

Tuberculosis along the United States-Mexico border, 1993–2001

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ABSTRACT

Objectives. Tuberculosis (TB) is a leading public health problem and a recognized priority for the federal Governments of both Mexico and the United States of America. The objectives of this research, primarily for the four states in the United States that are along the border with Mexico, were to: (1) describe the epidemiological situation of TB, (2) identify TB risk factors, and (3) discuss tuberculosis program strategies.

Methods. We analyzed tuberculosis case reports collected from 1993 through 2001 by the tuberculosis surveillance system of the United States. We used those data to compare TB cases mainly among three groups: (1) Mexican-born persons in the four United States border states (Arizona, California, New Mexico, and Texas), (2) persons in those four border states who had been born in the United States, and (3) Mexican-born persons in the 46 other states of the United States, which do not border Mexico.

Results. For the period from 1993 through 2001, of the 16 223 TB cases reported for Mexican-born persons in the United States, 12 450 of them (76.7%) were reported by Arizona, California, New Mexico, and Texas. In those four border states overall in 2001, tuberculosis case rates for Mexican-born persons were 5.0 times as high as the rates for persons born in the United States; those four states have 23 counties that directly border on Mexico, and the ratio in those counties was 5.8. HIV seropositivity, drug and alcohol use, unemployment, and incarceration were significantly less likely to be reported in Mexican-born TB patients from the four border states and the nonborder states than in patients born in the United States from the four border states ($P < 0.001$). Multivariate analysis revealed that among pulmonary tuberculosis patients who were 18–64 years of age and residing in the four border states, the Mexican-born patients were 3.6 times as likely as the United States-born patients were to have resistance to at least isoniazid and rifampin (i.e., to have multidrug-resistant TB) and twice as likely to have isoniazid resistance. Mexican-born TB patients from the four border states and the nonborder states were significantly more likely to have moved or to be lost to follow-up than were the TB patients born in the United States from the four border states ($P < 0.001$).

Conclusions. Increased collaborative tuberculosis control efforts by the federal Governments of both Mexico and the United States along the border that they share are needed if tuberculosis is to be eliminated in the United States.

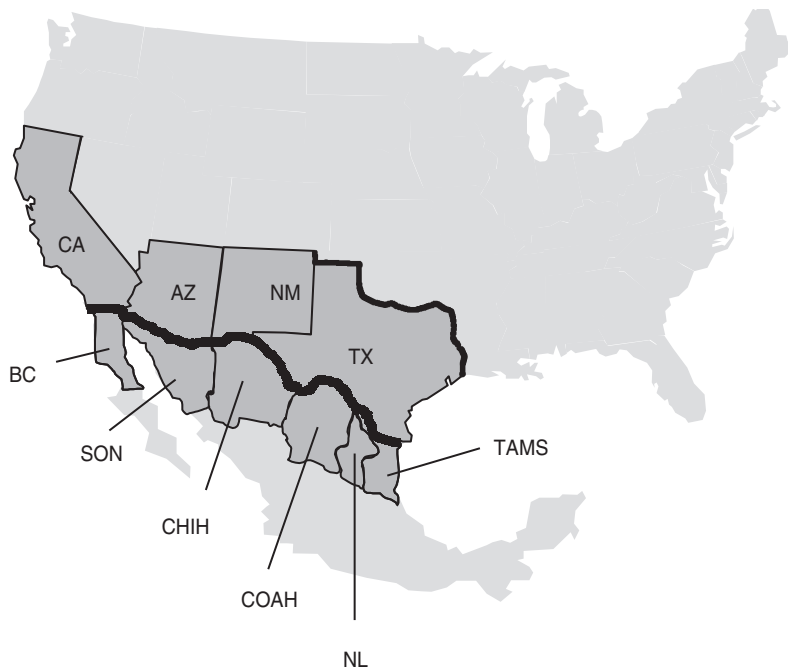
Key words

Tuberculosis, population surveillance, antitubercular agents, Mexico, United States, international cooperation.

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FIGURE 1. United States-Mexico border map, 2001**United States-Mexico border**

- States: four in the United States, six in Mexico
- Length: 1 952 miles (3 141 kilometers) (3)
- Border area^a population: ~11.5 million persons (1)
- Annual northbound border crossings: ~264 million persons (4)

	TB cases ^b	TB rate ^{b,c}
Arizona (AZ)	289	5.4
California (CA)	3 332	9.7
New Mexico (NM)	54	3.0
Texas (TX)	1 643	7.7
U.S. border states	5 318	8.4
U.S. national	15 989	5.6
Baja California Norte (BC)	1 321	54.0
Chihuahua (CHIH)	533	17.1
Coahuila (COAH)	150	6.2
Nuevo León (NL)	1 221	31.1
Sonora (SON)	514	22.6
Tamaulipas (TAMS)	1 041	37.5
Mexican border states	4 780	28.1
Mexican national	16 323	16.2

^a Border area is defined as the area extending 100 kilometers (62 miles) north-south on either side of the United States-Mexico border.

^b Sources: United States TB data: Centers for Disease Control and Prevention. Reported tuberculosis in the United States, 2001. Atlanta: United States Department of Health and Human Services, CDC; 2002 (2). Mexican TB data: Sistema Único de Información para la Vigilancia Epidemiológica/Dirección General de Epidemiología/Secretaría de Salud.

^c TB rate = TB cases per 100 000 population.

Tuberculosis (TB) among populations along the border shared by Mexico and the United States of America is a leading public health problem and a recognized priority for the federal Governments of the two countries (1). There are four states in the United States and six states in Mexico along the United States-Mexico border. As shown in Figure 1, in 2001, TB rates on each side of the border were 1.5 times their respective national averages, according to published (1–4) and unpublished sources.² Prolonged infectiousness, ongoing transmission, and increased drug resistance have been documented among TB patients residing along the border (5–9). Moreover,

TB control, including TB case management and completion of the standard six-month treatment regimen, is made more difficult in this area by poor socioeconomic conditions, limited health care access, and an extremely mobile population (1, 4, 10–13).

