HIV–Tuberculosis Coinfection in Southern California: Evaluating Disparities in Disease Burden

Timothy C. Rodwell, MD, PhD, MPH, Richard F.W. Barnes, PhD, Marisa Moore, MD, MPH, Steffanie A. Strathdee, PhD, Annie Raich, MPH, Kathleen S. Moser, MD, and Richard S. Garfein, PhD

Objectives. We sought to understand tuberculosis (TB) and HIV coinfection trends in San Diego County, California, and to identify associations between sociodemographic risk factors and TB and HIV coinfection.

Methods. We analyzed TB surveillance data from 1993 through 2007. TB cases were grouped by HIV status: positive, negative, or unknown. We used Poisson regression to estimate trends and tested associations between TB and HIV coinfection and sociodemographic risk factors with polychotomous logistic regression.

Results. Of 5172 TB cases, 8.8% were also infected with HIV. Incidence of coinfected cases did not change significantly over the period studied, but the proportion of cases among Hispanics increased significantly, whereas cases among non-Hispanic Whites and Blacks decreased. TB cases with HIV coinfection were significantly more likely to be Hispanic, male, injection drugs users, and aged 30 to 49 years, relative to cases with TB disease only.

Conclusions. The burden of TB and HIV in San Diego has shifted to Hispanics in the last decade. To address this health disparity, binational TB and HIV prevention efforts are needed. (*Am J Public Health.* 2010;100:S178–S185. doi:10.2105/AJPH.2009.170142)

HIV is a potent risk factor for tuberculosis (TB) disease. HIV increases the risk of latent TB infection reactivation, the rate of disease progression, and the risk of new infections by an order of magnitude.[1] TB disease also accelerates HIV disease progression, increasing infectivity and reducing HIV treatment efficacy.[2] The synergy of TB and HIV has created a worldwide public health crisis[1,3,4] and has significantly complicated attempts to eliminate TB in both the industrialized and developing worlds.[3]

In the United States, after 3 decades of decreasing TB incidence, there was a resurgence in TB cases in the mid-1980s that was strongly correlated with the HIV/AIDS epidemic.[5,6] Increased federal investment in TB-control programs, improvements in HIV management and prevention, and the introduction of effective antiretroviral treatment were significant factors in the reversal of the epidemic. Since 1993, the incidence of TB and TB–HIV coinfection has continued to decline throughout most of the United States.[7,8]

In San Diego, California, where over 70% of TB cases are concentrated among individuals born outside of the United States,[9] the proportion of TB cases with HIV coinfection has remained largely unchanged in the last decade, despite a decrease in TB incidence.[10] To understand what might be driving TB–HIV dynamics in this region, we examined trends in TB cases with HIV coinfection from 1993 through 2007, as well as sociodemographic risk factors and clinical correlates of TB and HIV coinfection.

METHODS

We conducted a retrospective reconstruction of cohorts analysis of all incident TB cases recorded in San Diego County from 1993 through 2007. Trends in TB–HIV cases were estimated for all of the years studied. Univariate and multivariate analyses to identify risk factors for coinfection were restricted to the years 1999 through 2007.

Data Sources

Routine TB surveillance data from 1993 through 2007 were collected by the County of San Diego Health and Human Services Agency. Data came from the Report of a Verified Case of Tuberculosis database supplemented with locally collected variables and was collected based on national TB surveillance guidelines. All TB cases included in the study met the national surveillance TB case definition (i.e., laboratory or clinical evidence of disease caused by *Mycobacterium tuberculosis* complex).[11] Where culture results were available (79% of cases), TB isolates were further identified as either *Mycobacterium bovis* or *M. tuberculosis* on the basis of culture, morphologic findings, results of the niacin strip test and the nitrate reduction test, and susceptibility to pyrazinamide.[12]

The HIV status of TB cases, not routinely collected as part of the TB surveillance record in California, has been collected as a local variable in San Diego since 1993. From 1993 through 1996, only positive HIV status was captured. All other TB cases were categorized as having "HIV unknown" status. In 1997, collection of HIV-negative results began and TB cases were placed into 3 categories of HIV serostatus: HIV positive, HIV negative, and HIV unknown. TB–HIV unknown included cases that were not offered testing, refused to be tested, and those for whom verification of HIV test results could not be obtained. Population data for San Diego County were obtained from San Diego Association of Governments' estimates.[13]

Demographic variables included gender, age, race/ethnicity, and country of birth. Drug use, alcohol abuse, and homelessness within the year prior to TB diagnosis were coded as "yes," "no," or "unknown." Clinical variables included acid-fast bacilli in sputum smear, previous diagnosis of TB, anatomical site of disease and TB drug susceptibility.

