and (3) all unknown HIV status considered as HIV uninfected. In all 3 analyses, South Asians were still significantly more likely to have extrapulmonary disease (adjusted ORs, 1.6-1.7, compared with an adjusted OR, 1.7, in our final model). When we eliminated California cases from the model (because of state reporting rules, TB cases from California are reported as either HIV infected or unknown), odds for South Asians to have extrapulmonary disease increased (adjusted OR, 1.8; 95% CI, 1.7-2.0).

We compared the frequency of extrapulmonary disease in those patients who had any 1 of the characteristics traditionally associated with extrapulmonary TB (HIV infection, age  $\leq 4$  years, *M bovis* infection as determined by the presence of monoresistance to pyrazinamide) with patients who had none of these characteristics. Of the 183 patients with any 1 of these characteristics, 62 (33.9%) had extrapulmonary TB. Of the 2729 patients who were HIV uninfected, at least 5 years old, and not pyrazinamide monoresistant, 1091 (40.0%) had extrapulmonary disease.

To determine the possible role of misdiagnosis in explaining the high frequency of extrapulmonary TB in South Asians, we calculated the percentages of TB patients with laboratory-confirmed diagnoses (either a positive culture or a positive sputum or tissue smear for acid-fast bacilli) compared with diagnoses that lacked laboratory confirmation, based on the CDC clinical case definition<sup>3</sup> or simply a health care provider's diagnosis (**Table 4**). South Asian patients (82.2%) had laboratory-confirmed diagnoses of TB more often than did other foreign-born patients (80.1%) or US-born patients (81.4%).

To our knowledge, our study is the first to look at a large number (7624) of patients who were born in South Asia and developed TB in the United States, a country with relatively low TB incidence and advanced diagnostic capacity. This large number allowed us to describe trends in the rate of TB among South Asians over the last 12 years and to determine differences in disease characteristics, not only between South Asians and US-born patients but also between South Asians and other foreign-born patients diagnosed as having TB in the United States. We found that the rate of TB among South Asians has been declining over time but remains higher than among other foreign-born and US-born persons. We also found that South Asians were more likely than other foreign-born patients to be middle aged, HIV uninfected, and to lack traditional risk factors found in US-born persons with TB (homelessness, substance abuse, or unemployment). South Asians more commonly had extrapulmonary TB and were more likely to refuse an HIV test or not have the test offered to them compared with other foreign-born patients.

Previous studies from the United States and from other Western countries have reported that foreign-born patients with TB are less likely to have common risk factors found in native-born patients with TB.<sup>7-11</sup> Our findings are consistent with previous studies and also show that these differences are more marked in South Asians with TB compared with other foreign-born TB patients. The differences of age distribution in TB patients seen in South Asians and US-born persons could be the result of differences in the age distribution of the underlying subpopulations. South Asian patients less often have a history of previous TB than US-born patients even though the incidence of TB is higher in South Asia. We are not certain why this might be the case, but 2 possible explanations are that in South Asia, previous TB might have been diagnosed as something else, and that there might be a fear among South Asians to admit a history of TB because that information could have a negative impact on the immigration process.

One of the most striking clinical characteristics that distinguished the South Asian TB patients in our study from other TB patients was the high percentage with extrapulmonary TB, which was twice as common among South Asians as among other foreign-born TB patients and more than 2.5 times as likely as among US-born patients. Other investigations have linked extrapulmonary TB disease with female sex, young or old age, immunodeficiency (including coinfection with HIV), being infected with *M bovis*, and socioeconomic factors; however, associations are sometimes contradictory depending on the region of the world.<sup>9-14</sup> Although the data we examined did not include socioeconomic factors, we did look at each of the other characteristics to see if they could explain (alone or in combination) the high percentage of South Asians with extrapulmonary TB. We determined that the risk of extrapulmonary disease in South Asians is still elevated even when adjusted for these previously described predictors of extrapulmonary disease. When we restricted our calculations to South Asian patients who did not have traditional risk factors for extrapulmonary disease, we still found that

