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Multidrug-resistant tuberculosis in the United States, 2011–2016: patient characteristics and risk factors

M. P. Chen, **R. Miramontes**, **J. S. Kammerer**

Division of Tuberculosis Elimination, National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention, Centers for Disease Control and Prevention, Atlanta, Georgia, USA

SUMMARY

OBJECTIVE : To determine risk factors for multidrug-resistant tuberculosis (MDR-TB) and describe MDR-TB according to three characteristics: previous TB disease, recent transmission of MDR-TB, and reactivation of latent MDR-TB infection.

SETTING AND DESIGN : We used 2011–2016 surveillance data from the US National Tuberculosis Surveillance System and National Tuberculosis Genotyping Service and used logistic regression models to estimate risk factors associated with MDR-TB.

RESULTS : A total of 615/45 209 (1.4%) cases were confirmed as MDR-TB; 111/615 (18%) reported previous TB disease; 41/615 (6.7%) were attributed to recent MDR-TB transmission; and 449/615 (73%) to reactivation. Only 12/41 (29%) patients with TB attributed to recent transmission were known to be contacts of someone with MDR-TB. For non-US-born patients, the adjusted odds ratios of having MDR-TB were 32.6 (95%CI 14.6–72.6) among those who were known to be contacts of someone with MDR-TB and 6.5 (95%CI 5.1–8.3) among those who had had previous TB disease.

CONCLUSION : The majority of MDR-TB cases in the United States were associated with previous TB disease or reactivation of latent MDR-TB infection; only a small proportion of MDR-TB cases were associated with recent transmission.

RÉSUMÉ

Estimer les facteurs de risque de tuberculose multirésistante (MDR-TB) et décrire la MDR-TB en fonction de trois caractéristiques : TB maladie préalable, transmission récente de la MDR-TB et réactivation d'une infection latente de MDR-TB.

Nous avons utilisé les données de surveillance 2011–2016 du Système national US de surveillance de la Tuberculose et du service national de génotypage de la TB. Nous avons eu recours à des modèles de régression logistique afin d'estimer les facteurs de risque associés à la MDR-TB.

Un total de 615/45209 (1,4%) cas ont été confirmés comme étant des MDR-TB; 111/615 (18%) ont rapporté des antécédents de TB maladie; 41/615 (6,7%) ont été considérés comme attribués à une transmission récente de MDR-TB; et 449/615 (73%), à une réactivation. Seulement 12/41

Correspondence to: Michael P Chen, Division of Tuberculosis Elimination, National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention, Centers for Disease Control and Prevention, 1600 Clifton Rd., NE, MS A-19, Atlanta, GA 30329-4027, USA. mchen1@cdc.gov.

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(29%) patients atteints de TB attribuée à une transmission récente etaient des contacts connus d'un patient MDR-TB. En cé qui concerne les patients nés hors des Etats-Unis, les odds ratios ajustés de MDR-TB et leurs intervalles de confiance à 95% (IC95%) ont été de 32,6 (IC95% 14,6–72,6) parmi ceux qui étaient des contacts connus de patients MDR-TB et de 6,5 (IC95% 5,1–8,3) parmi ceux qui avaient déjà eu une TB maladie.

La majorité des cas de MDR-TB aux Etats-Unis ont été associés à une TB préalable ou à une réactivation d'infection latente de MDR-TB; une petite proportion de cas de MDR-TB seulement a été associée à une transmission récente.

RESUMEN

Estimar los factores de riesgo de contraer la tuberculosis multirresistente (MDR-TB) y describirla con respecto a tres características, a saber: el antecedente de enfermedad tuberculosa, la transmisión reciente de MDR-TB y la reactivación de una infección latente de MDR-TB.

Se utilizaron los datos de vigilancia del 2011 al 2016 del sistema nacional de vigilancia y del servicio nacional de genotipificación de los Estados Unidos y se aplicaron modelos de regresión logística con el fin de evaluar los factores de riesgo asociados con la presencia de MDR-TB.