Tuberculosis–HIV Coinfection Trends

We examined trends in race/ethnicity and age of TB–HIV coinfected individuals from

1993 to 2007. We used Poisson regression to analyze TB–HIV coinfection incidence trends, with time in years as the predictor variable, the number of coinfection cases as the dependent variable, and the population size of San Diego County as the offset. We adjusted for overdispersion.[14] We also used Poisson regression for evaluating trends in race/ethnicity of TB–HIV coinfected individuals while accounting for changes in the numbers of each racial/ethnic group. We tested for trends in the proportions of ethnic groups among TB–HIV coinfection cases from 1993 to 2007 with the Cochran–Armitage test.[15] We also used the Cochran–Armitage test to evaluate changes in the proportion of TB–HIV coinfected individuals who were older than 40 years.

Risk Factors

We compared sociodemographic and clinical characteristics of TB–HIV negative, TB–HIV coinfection, and TB–HIV unknown groups from 1999 through 2007. We used the χ^2 test and analysis of variance to compare categorical variables and continuous variables, respectively, and transformed variables with nonhomogenous variance. The median test was used when transformation did not normalize the variable or homogenize the variance. Because the TB–HIV unknown group could have included TB–HIV coinfected individuals, we used polychotomous logistic regression[16] to estimate the sociodemographic factors associated with HIV infection among TB patients. The 3 TB–HIV categories formed the nominal outcome variables, with TB–HIV negative as the reference group. Independent variables were significant ($P<.05$) sociodemographic variables from the univariate analysis. Year of TB diagnosis was added as a centered independent variable to account for possible time trends. We assessed the fit of the model by testing 2 separate logistic regression models[16]: TB–HIV coinfection against TB–HIV negative, and TB–HIV unknown against TB–HIV negative. All analyses were performed using SAS version 9.1 (SAS Institute Inc., Cary, NC).

RESULTS

The annual number of TB cases reported in San Diego County declined from 469 in 1993 to 280 in 2007. When recording of TB and HIV status was initiated in 1997, the number of TB–HIV unknown cases declined rapidly, because reporting of TB–HIV negative cases increased. From 1999 onward, the number of TB–HIV negative and TB–HIV unknown cases stabilized, indicating consistent reporting and testing for HIV.

Tuberculosis–HIV Coinfection Trends

A total of 5172 TB cases were reported from 1993 through 2007. Of these patients, 455 (8.8%) were coinfected with HIV. A total of 1515 (29.3%) were HIV negative, and the HIV status of 3202 TB-infected individuals (61.9%) was unknown. The proportion of TB-infected individuals coinfected with HIV (8.8%) did not change significantly from 1993 through 2007 (Cochran–Armitage test for trend, 2-sided, $z=1.76$; $P=.078$). Incidence of TB–HIV coinfection in the general population of San Diego County decreased from 1.23 cases per 100 000 in 1993 to 0.87 cases per 100 000 in 2007, but the trend was not significant (Table 1).

Non-Hispanic Blacks and Hispanics had the highest incidence of TB–HIV coinfection in 1993 (Table 1). The TB–HIV coinfection incidence among Blacks declined by 65% from 1993 through 2007 ($P=.031$) and TB–HIV coinfection incidence among Whites also decreased significantly (81%) in the same period. There was no significant change in incidence among Hispanics. Asian/Pacific Islanders had the lowest incidence, with no TB–HIV coinfection reported for this group in 8 out of the 15 years analyzed. By 2007, the TB–HIV coinfection incidence rate for Hispanics was almost double that of Blacks and was an order of magnitude greater than the incidence rates for Whites and Asian/Pacific Islanders (Table 1). Additionally, Hispanics, who accounted for only 29% of the population and 31% of the HIV cases in the county, accounted for 52% of the TB cases and 82% of the TB–HIV coinfection cases in 2007 (Table 2).

Among all TB–HIV coinfection cases, the proportion with Hispanic ethnicity increased significantly from 1993 through 2007 (Cochran–Armitage test for trend, 1-sided, $z=-4.88$; $P<.001$). This was not the result of an increased proportion of TB cases in the Hispanic population, because the same test for ethnic proportions in TB–HIV negative and TB–HIV unknown cases for 1993 through 2007 showed no significant trend ($z=-0.81$; $P=.209$, and $z=-1.21$; $P=.113$, respectively).

From 1993 through 2007, the age distribution of TB–HIV coinfected patients shifted, with an increasing proportion of individuals aged at least 40 years at diagnosis (Cochran–Armitage test for trend, 1-sided, $z=-3.45$; $P<.001$).