**Table 4. Case Verification Among Patients With TB in the United States, 1993-2004**

Diagnostic Criteria	Patients, No. (%)		
	South Asians	Other Foreign-Born	US-Born
Positive finding from culture	6181 (81.1)	67 700 (79.5)	105 712 (80.5)
Positive finding from smear or tissue sample	87 (1.1)	490 (0.6)	1175 (0.9)
Clinical case definition	888 (11.6)	11 716 (13.8)	14 571 (11.1)
Health care provider diagnosis	468 (6.1)	5265 (6.2)	9848 (7.5)
<b>Total</b>	<b>7624</b>	<b>85 171</b>	<b>131 306</b>

Abbreviation: TB, tuberculosis.

40.0% had extrapulmonary TB. Finally, we looked at the possible role of misdiagnoses in explaining our findings, but we concluded that, if anything, diagnoses of TB among South Asians were more likely to be laboratory confirmed than among other foreign-born or US-born patients. We conclude that these previously described predictors of extrapulmonary disease account for very few of the extrapulmonary cases in South Asians we report herein.

Other studies have shown an increased frequency of extrapulmonary TB disease among certain populations, such as 61% of Asian TB patients living in Canada,<sup>15</sup> 51.7% of 296 cases in a cross-sectional study in Turkey,<sup>16</sup> and 56% of 229 children in a hospital in Cape Town, South Africa.<sup>17</sup> Two studies of Somali patients residing in the Netherlands<sup>18</sup> and in Minnesota<sup>19</sup> have shown elevated rates of extrapulmonary TB disease.

The percentage of extrapulmonary-only disease among South Asian patients in our study (40.8%) is higher than that reported from several studies of patients living in South Asia. A tertiary clinic in India reported that 22.2% of 893 TB patients had extrapulmonary disease and that this percentage was similar for those infected (24%) and those uninfected (22%) with HIV.<sup>20</sup> In 176 HIV-coinfected TB patients in India, 28% had extrapulmonary disease.<sup>21</sup> In another study in India, 21% of TB cases were extrapulmonary.<sup>22</sup> In most of South Asia, TB is first diagnosed and treated by local health care providers in the private sector, with chest radiograph and then sputum smear (if available).<sup>23,24</sup> The greater percentage of extrapulmonary TB among South Asians in the United States than among those living in their native countries might be explained by access to better diagnostic tests in the United States.

If the high percentage of extrapulmonary TB among South Asians is not explained by factors such as HIV coinfection, age, or infection with *M bovis*, it may be explained by some as-yet unidentified physiological response unique to the South Asian population. For example, South Asians have a greater risk for coronary heart disease outside their home countries compared with the host populations,<sup>25</sup> and physiological and lifestyle differences have been implicated in explaining these differences.<sup>26-33</sup> Similarly, South Asian immigrants have been shown to have an elevated frequency of TB even in the absence of traditional TB risk factors. Vitamin D de-

iciency, vitamin D receptor polymorphism, peripheral neutrophil count,<sup>34,35</sup> and immunodeficiency other than HIV infection have been suggested as explanations.<sup>36-39</sup>

Our study is limited by the fact that it is based on surveillance data, and ascertainment of risk factor data can vary among surveillance reporting sites. In addition, HIV status was unknown for three-fifths of our study population, making it impossible to draw firm conclusions about the role of HIV infection. In addition, pyrazinamide susceptibility testing was reported for only 60% of cases with positive findings from culture samples.

Our results have important practical implications. Because most TB in South Asians is reactivation of latent infection, a program of targeted testing for latent tuberculosis and preventive therapy as directed by the test result may be beneficial. Health care providers should maintain a high level of clinical suspicion for the possibility of extrapulmonary TB when caring for South Asians, especially those with lymphadenopathy.

Health care programs that serve South Asians should also consider programmatic changes, such as more flexible clinic hours, that might facilitate providing services to a population that is often more educated<sup>7</sup> and less likely to be unemployed than other foreign-born groups. Finally, patient and provider health education is needed to address cultural taboos that may hinder an open discussion of HIV status.

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