In 2001, 49% of the total TB cases reported in the United States were among foreign-born persons. Almost one-quarter of the foreign-born TB patients (23%) were born in Mexico, and 69% of these Mexican-born TB patients were reported from Arizona, California, New Mexico, and Texas, the four states in the United States that border Mexico (2). The health of immigrant populations in the United States, and of the Mexican-born population in particular, is of increasing importance, as 31.1 million people in the United States are foreign-born and almost one-third of them (9.2 million) are of Mexican origin, the largest subgroup (14).

Growing concerns about the TB problem along the United States-Mexico border have led to recent local and federal strategic public health initiatives in both Mexico and the United States, including a mandate for increased TB control efforts (1, 15–21). We sought to describe TB along the United States-Mexico border in order to identify TB risk factors as well as to use the information to facilitate case management and prevention of TB along the United States-Mexico border. Using data for 1993 through 2001 collected by the national TB surveillance system of the United States, we compared TB cases among three groups: (1) the Mexican-born population in the four United States border states, (2) persons in those four border states who were born in the United States, and (3) Mexican-born persons residing in the 46 other states of the United States, which do not border Mexico.

² Velázquez Monroy O. Epidemiological situation of tuberculosis in Mexico. Presentation made at United States-Mexico Binational Tuberculosis Workshop, 14–16 October 2001, El Paso, Texas, United States.

METHODS

The national TB surveillance system of the United States uses a standardized case report form to collect information on newly diagnosed persons with TB from the 50 states and the District of Columbia (i.e., Washington, D.C.) (22). Completed for each reported TB case, the form contains demographic, clinical, laboratory, and sociodemographic information, including country of origin, date of arrival in the United States, human immunodeficiency virus (HIV) seropositivity status, and anti-TB drug resistance. In the state of California, instead of reporting HIV test results, TB and acquired immunodeficiency syndrome (AIDS) registries are compared annually, and TB patients found on the AIDS registry are reported as testing positive for HIV infection; all other California TB cases are classified as having an unknown HIV status for the purpose of data analysis. For our study we analyzed national TB surveillance data collected in the United States from 1993 through 2001.

We used the United States Census Bureau definition of a native or a person born in the United States and also the Bureau's definition of foreign-born status (23). Persons were classified as a native or as born in the United States if: (1) they were born in one of the 50 states, the District of Columbia, or a United States territory, "island area," or "outlying area" (e.g., Puerto Rico, Guam) or (2) they were born outside the United States to at least one parent who was a United States citizen. All other persons were classified as foreign-born.

In order to evaluate TB among Mexican-born persons and along the United States-Mexico border, we compared Mexican-born persons in the four United States border states (Arizona, California, New Mexico, and Texas) to Mexican-born persons in the 46 nonborder states in the United States and to persons who had been born in the United States and were residing in the four United States border states. We used data for 1993 through

2001 that had been collected by the national TB surveillance system of the United States. Non-Mexican foreign-born TB patients from the four United States border states ("other foreign-born border") were compared to Mexican-born TB patients for specific variables (e.g., years spent in United States prior to TB diagnosis).

The Centers for Disease Control and Prevention (CDC) National TB Surveillance System is an approved data collection system and has been determined by the Associate Director of Science, CDC, National Center for HIV, STD and TB Prevention as not constituting research. Therefore, specific institutional review board approval was not needed for this study. The CDC National TB Surveillance System is considered routine disease surveillance and does not constitute human or animal subjects research.

Analysis

Population data used to calculate rates were obtained from the United States Census Bureau, Census 2000 (24). Population data from the Census 2000 for persons born in the United States were calculated by subtracting foreign-born population data from total population data. For our univariate analysis, we calculated relative risks (RRs), 95% confidence intervals (CIs), and two-tailed *P* values using a Mantel-Haenszel chi-square (χ^2) test for dichotomous variables. Unknown values were excluded when calculating the relative risk and odds ratio, except for HIV status. Multivariate logistic regression was used to determine factors associated with multidrug resistance (i.e., resistance to at least isoniazid and rifampin) and resistance to isoniazid among pulmonary TB patients 18 to 64 years of age. Potential covariates for the logistic regression models included those with *P* < 0.20 in univariate analysis, known confounders, and those considered to be epidemiologically relevant. Epidemiologically plausible interactions were tested; none was significant. The corre-

lation coefficients for all variables introduced into the model were less than 0.5. The SAS 8.2 (25), Epi Info 6.04d (26), and Stata 7.0 (27) software programs were used for analysis; a result was determined to be statistically significant if *P* < 0.05.

RESULTS

From 1993 through 2001 a total of 181 111 new TB cases were reported in the United States, of which 69 232 (38.2%) were among foreign-born persons. The proportion of TB cases among foreign-born persons significantly increased over that time period, from 29.5% (7 399/25 109) in 1993 to 49.2% (7 865/15 989) in 2001 (χ^2 for trend, *P* < 0.001). The country contributing the largest number of foreign-born TB cases was Mexico, with 1 874 (25.3%) of the 7 399 cases reported in 1993 and 1 845 (23.5%) of the 7 865 cases reported in 2001. The majority of Mexican-born TB patients were consistently reported by the four border states (Arizona, California, New Mexico, and Texas); those four states reported 76.7% (12 450/16 223) of the total Mexican-born TB patients from 1993 through 2001, and they reported 68.8% (1 269/1 845) in 2001. In 2001 seven states in the United States reported 50 or more Mexican-born TB cases and together comprised greater than 80% of the national total of Mexican-born TB cases: California (791 cases), Texas (388 cases), Arizona (82 cases), Illinois (75 cases), Florida (62 cases), North Carolina (58 cases), and New York (51 cases). In 2001, Mexican-born TB patients represented approximately one-quarter of the total number of reported cases in the states of Arizona (28.4%), Colorado (25.4%), California (23.7%), Texas (23.6%), and Oregon (20.3%).