De los 45209 casos, se confirmó la MDR-TB en 615 (1,4%); de los cuales 111 (18%) refirieron un antecedente de enfermedad tuberculosa; se atribuyeron 41 casos (6,7%) a una transmisión reciente de MDR-TB y 449 (73%) a una reactivación. Solo en 12 de los 41 pacientes (29%) con TB atribuida a una transmisión reciente se conocía el antecedente de contacto con un caso de MDR-TB. El cociente de posibilidades ajustado de contraer la TB en los pacientes nacidos fuera de los Estados Unidos fue 32,6 (IC95% 14,6–72,6) en quienes tenían contacto conocido con un caso de MDR-TB y 6,5 (IC95% 5,1–8,3) en los pacientes con antecedente de enfermedad tuberculosa.

La mayoría de los casos de MDR-TB en los Estados Unidos se asocia con un antecedente de enfermedad tuberculosa o con la reactivación de una infección latente de MDR-TB; solo una proporción pequena de casos de MDR-TB se asoció con unã transmisión reciente.

Keywords

recent transmission; previous TB; MDR-TB contacts; reactivation

MULTIDRUG-RESISTANT TUBERCULOSIS (MDR-TB) is a form of TB disease caused by strains of *Mycobacterium tuberculosis* that are resistant to at least isoniazid (INH) and rifampin (RMP), the two most efficacious TB drugs. MDR-TB often requires complex treatment regimens that are associated with more adverse events, longer treatment time, higher cost, and higher treatment failure and mortality.[1–7] In 2016, 3.3% of new TB cases worldwide and 1.2% of the reported US TB cases were MDR-TB.[1,8] In the United States, the majority of TB incident cases (69%) and the vast majority of MDR-TB incident cases (92%) reported during 2016 were among non-US-born persons.[8]

New TB cases can result from recent *M. tuberculosis* transmission or reactivation of longstanding, untreated latent infection. Cases resulting from recent transmission, especially MDR-TB cases, are of major public health concern because they might represent

uncontrolled transmission or an outbreak. Availability of genotyping data in the United States for culture-confirmed TB cases allowed for estimates of recent transmission because clustered cases sharing the same genotype are more likely attributable to recent transmission.[9–12] The US Centers for Disease Control and Prevention (CDC) has developed a plausible source-case method for refining estimates of recent TB transmission in the United States by using nationally available genotyping and surveillance data; using the algorithm, it was estimated that 14% of genotyped TB cases were attributable to recent transmission during 2011–2014.[13,14] The method can help identify populations and geographic areas with ongoing transmission or an outbreak, which can prompt additional control efforts for minimizing transmission.

MDR-TB cases result either from a person being infected through contact with a person who already had MDR-TB (i.e., MDR-TB transmission), or it can occur in a patient who originally had non-MDR-TB but then acquired MDR-TB as a result of inadequate or inappropriate TB treatment (i.e., acquired MDR-TB).[15] Acquired MDR-TB is often assumed to be the cause of drug resistance among persons who have been treated for TB previously, or as defined in this study, among persons who reported a previous diagnosis of TB. During 2016, an estimated 19% of TB cases worldwide among persons who had been treated previously for TB disease were diagnosed as MDR-TB or at least RMP-resistant.[1,15–20] With *M. tuberculosis* genotyping, however, we can now examine MDR-TB transmission. Furthermore, using genotyping methods, we can estimate which MDR-TB cases are associated with recent TB transmission and which are associated with the reactivation of latent TB infection. Analyzing data regarding MDR-TB cases by these three groups—previous TB disease, recent transmission, and reactivation from latent MDR-TB infection—can provide important insights into how to prevent MDR-TB. Previous studies have been based on relatively limited sample sizes, and the majority of studies were set in high MDR-TB incidence countries.[19–26] Our study describes the demographic and epidemiologic characteristics of MDR-TB patients in the United States, a low MDR-TB incidence country. We were also able to estimate risk factors for MDR-TB among non-US-born and US-born persons, two population groups with different TB risk characteristics.[8]

STUDY POPULATION AND METHODS

We used 2011–2016 US surveillance data from the National Tuberculosis Surveillance System (NTSS) and the National Tuberculosis Genotyping Service (NTGS). NTSS collects clinical, demographic, and risk factor data for all reported US TB cases; NTGS collects genotyping results for culture-positive TB cases. These two data systems are linked through unique case numbers. All data collected and analyzed were part of routine public health surveillance. This project was determined not to be human subject research by the US CDC and therefore did not require ethical approval by an institutional review board.