Univariate Analysis

Sociodemographic correlates. There were 2787 TB cases analyzed from 1999 through 2007, of which 9.4% were HIV positive and 50.8% were HIV negative. The remaining 39.8% were of unknown HIV status (Table 3). Asians/Pacific Islanders contributed more than 30% of the TB–HIV negative and TB–HIV unknown groups (Table 3) but less than 2% of the TB–HIV coinfection group. Whites were evenly distributed among the HIV groups, and Blacks were underrepresented among the

TABLE 1—TB–HIV Coinfection Incidence Estimates From Poisson Regression Models of TB–HIV Coinfection Trends Among Primary Race/Ethnicity Groups: San Diego, CA, 1993–2007

Racial/ethnic group	RR (95% CI)	TB–HIV Coinfection Starting and Ending Incidence Rates, per 100 000		P
		1993	2007	
All	0.98 (0.95, 1.00)	1.23	0.87	.077
Hispanic	0.99 (0.96, 1.02)	3.05	2.75	.625
Non-Hispanic White	0.89 (0.82, 0.96)	0.73	0.14	.002
Non-Hispanic Black	0.93 (0.87, 0.99)	4.35	1.52	.031
Asian/Pacific Islander	0.95 (0.81, 1.13)	0.39	0.20	.574

Note. CI = confidence interval; RR = rate ratio; TB = tuberculosis.

TABLE 2—Proportional Contribution of Ethnic Groups to the General Population Size, TB Cases, HIV Cases, and TB–HIV Coinfection Cases: San Diego County, CA, 1993–1994 and 2006–2007

		% Contribution to Disease Population[bc]		
	% of San Diego County Population[a]	TB	HIV[d,e]	TB–HIV Coinfection
1994				
No.	2 612 340	889		78
Race/ethnicity, %				
American Indian/Alaska Native	NA	<1		1
Asian/Pacific Islander	8	29		3
Non-Hispanic Black	6	11		22
Non-Hispanic White	60	16		27
Hispanic	23	44		47
2007				
No.	3 098 269	595	1 348	55
Race/ethnicity, %				
American Indian/Alaska Native	<1	<1	1	2
Asian/Pacific Islander	10	33	3	2
Non-Hispanic Black	5	7	13	13
Non-Hispanic White	52	7	52	2
Hispanic	29	52	31	82

Note. NA = not available; TB = tuberculosis.
[a]Data were obtained from the San Diego Association of Governments.[13]
[b]Combined 1993-1994 data.
[c]Combined 2006-2007 data.
[d]HIV data were not available for 1993-1994.
[e]Percentages were based on incident HIV cases recorded from 2006 through 2007 by the San Diego County Public Health Department.

TB–HIV unknown group. Hispanics accounted for three quarters of the TB–HIV coinfection group. Patients born in Mexico accounted for 33.6% of all TB cases and 62.6% of TB–HIV coinfection cases. US-born patients accounted for 28.4% of all TB cases and 30.5% of TB–HIV coinfection cases. Other foreign-born persons accounted for 38.0% of all TB cases, but only 6.9% of TB–HIV coinfection cases. Drug use, alcohol abuse, homelessness, and imprisonment were uncommon in the TB–HIV unknown group. However, three quarters of TB–HIV unknown individuals were not employed in the 2 years prior to diagnosis, in contrast to less than half of the other 2 groups. Foreign-born TB–HIV coinfected individuals reported being in the United States for an average of 13.1 years before being diagnosed, which was not significantly different (P=.346) from individuals in the TB–HIV negative group (14.0 years) and TB–HIV unknown group (18.0 years). Approximately 10% (n=19) of the foreign-born TB–HIV coinfected individuals reported being in the United States for less than 90 days before being diagnosed with TB and HIV.

Clinical correlates. The TB–HIV coinfection group was twice as likely to have had a previous diagnosis of TB relative to the TB–HIV negative and TB–HIV unknown groups, but half as likely to have a positive tuberculin skin test result relative to the other 2 groups. Over 20% of the TB disease in the TB–HIV coinfection group was caused by the *M. bovis* compared with 6% in the TB–HIV negative group. The TB–HIV coinfection group also had 4 times the proportion of combined pulmonary and extrapulmonary TB compared with the other 2 groups. The TB–HIV coinfection group had the lowest proportion of cavitary pulmonary lesions (Table 3).

Only 2.1% of culture-confirmed TB cases analyzed from 1999 through 2007 were multidrug-resistant TB cases (i.e., resistant to isoniazid and rifampin), and there was no significant difference between the HIV groups with respect to multidrug-resistant TB. The proportion of TB–HIV coinfection cases with monoresistance to rifampin, isoniazid, or ethambutol was not significantly different from the HIV negative and HIV unknown groups, but the prevalence of pyrazinamide resistance in TB–HIV coinfection cases (24.1%) was triple that in the other 2 groups (Table 3).