TB case rates were many times higher among Mexican-born persons than among persons born in the United States, especially in United States counties along the border (i.e., counties in the United States that are contiguous to the United States-Mexico border)

TABLE 1. Mexican-born and U.S.-born tuberculosis (TB) cases and TB case rates by area, United States (U.S.), 2001

Area	Mexican-born TB cases		U.S.-born TB cases	
	No.	Rate ^a	No.	Rate ^a
Arizona				
State	82	18.8	152	3.4
4 border counties ^b	28	23.2	34	3.4
California				
State	791	20.1	840	3.3
2 border counties ^b	131	39.0	112	4.8
New Mexico				
State	8	7.5	42	2.5
3 border counties ^b	2	5.7	4	2.4
Texas				
State	388	20.6	934	5.2
14 border counties ^b	142	27.3	106	7.5
Total border states (4 states)	1 269	20.0	1 968	4.0
Total border counties ^b (23 counties)	303	30.0	256	5.2
Total nonborder states (46 states)	576	20.4	5 877	2.9
U.S. national	1 845	20.1	7 845	3.1

^a Rate = TB cases per 100 000 population; 2001 TB case rate calculated using 2000 Census (Summary File 3), United States Census Bureau (24).

^b Border counties = counties in the United States that are contiguous to the United States-Mexico border.

(Table 1). In 2001 in the four border states together, TB case rates for Mexican-born persons were 5.0 times as high as the rates for persons born in the United States; in the 23 counties on the border with Mexico, that ratio was 5.8. In that same year the TB case rate among Mexican-born persons was similar for the four border states (20.0 per 100 000 population) and the 46 nonborder states (20.4 per 100 000 population). Also in 2001, among TB cases in California and Texas in persons who had been born in the United States, case rates were higher among persons living in the border counties than they were for the state overall.

From 1993 through 2001, among both the United States-born and Mexican-born cases, the age group contributing the largest proportion to the TB burden were persons 25 to 44 years old. However, among pediatric TB patients (i.e., < 15 years old), the proportion of United States-born border-state patients was around twice that of both Mexican-born border-state patients (RR = 1.8; 95% CI, 1.7–1.9) and Mexican-born nonborder-state patients

(RR = 2.0; 95% CI 1.8–2.3) (Table 2). Pulmonary TB was found in greater than 80% of TB cases (Mexican-born border: 83.7%; United States-born border: 84.3%; Mexican-born nonborder: 80.6%). Among adult pulmonary TB patients (i.e., ≥ 15 years old), positive sputum smears for acid-fast bacilli were more frequently reported for Mexican-born TB patients (border: 52.0%; nonborder: 56.2%) than for United States-born border TB patients (46.0%). However, the proportion of positive sputum cultures for *Mycobacterium tuberculosis* was similar for Mexican-born TB patients (border: 77.1%; nonborder: 77.8%) and United States-born border patients (74.4%). Among pulmonary TB cases, more than 92% of chest radiographs were abnormal for all comparison groups. However, among persons with an abnormal chest radiograph, the proportion of Mexican-born patients with cavitary disease (border: 29.4%; nonborder: 32.4%) was significantly higher than that of United States-born border patients (25.5%) (χ^2 , $P < 0.001$ for both comparisons). HIV test results were

not available for a large proportion of TB patients 25 to 44 years of age, especially along the border (Table 2). However, United States-born border TB patients were more than twice as likely to be coinfecting with HIV as Mexican-born TB patients; this was true both for Mexican-born TB patients in the border states (RR = 2.1; 95% CI, 2.0–2.3) and for those in the nonborder states (RR = 2.8; 95% CI, 2.4–3.2). Adult Mexican-born border TB patients had resided in the United States for a longer period of time before TB was diagnosed (median: 10.0 years; diagnosed within 5 years: 29.9%; diagnosed after 5 years: 59.6%; unknown: 10.5%) than either Mexican-born nonborder patients (median: 4.0 years; diagnosed within 5 years: 47.3%; diagnosed after 5 years: 37.4%; unknown: 15.3%) or border TB patients born in countries other than Mexico (median: 6.6 years; diagnosed within 5 years: 39.6%; diagnosed after 5 years: 52.8%; unknown: 7.6%).

Among persons aged 18 to 64 years the proportions of TB cases in United States-born border residents who were in a correctional facility (e.g., jail, prison) at diagnosis (12.4%); had used injecting drugs (7.9%), noninjecting drugs (14.4%), or excess alcohol (24.9%) within the past year; or were homeless (16.0%) within the past year were significantly greater than in Mexican-born border TB patients (7.3%, 2.7%, 6.4%, 16.1%, and 6.6%, respectively); the same was true for Mexican-born nonborder TB patients (3.5%, 1.0%, 3.0%, 12.2%, and 6.4%, respectively) (Table 3) (χ^2 , $P < 0.001$ for all comparisons). Except for a history of homelessness, Mexican-born border TB patients reported those five risk factors more frequently than did Mexican-born nonborder TB patients (χ^2 , $P < 0.001$ for all comparisons). United States-born border TB patients reported being unemployed during the two years prior to TB diagnosis more frequently (50.5%) than did Mexican-born border TB patients (37.5%) and Mexican-born nonborder TB patients (21.1%) (χ^2 , $P < 0.001$ for both comparisons).