We combined 6 years of NTSS data (n = 45 209 cases) to obtain better statistical power and used NTGS data and an established plausible source-case method (described elsewhere).[13] We defined a case of MDR-TB as TB disease that is resistant to at least INH and RMP on the basis of initial drug susceptibility testing (DST) results. We analyzed the following demographic variables and potential risk factors for MDR-TB: US/non-US-born, age group,

sex, race/ethnicity, years of residence in the United States in case of non-US-born persons, incarceration at diagnosis, homelessness any time during the previous year, excess alcohol use, injection drug use any time during the 12 months before diagnosis, human immunodeficiency virus (HIV) infection, history of previous contact with an MDR-TB patient during the past 2 years (known contact of an MDR-TB patient, only values of 'Yes' are coded), previous history of TB disease, and whether the case was attributed to recent transmission.

We classified each MDR-TB case into one of three distinct, non-overlapping categories according to the following hierarchical order: 1) previous TB (PreTB); 2) recent transmission only (RT; cases were attributable to recent transmission [i.e., a plausible source case within 2 years before diagnosis could be identified] but the patient had no previous TB); or 3) reactivation (RA; persons had no previous TB and infections were not attributable to recent transmission). An MDR-TB case attributed to recent transmission had at least one plausible source case identified by the plausible source-case method that had either MDR- or INH- or RMP-monoresistant TB (this definition for recent transmission of MDR-TB is slightly different from the definition of recent transmission of TB[13,14]). We included plausible monoresistant sources because the surveillance system only collects a single initial DST result, which sometimes leads to incomplete levels of reported drug resistance. If an MDR-TB case was not in one of these three groups, we classified the case as 'Other' (cases with missing values of previous TB or recent transmission).

We calculated the proportions of MDR-TB cases by each demographic variable and potential risk factor. We also computed the proportions of MDR-TB cases in each of the three source categories (PreTB, RT, RA) stratified by demographic variable and potential risk factor. We then used logistic regression models to identify risk factors associated with MDR-TB among all culture-positive MDR-TB and non-MDR-TB cases with genotyping data and initial DST results. All variables with a $P < 0.3$ were included in the bivariate analyses. Both manual forward and backward eliminations were used to estimate adjusted odds ratios (aORs) and 95% confidence intervals (95%CIs). The results from both selection methods were identical. For multivariable analyses, we used separate logistic models for non-US-born and US-born persons because they had different risk factors. Variables with $P < 0.05$ were retained in the models. We focused on main effects for each of these models. The interaction terms of recent transmission with previous TB disease ($P > 0.8$) and age group ($P > 0.25$) were also examined, but these were not significant. Sparse data bias can be worrying in case of small case counts and wide 95%CIs,[27] but in this study, after the bivariate analyses, the case counts of the remaining variables used in multivariable models were found to be adequate. Records with missing values for variables removed from earlier models were nevertheless included in the final model. Statistical analyses were performed using SAS® v9.4 (SAS Institute, Cary, NC, USA).

RESULTS

During 2011–2016, 30 211 (66.8%) of 45 209 TB cases with both initial INH and RMP DST results were diagnosed among non-US-born persons. Proportions for MDR-TB cases were 1.8% ($n = 537$) among non-US-born and 0.5% ($n = 77$) among US-born persons (Tables 1

and 2). Among non-US-born persons, the MDR-TB rate was highest (3.0%) in those who had resided in the United States for ≤4 years. MDR-TB rates were not higher in persons reporting incarceration, homelessness, excess alcohol use, injecting drug use, or HIV infection than in TB patients who did not have these characteristics (Table 1). MDR-TB rates were high in persons who had known contact with an MDR-TB patient, compared with those who had no known contacts (38.0% vs. 1.7% in non-US-born and 25.0% vs. 0.5% in US-born, respectively). The MDR-TB rate was much higher in non-US-born persons with previous TB disease than in persons without previous TB disease (7.7% vs. 1.5%). Among cases attributed to recent transmission, MDR-TB rates were respectively 1.3% and 0.3% in non-US-born and US-born persons (Table 2).