The median number of treatment days for TB–HIV coinfection cases was 78 days longer than for TB–HIV negative cases, and the proportion of TB–HIV coinfected individuals who died before TB treatment was completed (13.3%) was over 3 times greater than for those with no known HIV coinfection (3.6%). The mean length of treatment of TB–HIV unknown cases was similar to that for TB–HIV negative, but a significantly higher proportion of TB–HIV unknown individuals (11.6%) died before TB treatment was completed relative to the TB–HIV negative group.

Multivariate Risk Factor Analysis

After adjusting for the other variables in the polychotomous logistic model (Table 4), a TB–HIV coinfected patient was more likely to be male (adjusted odds ratio [AOR]=2.86; 95% confidence interval [CI]=1.97, 4.14) and aged 30 to 39 years (AOR=3.23; 95% CI=2.11, 4.95) compared with patients infected only with TB. TB–HIV coinfected individuals were almost 4 times (AOR=3.90; 95% CI=2.79, 5.45) as likely to be Hispanic compared with TB–HIV negative individuals. TB–HIV coinfected individuals were 2.3 times as likely to report injection drug use but were significantly less likely to be incarcerated in a correctional facility (AOR=0.17; 95% CI=0.09, 0.34) relative to TB–HIV negative individuals.

The AOR for the "year of diagnosis" variable was 1.00 (95% CI=0.94, 1.06) for TB–HIV coinfection cases (Table 4), indicating that the number of TB–HIV coinfection cases changed at the same rate as those in the reference group (TB–HIV negative). The TB–HIV unknown group, however, became smaller over the period studied (AOR=0.92; 95% CI=0.89, 0.96).

The Hosmer–Lemeshow test for the logistic regression comparing TB–HIV coinfection against TB–HIV negative status indicated

TABLE 3—Univariate Comparison of TB Cases (N = 2787), by HIV Category: San Diego County, CA, 1999–2007

	HIV Negative (n = 1416), No. (%) or Mean (SD)	HIV Positive (n = 262), No. (%) or Mean (SD)	HIV Unknown (n = 1109), No. (%) or Mean (SD)	*P*
Gender				<.001
Men	879 (62.1)	218 (83.2)	592 (53.4)	
Women	537 (37.9)	44 (16.8)	517 (46.6)	
Age at diagnosis,[a] y				<.001
< 20	112 (7.9)	2 (0.8)	266 (24.0)	
20–29	370 (26.1)	41 (15.7)	77 (6.9)	
30–39	281 (19.8)	90 (34.4)	79 (7.1)	
40–49	279 (19.7)	77 (29.4)	80 (7.2)	
≥ 50	374 (26.4)	52 (19.9)	607 (54.7)	
Race/ethnicity[b]				<.001
American Indian/Alaska Native	5 (0.4)	2 (0.8)	0	
Asian/Pacific Islander	455 (32.1)	5 (1.9)	431 (38.9)	
Non-Hispanic Black	116 (8.2)	28 (10.7)	51 (4.6)	
Non-Hispanic White	121 (8.6)	31 (11.8)	134 (12.1)	
Hispanic	719 (50.8)	196 (74.8)	493 (44.5)	
Country of birth[c]				<.001
United States	330 (23.3)	80 (30.5)	380 (34.3)	
Mexico	519 (36.7)	164 (62.6)	253 (22.8)	
Philippines	277 (19.6)	3 (1.2)	249 (22.5)	
Vietnam	87 (6.1)	0 (0.0)	66 (6.0)	
Somalia	22 (1.6)	3 (1.2)	19 (1.7)	
Laos	7 (0.5)	0 (0.0)	21 (1.9)	
Other or unknown	174 (12.3)	12 (4.6)	121 (10.9)	
Injection drug user				<.001
Yes	43 (3.0)	22 (8.4)	3 (0.3)	
No	1367 (96.5)	236 (90.1)	1085 (97.8)	
Unknown	6 (0.4)	4 (1.53)	21 (1.89)	
Noninjection drug user				<.001
Yes	133 (9.4)	47 (17.9)	24 (2.2)	
No	1276 (90.1)	211 (80.5)	1063 (95.9)	
Unknown	7 (0.5)	4 (1.5)	22 (2.0)	
Excessive alcohol use[d]				<.001
Yes	195 (13.8)	53 (20.2)	71 (6.5)	
No	1215 (85.8)	205 (78.2)	1018 (91.8)	
Unknown	6 (0.4)	4 (1.5)	20 (1.8)	
Homeless[d]				<.001
Yes	105 (7.4)	37 (14.1)	40 (3.6)	
No	1304 (92.1)	225 (85.9)	1057 (95.3)	
Unknown	7 (0.5)	0	12 (1.1)	
Correctional facility resident[d]				<.001
Yes	142 (10.0)	12 (4.6)	37 (3.3)	
No	1273 (89.9)	250 (95.4)	1065 (96.0)	
Unknown	1 (0.1)	0	7 (0.6)	

Continued

a good fit (χ^2_8=10.59; *P*=.226). However, the same test for comparing TB–HIV unknown against TB–HIV negative status revealed a significant misfit (χ^2_8=24.04; *P*=.002).