Higher drug-resistance rates were noted among isolates from *Mycobac-*

TABLE 2. Basic characteristics among tuberculosis (TB) cases for the three comparison groups, United States (U.S.), 1993–2001

Characteristic	Mexican-born border ^a		U.S.-born border ^b		Mexican-born nonborder ^c	
	No.	%	No.	%	No.	%
Gender	12 450	100.0	25 508	100.0	3 773	100.0
Male	8 083	64.9	17 194	67.4	2 599	68.9
Female	4 367	35.1	8 305	32.6	1 174	31.1
Unknown	0	0.0	9	< 0.1	0	0.0
Age (years)	12 450	100.0	25 508	100.0	3 773	100.0
< 15	868	7.0	3 218	12.6	240	6.4
15–24	1 821	14.6	1 540	6.0	901	23.9
25–44	4 911	39.4	8 572	33.6	1 734	46.0
45–64	2 863	23.0	7 152	28.0	639	16.9
65+	1 985	15.9	5 024	19.7	259	6.9
Unknown	2	< 0.1	2	< 0.1	0	0.0
Site of disease	12 450	100.0	25 508	100.0	3 773	100.0
Pulmonary only	9 414	75.6	19 423	76.1	2 754	73.0
Extrapulmonary only	2 021	16.2	3 991	15.6	733	19.4
Pulmonary and extrapulmonary	1 011	8.1	2 081	8.2	285	7.6
Unknown	4	< 0.1	13	0.1	1	< 0.1
Sputum smear for acid fast bacilli ^d (adults ^e)	9 766	100.0	19 055	100.0	2 855	100.0
Positive	5 076	52.0	8 759	46.0	1 605	56.2
Negative	3 980	40.8	7 645	40.1	1 070	37.5
Unknown ^f	710	7.3	2 651	13.9	180	6.3
Sputum culture ^d (adults ^e)	9 766	100.0	19 055	100.0	2 855	100.0
<i>Mycobacterium tuberculosis</i> -positive	7 526	77.1	14 174	74.4	2 221	77.8
<i>Mycobacterium tuberculosis</i> -negative	1 524	15.6	2 486	13.0	441	15.5
Unknown ^f	716	7.3	2 395	12.6	193	6.8
Chest radiograph ^d	10 425	100.0	21 504	100.0	3 039	100.0
Normal	212	2.0	662	3.1	95	3.1
Abnormal	9 994	95.9	19 813	92.1	2 910	95.8
Cavitary ^g	2 938	29.4	5 048	25.5	944	32.4
Unknown ^f	219	2.1	1 029	4.8	34	1.1
Tuberculin skin test (TST)	12 450	100.0	25 508	100.0	3 773	100.0
Positive	8 339	67.0	14 276	56.0	2 615	69.3
Negative	1 525	12.3	3 893	15.3	392	10.4
Unknown ^f	2 586	20.8	7 339	28.8	766	20.3
HIV status among TB patients aged 25–44 yrs old ^h	4 411	100.0	8 036	100.0	1 461	100.0
Positive	648	14.7	2 504	31.2	165	11.3
Negative	561	12.7	1 287	16.0	740	50.7
Unknown ^f	3 202	72.6	4 245	52.8	556	38.1
Reason therapy was stopped ^{i,j}	9 655	100.0	20 597	100.0	2 589	100.0
Completed therapy	7 849	81.3	16 500	80.1	2 043	78.9
Did not complete therapy						
Moved	754	7.8	686	3.3	265	10.2
Lost	353	3.7	768	3.7	149	5.8
Died	584	6.0	2 335	11.4	85	3.3
Other/Unknown	115	1.2	308	1.5	47	1.8

^a Mexican-born border = TB cases among Mexican-born persons from the 4 U.S. border states (Arizona, California, New Mexico, Texas).

^b U.S.-born border = TB cases among U.S.-born persons from the 4 U.S. border states (Arizona, California, New Mexico, Texas).

^c Mexican-born nonborder = TB cases among Mexican-born persons from the 46 states in the United States that are not on the border with Mexico.

^d Includes only persons with pulmonary TB.

^e Adult is defined as a person aged ≥ 15 years.

^f Unknown includes "Not done" and "Unknown."

^g Percentage is among those with an abnormal chest radiograph.

^h Includes only TB cases reported between 1993 and 2000.

ⁱ Includes only TB cases reported between 1993 and 1999.

^j Includes only persons with TB who were alive at diagnosis and placed on one or more anti-TB drugs initially.

TABLE 3. Sociodemographic characteristics^a among tuberculosis (TB) cases aged 18 to 64 years for the three comparison groups, United States (U.S.), 1993–2001

Characteristic	Mexican-born border ^c		U.S.-born border ^b		Mexican-born nonborder ^d		U.S.-born border ^b		MX-born border ^c
	No.	%	No.	%	No.	%	MX-b b ^{c,e}	MX-b nb ^{d,f}	MX-b nb ^{d,g}
							RR ^h (95% CI) ⁱ	RR ^h (95% CI) ⁱ	RR ^h (95% CI) ⁱ
Total	9 365	100.0	16 934	100.0	3 185	100.0			
At TB diagnosis									
Correctional facility									
Yes	680	7.3	2 097	12.4	112	3.5	1.7	3.5	2.1
No	8 664	92.5	14 786	87.3	3 040	95.5	(1.6, 1.9)	(2.9, 4.2)	(1.7, 2.5)
Unknown	21	0.2	51	0.3	33	1.0			
Within past year of TB diagnosis									
Homeless									
Yes	621	6.6	2 709	16.0	203	6.4	2.4	2.4	1.0
No	8 249	88.1	13 645	80.6	2 753	86.4	(2.2, 2.6)	(2.1, 2.8)	(0.9, 1.2)
Unknown	495	5.3	580	3.4	229	7.2			
Injecting drug use									
Yes	256	2.7	1 338	7.9	33	1.0	2.9	7.4	2.5
No	8 008	85.5	13 369	79.0	2 663	83.6	(2.6, 3.4)	(5.3, 10.5)	(1.8, 3.6)
Unknown	1 101	11.8	2 227	13.1	489	15.4			
Noninjecting drug use									
Yes	599	6.4	2 440	14.4	97	3.0	2.3	4.5	2.0
No	7 583	81.0	12 293	72.6	2 547	80.0	(2.1, 2.5)	(3.7, 5.5)	(1.6, 2.5)
Unknown	1 183	12.6	2 201	13.0	541	17.0			
Excess alcohol use									
Yes	1 506	16.1	4 218	24.9	389	12.2	1.5	1.9	1.3
No	6 764	72.2	10 860	64.1	2 296	72.1	(1.5, 1.6)	(1.8, 2.1)	(1.1, 1.4)
Unknown	1 095	11.7	1 856	11.0	500	15.7			
Occupation within past 2 years of TB diagnosis ^j									
Not employed	3 516	37.5	8 556	50.5	673	21.1	1.4	2.6	1.8
Health care worker	84	0.9	481	2.8	16	0.5	(1.4, 1.5)	(2.4, 2.7)	(1.7, 1.9)
Correctional employee	1	<0.1	61	0.4	0	0.0			
Migratory/agriculture	680	7.3	84	0.5	489	15.4			
Other	3 817	40.8	4 816	28.4	1 619	50.8			
Multiple occupations	11	0.1	11	0.1	15	0.5			
Unknown	1 256	13.4	2 925	17.3	373	11.7			