Of the 615 MDR-TB cases reported during 2011–2016, 6 of 111 PreTB cases were also attributed to recent transmission; 14 were classified as Other. In non-US-born persons, the proportions of PreTB, RT only, RA, and Other cases were respectively 19.4%, 5.2%,73.2% and 2.2%; those residing in the United States for ≤4 years had the highest rates of PreTB (24.6%) and low rate of RT only (1.9%). The proportions of PreTB, RT only, and RA cases in persons who had known contact with an MDR-TB patient were respectively 4.0%, 48.0%, and 48.0%. Only 12 of 41 patients from the RT group had documented contact with an MDR-TB patient (Table 3).

The results of variables with $P < 0.3$ in bivariate analyses are presented in Table 4. These variables were included in multivariable analyses. For non-US-born persons, risk factors that remained statistically significant in the multivariable logistic regression model were age, sex, race/ethnicity, years residing in the United States, being a known contact of an MDR-TB patient, previous TB disease, and recent transmission. The aORs were 32.6 (95%CI 14.6–72.6) for being an MDR-TB patient contact and 6.5 (95%CI 5.1–8.3) for persons with previous TB disease. For US-born persons, the significant risk factors were age, race/ethnicity, being an MDR-TB patient contact, previous TB disease, and recent transmission. The aORs were 46.2 (95%CI 16.3–130.7) for MDR-TB contacts and 2.8 (95%CI 1.2–6.1) for persons with previous TB disease (Table 4).

DISCUSSION

US national TB genotyping surveillance coverage, defined as the percentage of culture-positive TB cases having at least one isolate genotyped, increased from 52.6% in 2004 to 96.4% in 2016.[8] During 2011–2016, the genotyping coverage for MDR-TB cases was 97.6%, which allowed for the classification of the majority of MDR-TB cases by recent transmission status. Among the seven MDR-TB cases classified as reactivation among children aged ≤14 years, two were under 5 years. These two children are likely to have disease that is a result of recent transmission, but as they did not have a culture result, they did not have genotyping results available. Because only six of 111 persons with previous TB disease in this study were attributed to recent transmission, the current hierarchical classification (without further classification of these six persons) should be adequate.

Among persons with MDR-TB, we estimated that recent transmission was low, at 6.7%, in 2011–2016. The low rate might be the result of prompt public health action or lower fitness

of MDR-TB stains,[28] but is more likely due to program effectiveness. Our data revealed that non-US-born persons had a higher proportion of previous TB than US-born persons (19.4% and 9.1%, respectively). Furthermore, among persons with previous TB disease, the rate of MDR-TB among the non-US-born was higher than among the US-born (7.7% vs. 1.1%). These differences likely indicate that domestic TB treatment practices are effective in terms of preventing acquired drug resistance.

The characteristics and risk factors for MDR-TB differ between non-US-born and US-born persons.[8,29,30] On comparing the results between the two groups (Table 4), we determined that age groups 15–44 and 45–64 years, being a known contact of an MDR-TB patient, previous TB disease, and recent transmission were statistically significant risk factors for both non-US-born and US-born persons. Residing in the United States for ≤4 and 5–19 years and being White were additional risk factors for non-US-born persons; age group ≤ 14 years and being Asian were additional risk factors for US-born persons.