Using calculated logit values derived from the multivariate model, we determined that an adult male TB patient who was non-Hispanic and aged 30 to 39 years had only a 19% probability of being coinfected with HIV. If he used noninjecting drugs, the probability of coinfection rose to 27%, and then to 40% if he injected drugs. In adult Hispanic men, the risk of HIV coinfection was 50% for TB patients with no other risk factors. The risk rose to 61% if he used noninjection drugs and as high as 73% if he injected drugs.

DISCUSSION

The incidence of TB–HIV coinfection in San Diego County in 2007 (0.87 per 100 000 population) was almost double that of the national rate (0.5 per 100 000).[17] Furthermore, the ethnic composition of TB–HIV coinfection patients has shifted considerably in the last decade. The ethnic profile of TB–HIV coinfection patients has shifted from one similar to the national picture—largely comprising Blacks, Hispanics, and Whites—to one in which Hispanics predominate, indicating that health disparities in this region are growing.

Like in other regions in the United States, Blacks—who represent only a small proportion (5%) of the San Diego population—were overrepresented among HIV cases (13% of cases) and TB–HIV coinfection cases (13%). Consistent with national trends,[18] the incidence of TB–HIV coinfection among Blacks in San Diego declined rapidly over the last decade, but the incidence among Hispanics remained unchanged, leaving Hispanics accounting for an increasing proportion of TB–HIV coinfection cases—from 42% in 1993 to 82% by 2007. Our data suggest a regional Hispanic TB–HIV coinfection incidence that is out of step with national trends that have shown an 86% decline from 1993 through 2007,[18,19] but our data may reflect the situation in other US–Mexico border cities, such as El Paso and Ciudad Juarez, which have similar migration patterns and population dynamics. Whites have also played a decreasing role in TB–HIV dynamics, despite accounting for over 50% of the HIV

TABLE 3—*Continued*

Health care worker[e]				
Yes	39 (2.8)	4 (1.5)	16 (1.4)	
Unknown	1377 (97.0)	258 (98.5)	1093 (98.6)	
Migrant worker[e]				
Yes	9 (0.6)	3 (1.2)	4 (0.4)	
Unknown	1407 (99.4)	259 (98.9)	1105 (99.6)	
Unemployed[e]				
Yes	612 (43.2)	113 (43.1)	815 (73.5)	
Unknown	804 (56.8)	149 (56.9)	294 (26.5)	
Health care provider type[d]				<.001
Health department	513 (36.2)	9 (3.4)	238 (21.5)	
Private or other	662 (46.8)	197 (75.2)	687 (62.0)	
Health dept and private or other	164 (11.6)	30 (11.5)	125 (11.3)	
Unknown	77 (5.4)	26 (9.9)	59 (5.3)	
Previous TB diagnosis[d]				.007
Yes	55 (3.9)	21 (8.0)	43 (3.9)	
No	1360 (96.1)	240 (91.6)	1061 (95.7)	
Unknown	1 (0.1)	1 (0.1)	5 (0.5)	
TB skin test result[d]				<.001
Positive	852 (60.2)	78 (29.8)	566 (51.0)	
Negative	129 (9.1)	86 (32.8)	104 (9.4)	
Unknown	435 (30.7)	98 (37.4)	439 (39.6)	
TB skin test induration,[f] mean diameter (mm)	18.2 (10.3)	14.4 (13.5)	18.5 (10.9)	.001
Sputum smear result[d]				.546
Positive	630 (44.5)	119 (45.4)	362 (32.6)	
Negative	618 (43.6)	129 (49.2)	389 (35.1)	
No test/unknown	168 (11.9)	14 (5.3)	358 (32.3)	
Sputum culture[d]				.105
Positive	980 (69.2)	186 (71.0)	552 (49.8)	
Negative	256 (18.1)	58 (22.1)	181 (16.3)	
No test/unknown	180 (12.7)	18 (6.9)	376 (33.9)	
Site of disease				<.001
Pulmonary TB	1027 (72.5)	95 (36.3)	709 (63.9)	
Extrapulmonary TB	240 (17.0)	41 (15.7)	298 (26.9)	
Both	149 (10.5)	126 (48.1)	102 (9.2)	
X-ray results[d]				<.001
Cavitary lesion	283 (20.0)	18 (6.9)	137 (12.4)	
Noncavitary lesion	968 (68.4)	194 (74.1)	732 (66.0)	
Normal	159 (11.2)	48 (18.3)	229 (20.7)	
Unknown	6 (0.4)	2 (0.8)	11 (1.0)	
Isoniazid resistance[d]				.088
Resistant	139 (9.8)	15 (5.7)	84 (7.6)	
Susceptible	1103 (77.9)	215 (82.1)	773 (69.7)	
Unknown	174 (12.3)	32 (12.2)	252 (22.7)	
Rifampin resistance[d]				.621
Resistant	23 (1.6)	6 (2.3)	14 (1.3)	
Susceptible	1219 (86.1)	224 (85.5)	843 (76.0)	
Unknown	174 (12.3)	32 (12.2)	252 (22.7)	