^a Characteristics among TB cases determined using a combination of self-report and medical documentation (22).

^b U.S.-born border = TB cases among U.S.-born persons from the four U.S. border states (Arizona, California, New Mexico, Texas).

^c Mexican-born border (MX-born border, MX-b b) = TB cases among Mexican-born persons from the 4 U.S. border states (Arizona, California, New Mexico, Texas).

^d Mexican-born nonborder (MX-b nb) = TB cases among Mexican-born persons from the 46 U.S. states not on the border with Mexico.

^e Comparison is U.S.-born border to Mexican-born border.

^f Comparison is U.S.-born border to Mexican-born nonborder.

^g Comparison is Mexican-born border to Mexican-born nonborder.

^h RR = relative risk.

ⁱ 95% CI = 95% confidence interval.

^j For Occupation relative risk, "Not employed for 2 years" is compared to the other five occupation responses, excluding "Unknown."

terium tuberculosis culture-positive Mexican-born border and nonborder TB patients as compared to United States-born border TB patients (Table 4). This was especially true among patients with a prior history of TB disease. Among patients without a prior history of TB, 16.7% of Mexican-born

border, 15.9% of Mexican-born nonborder, and 9.4% of United States-born border TB patients had isolates resistant to at least one first-line drug (i.e., isoniazid, rifampin, ethambutol, pyrazinamide, streptomycin). In addition, there were significantly increased rates among persons with a prior his-

tory of TB. Within each border state in the United States, 13.6%–22.8% of TB cases caused by organisms resistant to at least one first-line drug were reported from a border county.

Drug resistance also varied by the number of years a TB patient had resided in the United States (Table 5).

TABLE 4. Drug resistance among culture-positive tuberculosis (TB) cases for the three comparison groups, United States (U.S.), 1993–2001

Culture-positive TB cases	MX-born border ^a				U.S.-born border ^b				MX-born nonborder ^c			
	No prior TB		Prior TB ^d		No prior TB		Prior TB ^d		No prior TB		Prior TB ^d	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total ^e	8 569	100	398	100	17 243	100	965	100	2 594	100	100	100
Isoniazid resistance ^{e,f}	736	8.6	92	23.1	728	4.2	69	7.2	225	8.7	21	21
Multidrug resistance (MDR) ^{e,g}	114	1.3	46	11.6	83	0.5	20	2.1	43	1.7	14	14
Total ^h	8 647	100	404	100	17 450	100	976	100	2 605	100	103	100
Any first-line drug resistance ^{h,i}	1 444	16.7	120	29.7	1 631	9.4	115	11.8	415	15.9	27	26.2

^a Mexican-born border (MX-born border) = TB cases among Mexican-born persons from the four U.S. border states (Arizona, California, New Mexico, Texas).

^b U.S.-born border = TB cases among U.S.-born persons from the four U.S. border states (Arizona, California, New Mexico, Texas).

^c Mexican-born nonborder (MX-born nonborder) = TB cases among Mexican-born persons from the 46 U.S. states not on the border with Mexico.

^d Prior TB: a person with TB was considered to have had a prior episode of TB if TB was verified in the past and the person completed therapy or was lost to supervision for more than 12 consecutive months.

^e Culture-positive for *Mycobacterium tuberculosis* with initial susceptibility testing done for isoniazid and rifampin.

^f Isoniazid resistance = resistance to at least isoniazid.

^g Multidrug resistance (MDR) = resistance to at least isoniazid and rifampin.

^h Culture-positive for *Mycobacterium tuberculosis* with initial susceptibility testing done for isoniazid, rifampin, ethambutol, pyrazinamide, or streptomycin.

ⁱ Any first-line drug resistance = resistance to at least isoniazid, rifampin, ethambutol, pyrazinamide, or streptomycin.

Isoniazid (INH) resistance among Mexican-born border TB patients was more frequently seen within the first year of arrival to the United States than was true for either Mexican-born nonborder TB patients or other foreign-born TB patients from the border states. Multidrug resistance (MDR) was more often diagnosed within the first year of arrival for all comparison groups.

Multivariate analysis revealed that among pulmonary TB patients 18 to 64 years of age, Mexican-born border TB patients were 3.6 times as likely to

have MDR TB as were United States-born border TB patients (Table 6). Those patients with at least one prior episode of TB were approximately 8 times as likely to have MDR TB as were those experiencing their first episode of TB. Other significant positive associations with MDR TB included the presence of cavitory and smear-positive disease at diagnosis. Reported excess alcohol use in the past year was negatively associated with MDR TB.