During 2000–2005, the average number of annual US MDR-TB cases decreased from 145 to 121; HIV co-infection prevalence among these patients ranged from 8% to 22%.[7] In contrast, the average number of annual MDR-TB cases during 2011–2016 was 103; HIV co-infection prevalence was 5%, decreasing markedly between 2000 and 2005. In previous studies, homelessness was identified as a risk factor for TB disease.[10,13,22,30] However, patients reporting homelessness within the previous year did not have higher risk for having MDR-TB than patients not reporting homelessness. This might be because of low case counts of MDR-TB among homeless populations. The low case counts may lead to wide confidence intervals and non-significant results. Although previous studies reported that incarceration, excess alcohol use, and HIV co-infection were risk factors for TB or MDR-TB,[4,10,31,32] we did not identify statistically significant associations with MDR-TB for these characteristics. Previous studies that reported risk factors of excess alcohol use and HIV infection for MDR-TB were conducted in Malaysia and Ethiopia,[4,31,32] countries with higher TB, MDR- and RMP-resistant TB incidence rates. This indicates that associations of excess alcohol use and HIV co-infection with MDR-TB might differ between high- and low-incidence countries.

We determined that a known contact with an MDR-TB patient and previous TB disease were the two risk factors most strongly associated with MDR-TB. In small-scale MDR-TB risk factor studies conducted in Ethiopia,[32] previous contact with TB and MDR-TB patients was reported to be a risk factor for acquiring MDR-TB. In other studies, a history of previous TB disease was identified as a risk factor for MDR-TB.[18,21,24,25,33–35] Although the majority of these studies had limited sample sizes, they included different settings, from low- to high-incidence countries (e.g., France, Western and Eastern European countries, Malaysia, China, Brazil, and Ethiopia). Therefore, unlike excess alcohol use and HIV co-infection, which vary in their associations with MDR-TB in different countries, previous TB disease remained a major risk factor universally; however, the magnitude might vary in different settings. MDR-TB intervention strategies in low-incidence countries will differ from those in higher TB incidence countries.

Our analysis was subject to certain limitations. First, we assumed that persons who reported previous TB disease had acquired drug resistance during the previous TB episode, without direct evidence that the persons had received previous treatment. Second, the current episode of TB that we studied might be associated with new transmission that occurred after the previous TB diagnosis. Third, although the method for attributing cases to recent transmission was validated by using field epidemiologic data and sensitivity and specificity analyses, misclassification errors might have occurred. Fourth, case counts were low for certain variables, contributing to non-significant results or wider confidence intervals for some variables. Fifth, we do not know whether treatment for previous TB disease of non-US-born persons occurred on shore or offshore. Sixth, incarceration at diagnosis may underrepresent infection acquired in the recent past; homelessness in the previous 12 months may not capture all MDR-TB acquired in such a setting.

In conclusion, we determined that among MDR-TB patients, the proportion of previous TB disease was higher among non-US-born persons than among US-born persons, and the proportion of recent transmission was low. Our data revealed that being a previous contact of an MDR-TB patient was the dominant risk factor for MDR-TB, followed by previous TB disease for non-US-born persons. The low proportions of recent transmission of MDR-TB might reflect the successful efforts of US TB programs in limiting transmission of MDR-TB in recent years.

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Disclaimer:

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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Table 1

Characteristics of MDR-TB patients, United States, 2011–2016

Characteristic and category	All MDR- and non-MDR-TB *n*	MDR-TB *n* (%)
All	45 209	615 (1.4)
Origin		
Non-US-born	30 211	537 (1.8)
US-born	14 947	77 (0.5)
Missing	51	1 (2.0)
Age, years		
≤14	885	9 (1.0)
15–44	18 831	384 (2.0)
45–64	14 297	147 (1.0)
≥65	11 187	74 (0.7)
Missing	9	1 (11.1)
Sex		
Female	17 203	294 (1.7)
Male	28 003	321 (1.1)
Missing	3	0
Race/ethnicity		
White	6 279	68 (1.1)
Black	9 208	80 (0.9)
Hispanic	12 678	124 (1.0)
Asian	14 889	313 (2.1)
Other	2 022	30 (1.5)
Missing	133	0
Years in the United States (non-US-born)		
≤4	8 944	264 (3.0)
5–19	10 299	183 (1.8)
≥20	8 372	58 (0.7)
Missing/US-born	17 594	110 (0.6)
Incarcerated at diagnosis		
Yes	1 627	18 (1.1)
No	42 712	576 (1.3)
Missing	870	21 (2.4)
Homeless any time during the previous year		
Yes	2 540	11 (0.4)
No	42 382	602 (1.4)
Missing	287	2 (0.7)
Excess alcohol use		
Yes	5 402	34 (0.6)
No	39 229	577 (1.5)
Missing	578	4 (0.7)