Continued

cases in 2007. These data suggest that Hispanics are not benefiting from the prevention measures that appear to be effectively decreasing TB and HIV in the Black and White subpopulations. These data indicate a need to increase TB prevention efforts in Hispanics with HIV, and HIV testing and care efforts in Hispanics with TB.

Our study, the first of its kind in the region, indicates that ethnic/racial groups in San Diego County have remained epidemiologically distinct with regards to TB and HIV over the last decade, with each ethnic subpopulation exhibiting independent dynamics and Hispanics accounting for an increasing proportion of TB–HIV comorbidity. Although the prevalence of TB–HIV disease in the county overall is modest, concentration of the disease in 1 particular segment of the population is cause for concern because that segment may become a reservoir from which infection spreads to the wider population. Even in places in which HIV prevalence is low and TB treatment rates are high, such as in San Diego County, the stochastic relationships between the 2 diseases can result in TB outbreaks by random chance. The probability of such an event is enhanced if both diseases are concentrated in a single subpopulation.[20]

Over 30% of San Diego's population is Hispanic, and a large proportion were born in Mexico, which shares one of the world's busiest land-border crossings with San Diego.[21] Although previous studies have found very little evidence of HIV infection among Mexican migrants coming into San Diego[22] and that Mexican-born TB patients in the 4 US–Mexico border states (Arizona, California, New Mexico, and Texas) were less likely to be coinfected with HIV than were US-born TB patients,[23] our data indicate that the majority of TB–HIV patients in San Diego were Hispanics born in Mexico. Given the high incidence of TB disease[23,24] and latent TB infection in Mexico,[25] it is likely that many of these TB–HIV patients entered the United States with active or latent TB infections, but the dynamics of their HIV infections are uncertain. Approximately 10% of the foreign-born TB–HIV coinfected individuals reported residing in the United States for less than 90 days prior to their HIV diagnosis, making it unlikely that those patients acquired their HIV in the United States given the window of seroconversion for new

TABLE 3—*Continued*

Ethambutol resistance[d]				.429
Resistant	18 (1.3)	1 (0.4)	10 (0.9)	
Susceptible	1223 (86.4)	229 (87.4)	846 (76.3)	
Unknown	175 (12.4)	32 (12.2)	253 (22.8)	
Pyrazinamide resistance[d]				<.001
Resistant	108 (7.6)	63 (24.1)	91 (8.2)	
Susceptible	1130 (79.8)	167 (63.7)	761 (68.6)	
Unknown	178 (12.6)	32 (12.2)	257 (23.2)	
Isoniazid and rifampin resistance[d]				.891
Resistant	21 (1.5)	3 (1.2)	13 (1.2)	
Susceptible	1221 (86.2)	227 (86.6)	844 (6.1)	
Unknown	174 (12.3)	32 (12.2)	252 (22.7)	
Culture species				<.001
Mycobacterium tuberculosis	1150 (81.2)	171 (65.3)	772 (69.6)	
Mycobacterium bovis	85 (6.0)	57 (21.8)	81 (7.3)	
Clinically confirmed case	174 (12.3)	32 (12.2)	250 (22.5)	
Mycobacterium tuberculosis complex	7 (0.5)	2 (0.8)	6 (0.5)	
Treatment method[d]				<.001
Self-administered	93 (6.6)	11 (4.2)	112 (10.1)	
Directly observed therapy	1235 (87.2)	220 (84.0)	909 (82.0)	
Unknown	88 (6.21)	31 (11.8)	88 (7.9)	
Treatment length,[f] median d	205	304	214	<.001
Treatment outcome[g]				<.001
Dead at diagnosis	9 (0.6)	4 (1.5)	42 (3.8)	
Died during treatment	42 (3.0)	31 (11.8)	86 (7.8)	
Completed treatment	1152 (81.4)	179 (68.3)	842 (75.9)	
Unknown	213 (15.0)	48 (18.3)	139 (12.5)	