Analysis of risk factors for resistance to INH revealed that Mexican-born

border TB patients were approximately two times as likely to have INH resistance as were United States-born border patients (Table 7). Those who had had a previous episode of TB were also about two times as likely to have INH-resistant disease. In contrast to MDR TB, significant positive risk factors for INH-resistant TB included being a correctional facility employee within the past two years, and residing (as an inmate) in a correctional facility at the time of diagnosis. Similar to MDR TB, the presence either of smear positivity or of cavitory disease at diagnosis was

TABLE 5. Primary drug resistance by years of residence in the United States among adult culture-positive tuberculosis (TB) cases^a for the three comparison groups, United States (U.S.), 1993–2001

Years in U.S. prior to TB diagnosis ^f	Mexican-born border ^b					Other-FB border ^c					Mexican-born nonborder ^d				
	No.	Resistance		Resistance		No.	Resistance		Resistance		No.	Resistance		Resistance	
		Isoniazid	MDR ^e	Isoniazid	MDR ^e		Isoniazid	MDR ^e	Isoniazid	MDR ^e					
< 1	1 129	128	11.3	38	3.4	2 474	358	14.5	59	2.4	518	45	8.7	13	2.5
1 to 4	1 398	122	8.7	23	1.6	2 688	416	15.5	53	2.0	699	50	7.2	7	1.0
5+	5 013	406	8.1	41	0.8	7 564	811	10.7	64	0.8	978	96	9.8	13	1.3
Unknown	934	71	7.6	12	1.3	1 107	89	8	11	1.0	364	29	8.0	8	2.2

^a Includes adult (i.e., ≥ 15 years) TB cases, without a prior history of TB, who were culture-positive for *Mycobacterium tuberculosis* with initial susceptibility testing done for isoniazid and rifampin.

^b Mexican-born border = TB cases among Mexican-born persons from the four U.S. border states (Arizona, California, New Mexico, Texas).

^c Other foreign-born border (Other-FB border) includes only foreign-born (FB) persons with TB who were born in countries other than Mexico and reported from the four U.S. border states (Arizona, California, New Mexico, Texas).

^d Mexican-born nonborder = TB cases among Mexican-born persons from the 46 U.S. states not on the border with Mexico.

^e Multidrug resistance (MDR) = resistance to at least isoniazid and rifampin.

^f Years in U.S. prior to TB diagnosis = number of years a TB case resided in the U.S. prior to TB diagnosis.

TABLE 6. Multivariate analysis of risk factors for multidrug resistance among 17 936 Mexican-born and United States-born pulmonary tuberculosis (TB) patients in the four United States border states^a, 1993–2001

Risk factor	No.	% ^b	Odds ratio	95% CI ^c
Mexican-born	6 222	34.7	3.6	2.6–5.1
History of previous TB disease	902	5.0	8.2	5.7–11.7
Male	13 209	73.7	0.96	0.68–1.4
Age (years)				
18–24	1 902	10.6	1.3	0.81–2.0
25–44	9 140	51.0	0.96	0.68–1.4
45–64	6 894	38.4	Ref	—
Excess alcohol use within past year ^d	4 499	28.1	0.58	0.38–0.88
Cavitary disease at diagnosis ^e	5 639	37.7	1.9	1.4–2.7
Sputum smear-positive for AFB at diagnosis ^f	10 522	63.8	1.5	1.0–2.2

^a Includes only persons 18–64 years old, with pulmonary TB, confirmed culture-positive for *Mycobacterium tuberculosis*, with initial susceptibility testing done for isoniazid and rifampin, and for whom country of birth and previous TB status were known. Multidrug resistance is defined as resistance to at least isoniazid and rifampin.

^b Percents reflect exclusion of unknowns.

^c 95% CI = 95% confidence interval.

^d Determined using a combination of self-report and medical documentation (22).

^e Cavitary disease at diagnosis = cavitary disease on initial chest radiograph.

^f AFB = acid fast bacilli.

TABLE 7. Multivariate analysis of risk factors for isoniazid resistance among 17 936 Mexican-born and United States-born pulmonary tuberculosis (TB) patients in the four United States border states^a, 1993–2001

Risk factor	No.	% ^b	Odds ratio	95% CI ^c
Mexican-born	6 222	34.7	2.2	1.9–2.5
History of previous TB disease	902	5.0	2.2	1.7–2.9
Male	13 209	73.7	0.96	0.81–1.1
Age (years)				
18–24	1 902	10.6	1.1	0.85–1.4
25–44	9 140	51.0	1.2	0.99–1.4
45–64	6 894	38.4	Ref	—
Homeless within past year ^d	2 582	14.9	0.71	0.56–0.90
In correctional facility at diagnosis ^d	1 997	11.2	1.3	1.0–1.6
Cavitary disease at diagnosis ^e	5 639	37.7	1.2	1.0–1.4
Sputum smear-positive for AFB at diagnosis ^f	10 522	63.8	1.3	1.1–1.5
Occupation ^g				
Unemployed	8 381	54.8	0.85	0.73–0.99
Health care worker	360	2.4	0.86	0.48–1.5
Correctional facility	32	0.21	3.6	1.2–10.7
Migratory agricultural worker	534	3.5	1.2	0.92–1.7
Multiple occupations	15	0.10	0.93	0.12–7.4
Other occupations combined	5 970	39.0	Ref	—

^a Includes only persons 18–64 years old, with pulmonary TB, confirmed culture-positive for *Mycobacterium tuberculosis*, with initial susceptibility testing done for isoniazid and rifampin, and for whom country of birth and previous TB status were known.

^b Percents reflect exclusion of unknowns.

^c 95% CI = 95% confidence interval.

^d Determined using a combination of self-report and medical documentation (22).

^e Cavitary disease at diagnosis = cavitary disease on initial chest radiograph.

^f AFB = acid fast bacilli.

^g Occupation = occupation in the two years prior to TB diagnosis.

positively associated with INH-resistant TB. Having been either unemployed within the past two years or homeless within the past year was negatively associated with INH-resistant TB.

A similar analysis among just Mexican-born pulmonary TB patients and their geographic location within the United States (i.e., border state vs. non-border state) revealed that geographic location was not an independent risk factor for MDR or INH-resistant TB. However, among Mexican-born TB patients, being unemployed in the two years prior to diagnosis (odds ratio (OR) = 1.9; 95% CI, 1.3–2.7) and reported excess alcohol use in the past year (OR = 0.45; 95% CI, 0.27–0.76) were associated (positively and negatively, respectively) with MDR TB, controlling for geographic location, history of previous TB, age, sex, and cavitary disease. Further, being HIV-positive was significantly negatively associated with INH resistance (OR = 0.52; 95% CI, 0.35–0.75), controlling for geographic location, history of previous TB, age, sex, cavitary disease, and smear-positivity.