Characteristic and category	All MDR- and non-MDR-TB *n*	MDR-TB *n* (%)
Injection drug use		
Yes	691	8 (1.2)
No	43 979	603 (1.4)
Missing	539	4 (0.7)
HIV infection		
Yes	2 562	30 (1.2)
No	37 249	547 (1.5)
Missing	5 398	38 (0.7)
Known contact of an MDR-TB patient		
Yes	74	25 (33.8)
Missing	45 135	590 (1.3)
Previous TB disease		
Yes	2 003	111 (5.5)
No	42 963	501 (1.2)
Missing	243	3 (1.2)
Recent transmission		
Yes	6 382	47 (0.7)
No	35 892	553 (1.5)
Missing	2 935	15 (0.5)

MDR-TB = multidrug-resistant tuberculosis; HIV = human immunodeficiency virus.

Table 2

Characteristics of MDR-TB patients by origin of birth, United States, 2011–2016

	Non-US-born		US-born	
Characteristic and category	**All MDR- and non-MDR-TB *n***	**MDR-TB *n* (%)**	**All MDR- and non-MDR-TB *n***	**MDR-TB *n* (%)**
All	30 211	537 (1.8)	14 947	77 (0.5)
Age, years				
≤14	243	2 (0.8)	641	7 (1.1)
15–44	14 000	352 (2.5)	4816	32 (0.7)
45–64	8 558	116 (1.4)	5719	31 (0.5)
≥65	7 404	66 (0.9)	3 768	7 (0.2)
Missing	6	1 (16.7)	3	0
Sex				
Female	12 241	259 (2.1)	4 947	34 (0.7)
Male	17 968	278 (1.5)	9 999	43 (0.4)
Missing	2	0	1	0
Race/ethnicity				
White	1 323	47 (3.6)	4953	21 (0.4)
Black	3 633	59 (1.6)	5 572	21 (0.4)
Hispanic	9 746	106 (1.1)	2 908	18 (0.6)
Asian	14 350	301 (2.1)	530	11 (2.1)
Other	1 069	24 (2.2)	943	6 (0.6)
Missing	90	0	41	0
Years in the United States (non-US-born)				
≤4	8 944	264 (3.0)	—	—
5–19	10 299	183 (1.8)	—	—
≥20	8 372	58 (0.7)	—	—
Missing/US-born	2 596	32 (1.2)	—	—
Incarcerated at diagnosis				
Yes	944	13 (1.4)	680	5 (0.7)
No	28 755	509 (1.8)	13 915	66 (0.5)
Missing	512	15 (2.9)	352	6 (1.7)

	Non-US-born		US-born	
Characteristic and category	**All MDR- and non-MDR-TB *n***	**MDR-TB *n* (%)**	**All MDR- and non-MDR-TB *n***	**MDR-TB *n* (%)**
Homeless any time during the previous year				
Yes	825	8 (1.0)	1 706	3 (0.2)
No	29 188	527 (1.8)	13 161	74 (0.6)
Missing	198	2 (1.0)	80	0
Excess alcohol use				
Yes	2135	22 (1.0)	3 260	12 (0.4)
No	27 717	512 (1.8)	11 485	64 (0.6)
Missing	359	3 (0.8)	202	1 (0.5)
Injection drug use				
Yes	172	4 (2.3)	518	4 (0.8)
No	29 716	530 (1.8)	14 233	72 (0.5)
Missing	323	3 (0.9)	196	1 (0.5)
HIV infection				
Yes	1 427	25 (1.8)	1 134	5 (0.4)
No	25 349	478 (1.9)	11 873	68 (0.6)
Missing	3 435	34 (1.0)	1 940	4 (0.2)
Known contact of an MDR-TB patient				
Yes	50	19 (38.0)	24	6 (25.0)
Missing	30 161	518 (1.7)	14 923	71 (0.5)
Previous TB disease				
Yes	1 349	104 (7.7)	654	7 (1.1)
No	28 689	431 (1.5)	14231	69 (0.5)
Missing	173	2 (1.2)	62	1 (1.6)
Recent transmission				
Yes	2 651	34 (1.3)	3721	13 (0.3)
No	25 674	489 (1.9)	10 183	63 (0.6)
Missing	1 886	14 (0.7)	1 043	1 (0.1)