[a]Cases aged younger than 20 years not included in χ^2 calculation.
[b]Non-Hispanic American Indian not included in χ^2 calculation.
[c]The χ^2 test compared United States against all others.
[d]"Unknown" result excluded from χ^2 test.
[e]The frequencies of "yes" and "unknown" were not compared with the χ^2 test.
[f]Compared with the median test.
[g]We used the χ^2 test to compare completed treatment against dead at diagnosis and died during treatment.

HIV detection can be up to 3 months.[26] However, the remaining 90% of foreign-born TB–HIV coinfected individuals were in the United States for many years (median=13.1) prior to diagnosis, and it is not clear when or where they acquired HIV and TB. It has been reported that migrants are at greater risk for being infected with HIV when they first enter the United States[27] because of structural factors and individual behaviors,[28,29] but prospective studies are needed to clarify the spatial and temporal aspects of the HIV and TB infections among this population.

There was no difference in the frequency of MDR-TB among the 3 HIV groups. This is consistent with the observations of many studies, which have not demonstrated an association between MDR-TB and HIV.[30] The TB–HIV coinfection group, however, was 3 times as likely as the other 2 groups to have pyrazinamide-resistant infections, potentially complicating treatment prospects in this group. The pyrazinamide resistance in the HIV-positive TB cases is mostly accounted for by the large number of *M. bovis* TB infections in HIV cases in this region, because almost 100% of *M. bovis* isolates are resistant to pyrazinamide.[31] However, although it appears from our univariate analysis that *M. bovis* disease is strongly associated with TB–HIV coinfection, a previous analysis of all *M. bovis* cases in this region demonstrated that this association was not significant once other confounding clinical and demographic variables were accounted for.[31]

We found no evidence to indicate that the incidence of multidrug resistant TB had increased among the TB–HIV coinfection cases over the study period, but there was some concern that the TB–HIV coinfection cases with isolated isoniazid or rifampin resistance (8% of cases) might be on the path to multidrug resistant TB, given that TB-drug resistance is acquired in a stepwise fashion[32] and that we found TB–HIV coinfected individuals were more likely to have had multiple TB treatments.

Mortality during TB treatment was almost 4 times higher among TB–HIV coinfection patients than among TB–HIV negative patients. Although this difference in mortality is high, it appears to be consistent with TB-treatment mortalities observed in HIV-positive and HIV-negative TB cases in a recent TB-treatment trial in the United States and Canada that had 3.75 times greater TB-treatment mortalities in the HIV-positive group compared with the HIV-negative group.[33]

After adjusting for other risk factors, the polychotomous logistic regression analysis indicated that the use of injection drugs, but not noninjection drugs, was significantly associated with TB–HIV coinfection cases, which is in contrast to national data indicating that both noninjection drug use and injection drug use significantly increased an individual's risk of coinfection.[34] Efforts to decrease TB–HIV coinfection in this region will have to include the difficult-to-reach, high-risk patients identified in our analyses: Hispanic men aged 30 to 49 years who are injection drug users. Furthermore, we recommend that all TB patients found to have HIV coinfection be administered standardized HIV risk assessment surveys as a part of the routine TB surveillance in this region to start developing an understanding of the HIV risk profile of these individuals.

The large proportion of TB cases—two fifths of the 1999 to 2007 sample—with an unknown HIV status was a potential source of bias in this analysis. One might expect the TB–HIV unknown group to be a random blend of the other 2 groups, but it contained an unknown, and possibly changing, ratio of TB–HIV coinfection and TB–HIV negative cases and differed from both groups. Instead of excluding the TB cases

TABLE 4—Multivariable Polychotomous Logistic Regression Results Comparing 3 TB–HIV Coinfection Groups: San Diego, California, 1999–2007