In 1999 the proportion of Mexican-born border TB patients (84.0%) who received at least some anti-TB treatment using directly observed therapy (DOT) was slightly greater than for Mexican-born nonborder patients (83.2%) and for United States-born patients (79.7%). In 1999, completion of therapy was similar for all comparison groups (United States-born border: 85.6%; Mexican-born border: 84.4%; Mexican-born nonborder: 84.1%). From 1993 through 1999, the most commonly reported reasons for stopping therapy, other than completing therapy, included moving, being lost to follow-up, and having died (any cause). Mexican-born TB patients were significantly more likely to have moved or be lost to follow-up as a final outcome than were United States-born border-state TB patients (Table 2). This was true both for Mexican-born TB patients in the border states (RR = 1.6; 95% CI, 1.5–1.8) and ones in the nonborder states (RR = 2.3; 95% CI, 2.1–2.5). More United States-born TB

border-state patients died (any cause) during therapy (11.3%) than did Mexican-born TB patients, in both the border states (6.1% died) and the nonborder states (3.3% died). In all three of those comparison groups, between one-quarter and one-third of the TB patients who died (any cause) before completing therapy were HIV-infected (Mexican-born border: 26.9%; Mexican-born nonborder: 28.2%; United States-born border: 32.1%).

DISCUSSION

To our knowledge, this is the first published analysis that uses data collected at the national level in the United States to make comparisons among Mexican-born border-state TB patients, United States-born border-state TB patients, and Mexican-born nonborder-state TB patients. The importance of this description can be highlighted by the fact that Mexico contributes the largest number and the largest proportion of foreign-born TB patients towards the total annual TB morbidity in the United States. Further, the four states in the United States that border Mexico account for the majority of the TB cases in Mexican-born persons in the United States. The overall TB case rate for Mexican-born persons in these four border states was five times as great as the rate for United States-born persons in these states. Importantly, the case rates for Mexican-born TB patients in the 46 nonborder states were also elevated compared to United States-born rates from the four border states and were also very similar to rates for Mexican-born patients reported from the border states. That was true even though there were fewer Mexican-born nonborder TB cases than there were Mexican-born border and United States-born border cases. Interestingly, among United States-born TB cases in California and Texas, case rates were elevated among persons living in the border counties as compared to the overall state TB case rate. These higher case rates may reflect risk associated with family immi-

gration patterns or travel history (28), or they may also reflect ongoing TB transmission along the border.

Among adult pulmonary TB cases, those in Mexican-born persons more frequently were sputum smear-positive and had evidence of cavitory disease on chest radiograph than was true for United States-born TB patients. This finding may indicate more extensive disease progression prior to TB diagnosis among Mexican-born TB patients. The reasons for this finding are unclear, but they may be related to more limited access to care or to a delay in seeking or obtaining care (29). These factors may prolong infectiousness and contribute to ongoing transmission within the community. Timely access to care is important for interrupting the transmission chain in this population. Unique to Mexican-born border-state TB patients was the longer amount of time spent in the United States prior to TB diagnosis (e.g., at least five years) compared to Mexican-born nonborder-state patients and to border-state TB patients who had been born in countries other than Mexico. This longer period before diagnosis may be related to residing longer in the United States and/or an increased opportunity for frequent border crossings between the United States and country of birth for persons living along the United States-Mexico border.

Specific risk factors, such as drug and alcohol use, incarceration, and unemployment, were less likely to be reported in Mexican-born TB patients than in United States-born patients. The most important risk factor for the Mexican-born TB patients appears to be birth in a country with a relatively high incidence of TB. HIV coinfection was more commonly reported among United States-born border-state TB patients than among Mexican-born TB patients. However, our analysis also revealed that HIV test results are not reported to the national TB surveillance system for a large proportion of TB patients despite the recommendation that all TB cases receive HIV counseling and testing (30). Possible expla-

nations for this deficient reporting include health providers not performing HIV counseling and testing or not reporting the HIV test results, as well as the existence of local confidentiality directives that restrict the reporting of HIV test results. To properly identify TB-HIV coinfecting patients and ensure appropriate therapy, all TB patients, independent of age or HIV risk factors, should receive HIV counseling and testing once TB disease is diagnosed (31).

Mexican-born TB patients were almost four times as likely to have MDR TB and twice as likely to have INH resistance as their United States-born counterparts, even after controlling for a previous history of TB. Among Mexican-born TB patients, location with respect to the United States-Mexico border was not a risk factor for either MDR TB or INH resistance. Therefore, the finding of drug resistance among Mexican-born TB patients who have recently arrived in the United States may reflect transmission of drug-resistant TB in Mexico prior to arrival. In a continued effort to address TB drug resistance, especially MDR TB, the Mexican National TB Program (*Programa de Acción Tuberculosis*) plans to conduct a national drug resistance survey to determine the current prevalence of drug resistance and to initiate a DOTS-Plus project with drugs purchased through the Green Light Committee of the World Health Organization (32, 33). Currently, partial assistance for drug-resistant TB patients is provided through binational TB projects located along the United States-Mexico border. A priority for these binational projects has been the identification and case management of patients with MDR TB by providing second-line anti-TB drugs, laboratory support (e.g., drug susceptibility testing), and outreach workers to ensure treatment adherence and to conduct contact investigations. Management of drug resistance in all of Mexico and in the United States along its border with Mexico is crucial for preventing the transmission of drug-resistant TB in the United States.