MDR-TB = multidrug-resistant tuberculosis; HIV = human immunodeficiency virus.

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Table 3

Characteristics of MDR-TB patients by previous TB disease, recent transmission only, reactivation, United States, 2011–2016

Characteristic and category	MDR-TB *n*	Previous TB *n* (%)	Recent transmission only* *n* (%)	Reactivation *n* (%)	Other† *n* (%)
All	615	111 (18.0)	41 (6.7)	449 (73.0)	14 (2.3)
Origin					
Non-US-born	537	104 (19.4)	28 (5.2)	393 (73.2)	12 (2.2)
US-born	77	7 (9.1)	13 (16.9)	55 (71.4)	2 (2.6)
Missing	1	0	0	1 (100.0)	0
Age, years					
≤14	9	0	2 (22.2)	7 (77.8)	0
15–44	384	63 (16.4)	24 (6.3)	289 (75.3)	8 (2.1)
45–64	147	36 (24.5)	10 (6.8)	97 (66.0)	4 (2.7)
≥65	74	12 (16.2)	5 (6.8)	55 (74.3)	2 (2.7)
Missing	1	0	0	1 (100.0)	0
Sex					
Female	294	55 (18.7)	25 (8.5)	207 (70.4)	7 (2.4)
Male	321	56 (17.4)	16 (5.0)	242 (75.4)	7 (2.2)
Race/ethnicity					
White	68	12 (17.6)	5 (7.4)	50 (73.5)	1 (1.5)
Black	80	13 (16.3)	4 (5.0)	63 (78.8)	0
Hispanic	124	17 (13.7)	8 (6.5)	95 (76.6)	4 (3.2)
Asian	313	65 (20.8)	17 (5.4)	223 (71.2)	8 (2.6)
Other	30	4 (13.3)	7 (23.3)	18 (60.0)	1 (3.3)
Years in the United States (non-US-born)					
≤4	264	65 (24.6)	5 (1.9)	193 (73.1)	1 (0.4)
5–19	183	29 (15.8)	13 (7.1)	136 (74.3)	5 (2.7)
≥20	58	9 (15.5)	1 (1.7)	46 (79.3)	2 (3.4)
Missing/US-born	110	8 (7.3)	22 (20.0)	74 (67.3)	6 (5.5)
Incarcerated at diagnosis					
Yes	18	4 (22.2)	2 (11.1)	12 (66.7)	0 (0)
No	576	105 (18.2)	35 (6.1)	423 (73.4)	13 (2.3)

Characteristic and category	MDR-TB *n*	Previous TB *n* (%)	Recent transmission only* *n* (%)	Reactivation *n* (%)	Other† *n* (%)
Missing	21	2 (9.5)	4 (19.0)	14 (66.7)	1 (4.8)
Homeless any time during the previous year					
Yes	11	5 (45.5)	1 (9.1)	5 (45.5)	0
No	602	105 (17.4)	40 (6.6)	444 (73.8)	13 (2.2)
Missing	2	1 (50.0)	0	0	1 (50.0)
Excess alcohol use					
Yes	34	5 (14.7)	5 (14.7)	24 (70.6)	0
No	577	106 (18.4)	36 (6.2)	423 (73.3)	12 (2.1)
Missing	4	0	0	2 (50.0)	2 (50.0)
Injection drug use					
Yes	8	1 (12.5)	1 (12.5)	6 (75.0)	0
No	603	110 (18.2)	40 (6.6)	440 (73.0)	13 (2.2)
Missing	4	0	0	3 (75.0)	1 (25.0)
HIV infection					
Yes	30	7 (23.3)	0	22 (73.3)	1 (3.3)
No	547	99 (18.1)	36 (6.6)	400 (73.1)	12 (2.2)
Missing	38	5 (13.2)	5 (13.2)	27 (71.1)	1 (2.6)
Known contact of an MDR-TB patient					
Yes	25	1 (4.0)	12 (48.0)	12 (48.0)	0
Missing	590	110 (18.6)	29 (4.9)	437 (74.1)	14 (2.4)