	HIV Positive, AOR (95% CI)	HIV Unknown, AOR (95% CI)	*P*
Gender			<.001
Women (Ref)	1.00	1.00	
Men	2.86 (1.97, 4.14)	0.69 (0.56, 0.85)	
Age at diagnosis,[a] y			<.001
20–29 (Ref)	1.00	1.00	
30–39	3.23 (2.11, 4.95)	1.38 (0.95, 1.99)	
40–49	2.63 (1.69, 4.09)	1.47 (1.02, 2.12)	
≥50	1.35 (0.85, 2.16)	8.22 (6.07, 11.15)	
Race/ethnicity			<.001
Non-Hispanic (Ref)	1.00	1.00	
Hispanic	3.90 (2.79, 5.45)	0.67 (0.54, 0.83)	
Country of birth			.002
United States (Ref)	1.00	1.00	
Other	0.54 (0.38, 0.76)	0.93 (0.72, 1.20)	
Year of diagnosis	1.00 (0.94, 1.06)	0.92 (0.89, 0.96)	<.001
Injection drug use			.002
Yes	2.30 (1.19, 4.43)	0.18 (0.04, 0.79)	
No (Ref)	1.00	1.00	
Noninjection drug use			.080
Yes	1.45 (0.90, 2.32)	0.68 (0.39, 1.18)	
No (Ref)	1.00	1.0	
Excessive alcohol use			.720
Yes	0.89 (0.59, 1.33)	0.89 (0.62, 1.27)	
No (Ref)	1.00	1.00	
Homeless			.013
Yes	0.99 (0.60, 1.63)	0.49 (0.30, 0.79)	
No (Ref)	1.00	1.00	
Correctional facility resident			<.001
Yes	0.17 (0.09, 0.34)	1.50 (0.93, 2.43)	
No (Ref)	1.00	1.00	

Note. AOR = adjusted odds ratio; CI = confidence interval; TB = tuberculosis. The HIV-negative group was the reference category among the HIV coinfection groups. There were 2357 total cases.
[a]TB cases aged younger than 20 years were excluded because there were only 2 HIV-positive (TB–HIV coinfection) patients in this age range.

with an unknown HIV status, we included the TB–HIV unknown group in the analysis as an independent group to account for their presence in the sample and to learn more about them. Because this group exhibited variable frequencies that were consistently different from both the TB–HIV coinfection and TB–HIV negative groups, we feel this approach was justified. Compared with the adult TB–HIV negative cases, TB–HIV unknown cases were more likely to be older and female and less likely to be injection drug users or homeless. The TB–HIV unknown group was most significantly associated with being older than 50 years (AOR = 8.2), which might suggest that this age group (especially women) are not being tested for HIV or that there is less emphasis on obtaining HIV test results for TB surveillance purposes among older women. Either way, the number of TB cases with unknown HIV status could be reduced dramatically by increasing HIV testing in this group.

Limitations

Because of the close relationship and population flow between Tijuana, Mexico, and San Diego, California, TB–HIV coinfection trends observed in San Diego may be unique to this region and might not reflect those of the rest of California, where population dynamics are different. We also did not have data on the temporal relationship between the recorded TB and HIV infections. The TB–HIV coinfection cases identified could be an underestimate because we did not know if the individuals with only TB at the time of the study were subsequently diagnosed as having HIV.

Conclusions

The incidence of TB and HIV coinfection among Hispanics in San Diego has not changed significantly in the last decade, whereas there have been significant declines among Whites and Blacks. Hispanics now account for over 80% of all TB–HIV coinfection cases, further widening existing health disparities in this region.[35,36] With over 40 000 people crossing the border between Mexico and San Diego on a daily basis, and our finding that the majority of new TB–HIV coinfection cases occurred among Hispanics that were born in Mexico, it is clear that future interventions to address this health disparity will need to be binational in nature. Because Mexico currently lacks the resources and policy guidelines for extensive contact tracing, routine culture-based TB diagnosis, and routine treatment of latent TB infection, an excellent place to start would be to assist Mexico with the resources needed to strengthen those aspects of their TB-control program. ■

About the Authors

At the time of the study, Timothy C. Rodwell, Richard F. W. Barnes, Steffanie A. Strathdee, and Richard S. Garfein were with the Department of Medicine, University of California, San Diego. Marisa Moore was with the Centers for Disease Control and Prevention, stationed at the Tuberculosis Control and Refugee Health Program in the San Diego County Health and Human Services Agency, California. Annie Raich was with the School of Public Health, San Diego State University, California. Kathleen S. Moser was the director of the Tuberculosis Control and Refugee Health Program in the San Diego County Health and Human Services Agency, California.

Correspondence can be sent to Timothy C. Rodwell, Department of Medicine, Division of Global Public Health, University of California San Diego School of Medicine, 9500 Gilman Dr, La Jolla, CA 92093-0507 (e-mail: trodwell@ucsd.edu). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints/Eprints" link.

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Contributions

All authors helped to conceptualize ideas, interpret findings, and review drafts of the article. T.C. Rodwell originated the study and supervised all aspects of its implementation. R.F.W. Barnes assisted with the study, completed analyses and assisted with the writing. M. Moore, S.A. Strathdee, K.S. Moser, and R.S. Garfein helped with the synthesis of the analyses and writing of the article. A. Raich assisted with analyses.

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