Currently, the national TB surveillance system in the United States does not collect information on binational status (34), immigration status, or, for pediatric TB patients, their travel history or the country of birth of their parents/guardians. To better capture this information, a workgroup of local, state, and national TB surveillance experts from the United States has proposed a revision of the case report, which is expected to be implemented in 2006 or later. The proposed changes to the national TB surveillance system in the United States would allow counties and states to more easily collect data on TB patients who are not officially counted in the annual morbidity totals for the country. In the United States, many border counties and states now provide care for TB patients that they cannot count towards their annual morbidity totals because these cases were or should have been counted elsewhere (e.g., Mexico) (2). These “uncounted” patients often receive extensive care in the United States, thus placing the burden for treatment, care, and contact investigations on local TB control programs. Proposed changes to the national TB surveillance system in the United States would enhance characterization of such TB patients as well as permit measurement of the burden, thus allowing local TB control programs to substantiate the need for additional funding and resources.

Despite the recent success against TB in the United States, control of TB along the United States-Mexico border remains challenging. During the study period, Mexican-born TB patients were almost twice as likely to have moved during therapy or to be lost to follow-up as were United States-born TB patients. This finding, combined with the fact that the population on both sides of the United States-Mexico border is highly mobile, has attracted the attention of the federal Governments of both Mexico and the United States and has resulted in an innovative new binational initiative, the U.S.-Mexico Binational TB Referral and Case Management Project. That proj-

ect tracks and manages binational patients with active TB disease who cross the United States-Mexico border.³ The project’s main objectives are to ensure continuity of care and treatment completion, thus preventing further TB transmission and the emergence of drug resistance. This project, which is the product of a collaboration among the local, state, and federal levels of both Mexico and the United States, is piloting an integrated system that uses a binational health card and a binational referral network in three sites in the United States and ten sites in Mexico. (The binational health card is a wallet-sized card in both English and Spanish that has a unique identification number that links the card to the TB patient and the patient’s TB information in two national databases as well as toll-free telephone contact numbers in the United States and Mexico where a patient or provider can call for necessary information to assure continuity of TB care.) This new project is building upon and integrating the efforts of two well-established programs, CureTB (20) and TBNet (21), and for the first time linking their referral services directly with a similar effort by the Mexican National TB Program. The Bureau of Immigration and Customs Enforcement of the United States, through its detention centers in the cities of El Paso, Texas, and San Diego, California, is also participating in order to facilitate continuity of care for immigration-law violators who are being returned to Mexico. If this binational TB project proves successful and cost-effective, plans include expansion to all TB patients in the United States and Mexico who cross the border. TB control efforts among the Mexican-born population in the United States and Mexico—many of whom in the

United States are undocumented and for whom accessing services is difficult—will need to rely on creative initiatives such as these.

The impact of TB among Mexican-born persons extends far beyond the United States-Mexico border, affecting TB control throughout the United States and Mexico. Binational local and federal public health action is essential for TB control and prevention in this distinctive region, the United States-Mexico border (35). Continued United States-Mexico collaboration and dedication of necessary resources are critical to the identification, successful treatment, and prevention of TB along the border.

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RESUMEN

La tuberculosis en la frontera mexicanoestadounidense

Objetivos. La tuberculosis es un problema de salud pública importante y es una prioridad reconocida por los gobiernos federales de México y Estados Unidos de América. Los objetivos de la presente investigación fueron los siguientes, atendiendo específicamente a los cuatro estados de los Estados Unidos que tienen frontera con México: 1) describir la situación epidemiológica de la tuberculosis, 2) identificar los factores de riesgo de contraer la enfermedad y 3) examinar las estrategias aplicadas en los programas antituberculosos.

Métodos. Analizamos las notificaciones de casos de tuberculosis recogidas entre 1993 y 2001 por el sistema estadounidense para la vigilancia de la tuberculosis. Con esos datos se compararon los casos de tuberculosis detectados en tres grupos principalmente: 1) personas nacidas en México que vivían en uno de los cuatro estados fronterizos de Estados Unidos (Arizona, California, Nuevo México y Texas); 2) residentes de esos cuatro estados que habían nacido en los Estados Unidos, y 3) personas nacidas en México con residencia en cualquiera de los otros 46 estados de Estados Unidos que no tienen frontera con México.

Resultados. Durante el período de 1993 a 2001, 12 450 (76,7%) de los 16 223 casos de tuberculosis en residentes de Estados Unidos nacidos en México se notificaron en Arizona, California, Nuevo México y Texas. En esos cuatro estados en general, la incidencia de tuberculosis en 2001 en personas nacidas en México fue 5,0 veces mayor que en personas nacidas en Estados Unidos. En dichos estados hay 23 condados que tienen frontera con México, y en ellos la razón observada fue de 5,8. Las probabilidades de que se notificaran seropositividad a VIH, abuso de alcohol, desempleo y encarcelamiento fueron menores, en grado significativo, entre pacientes tuberculosos nacidos en México con residencia en los cuatro estados fronterizos y en los otros estados que entre pacientes nacidos en Estados Unidos con residencia en los cuatro estados fronterizos ($P < 0,001$). Según el análisis multifactorial, en pacientes tuberculosos entre las edades de 18 y 64 años que vivían en los cuatro estados fronterizos las probabilidades de tener resistencia por lo menos a la isoniacida y la rifampicina (es decir, multiresistencia medicamentosa) eran 3,6 mayores cuando los pacientes habían nacido en México que cuando habían nacido en Estados Unidos. Asimismo, las probabilidades de tener resistencia a la isoniacida fueron dos veces mayores entre los pacientes nacidos en México que entre los nacidos en Estados Unidos. Los pacientes tuberculosos nacidos en México con residencia en los cuatro estados fronterizos y en los demás estados mostraron mayores probabilidades, en grado significativo, de haberse trasladado de lugar o de haber desaparecido durante el seguimiento que los pacientes tuberculosos nacidos en los Estados Unidos con residencia en los cuatro estados fronterizos ($P < 0,001$).

Conclusiones. Para poder eliminar la tuberculosis de los Estados Unidos, hace falta una mayor colaboración entre los gobiernos federales de este país y de México en lo que respecta a iniciativas para controlar la tuberculosis a lo largo de la frontera que comparten.