*Did not include six cases with both previous TB and recent transmission; these were included in the previous TB category.

†Cases with missing values of previous TB or recent transmission.

MDR-TB = multidrug-resistant tuberculosis; HIV = human immunodeficiency virus.

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Table 4

Risk factors from bivariate and multivariable models for MDR-TB among MDR- and non-MDR-TB patients by place of birth, United States, 2011–2016

	Bivariate models*		Multivariable models†	
Risk factor and category	**Non-US-born OR (95%CI)**	**US-born OR (95%CI)**	**Non-US-born aOR (95%CI)**	**US-born aOR (95%CI)**
Age, years				
≤14	0.9 (0.2–3.8)	5.9 (2.1–17.0)	1.0 (0.3–4.4)	4.9 (1.5–15.5)
15–44	2.9 (2.2–3.7)	3.6 (1.6–8.2)	2.4 (1.7–3.2)	3.2 (1.4–7.5)
45–64	1.5 (1.1–2.1)	2.9 (1.3–6.7)	1.6 (1.2–2.2)	3.1 (1.4–7.2)
≥65	Reference	Reference	Reference	Reference
Sex				
Female	1.4 (1.2–1.6)	1.6 (1.0–2.5)	1.3 (1.0–1.5)	
Male	Reference	Reference	Reference	
Race/ethnicity				
White	Reference	Reference	Reference	Reference
Black	0.4 (0.3–0.7)	0.9 (0.5–1.6)	0.3 (0.2–0.4)	0.9 (0.5–1.6)
Hispanic	0.3 (0.2–0.4)	1.5 (0.8–2.8)	0.3 (0.2–0.4)	1.3 (0.7–2.6)
Asian	0.6 (0.4–0.8)	5.0 (2.4–10.4)	0.5 (0.4–0.7)	2.7 (1.1–6.4)
Other	0.6 (0.4–1.0)	(0.6–3.7)	0.7 (0.3–1.3)	1.2 (0.5–3.3)
Years in the United States (non-US-born)				
≤4	4.4 (3.3–5.8)		3.1 (2.3–4.4)	
5–19	2.6 (1.9–3.5)		2.0 (1.4–2.7)	
≥20	Reference		Reference	
Homeless any time during the previous year				
Yes	0.5 (0.3–1.1)	0.3 (0.1–1.0)		
No	Reference	Reference		
Excess alcohol use				
Yes	0.6 (0.4–0.9)	0.7 (0.4–1.2)		
No	Reference	Reference		
Known contact of an MDR-TB patient				
Yes	35.1 (19.7–62.5)	69.8 (26.9–180.9)	32.6 (14.6–72.6)	46.2 (16.3–130.7)
Missing		Reference	Reference	Reference

Risk factor and category	Bivariate models*		Multivariable models†	
	Non-US-born OR (95%CI)	US-born OR (95%CI)	Non-US-born aOR (95%CI)	US-born aOR (95%CI)
Previous TB disease				
Yes	5.5 (4.4–6.8)	2.2 (1.0–4.9)	6.5 (5.1–8.3)	2.8 (1.2–6.1)
No	Reference	Reference	Reference	Reference
Recent transmission				
Yes	0.7 (0.5–0.9)	0.6 (0.3–1.0)	0.6 (0.4–0.9)	0.4 (0.2–0.8)
No	Reference	Reference	Reference	Reference

* $P < 0.3$.

† $P < 0.05$.

MDR-TB = multidnug-resistant tuberculosis; OR = odds ratio; CI = confidence interval; aOR = adjusted OR.