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# Use of Transnational Services to Prevent Treatment Interruption in Tuberculosis-Infected Persons Who Leave the United States<sup>1</sup>

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A major problem resulting from interrupted tuberculosis (TB) treatment is the development of drug-resistant TB, including multidrug-resistant TB (MDR TB), a more deadly and costly-to-treat form of the disease. Global health systems are not equipped to diagnose and treat the current burden of MDR TB. TB-infected foreign visitors and temporary US residents who leave the country during treatment can experience treatment interruption and, thus, are at greater risk for drug-resistant TB. Using epidemiologic and demographic data, we estimated TB incidence among this group, as well as the proportion of patients referred to transnational care–continuity and management services during relocation; each year, ≈2,827 visitors and temporary residents are at risk for TB treatment interruption, 222 (8%) of whom are referred for transnational services. Scale up of transnational services for persons at high risk for treatment interruption is possible and encouraged because of potential health gains and reductions in healthcare costs for the United States and receiving countries.

**D**rug-resistant tuberculosis causes tremendous suffering and high death rates, as well as disruption to public health budgets and TB control efforts (1,2). Multidrug-resistant TB (MDR TB), defined as TB resistant to the 2 main TB drugs, is a growing concern, and current global health systems are inadequate to deal with this airborne, deadly pandemic disease (3,4). Mobile populations are more likely to have TB because of various risk factors (e.g., crowded housing and stress of relocating) and to spread TB in the absence of timely and effective intervention (5,6). Most TB cases in high-income nations are in persons born outside those nations (7,8). Mobility also contributes to a risk for treatment interruption, a key cause of drug resistance (5,6,9).

An understanding of the magnitude and dynamics of treatment interruption among mobile populations is essential for public health surveillance and policymaking. To elucidate this problem, we used epidemiologic and demographic data from organizations such as the World

Health Organization (WHO), US Department of Homeland Security (DHS), and Pew Hispanic Center to estimate the incidence of TB in a population at elevated risk for drug resistance, namely foreign-born persons who depart the United States before clinically recommended TB treatment was completed. We then estimated the proportion of those persons who received transnational care–continuity services by using case management data from the provider organizations (the nonprofit Migrant Clinicians Network [MCN], Austin, Texas, USA, and the County of San Diego TB Control Program, San Diego, CA, USA).

## Methods

### Population

The study population included any nonimmigrant, non-refugee, nonnative visitor to the United States during 2008–2012 who had TB and left the country before treatment completion (Table 1). Because persons visit the United States from many countries and via many routes, both legal and illegal, the study population was categorized into subgroups. Sufficient data were available to calculate person-years among those temporarily in the United States with authorization. This subpopulation included all nonimmigrant visitors and temporary residents because they had been in the country long enough to receive a diagnosis of TB but had visa restrictions that nearly assured TB treatment would not be finished before they left.

We classified authorized visitors into 7 categories (online Technical Appendix Table 1, <http://wwwnc.cdc.gov/EID/article/22/3/14-1971-Techapp1.pdf>): tourists and business travelers, students and exchange visitors, temporary workers, diplomats and other representatives, persons with any other visa class, persons with unknown visa class, and Canada and Mexico nationals not requiring an entry–exit (I-94) card. The remaining persons within the study population were in the country without authorization and were

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divided into 4 data-driven groupings: persons detained and then removed by US officials (nonexpedited), all other nonexpedited removals, persons from Mexico who voluntarily left, and all other persons who voluntarily left.

Six subgroups, including an expedited removal subgroup, were excluded (Table 1). Exclusion criteria comprised permanent US residency and no US entry or exit during the study period. MCN and Brandeis University (Waltham, Massachusetts, USA) Institutional Review Boards approved this study.

**Data**

To estimate incident TB cases, we needed TB incidence rates and number of person-years for each subgroup. We obtained person-years by combining an appropriate measure of time at risk for active TB with a measure of magnitude (e.g., number of nonimmigrant visa admissions) (Table 2). We obtained country-specific TB incidence rates per 100,000 person-years from WHO (10). As in other studies (11), we defined countries with high, medium, and low TB incidence as  $\geq 100$ , 15–99, and 0–14 cases per 100,000 person-years, respectively.

**Table 1.** Study population inclusion and exclusion criteria, data sources, and estimation equations used to determine number at risk of treatment interruption among TB-infected, authorized and unauthorized visitors to the United States, 2008–2012\*

Subgroup	Justification	References	Calculation method
<b>Included in study</b>			
Resided in the United States with authorization†			
Tourist or business travelers	Left United States after <2 mo	(10–15)	$PY \times (\text{country-specific TB incidence rate})\ddagger$
Student or exchange visitors	Left United States after <9 mo	(10–15)	$PY \times (\text{country-specific TB incidence rate})\ddagger$
Temporary workers	Left United States after <5 mo	(10–15)	$PY \times (\text{country-specific TB incidence rate})\ddagger$
Diplomat or other representatives	Left United States after <3 mo	(10–15)	$PY \times (\text{country-specific TB incidence rate})\ddagger$
Persons with all other visa types	Left United States after <1 mo	(10–15)	$PY \times (\text{country-specific TB incidence rate})\ddagger$
Persons with unknown visa type	Left United States after <2 mo	(10–15)	$PY \times (\text{country-specific TB incidence rate})\ddagger$
Visitors from Canada and MX without I-94 card	Left United States after <1 mo	(10–15)	$PY \times (\text{country-specific TB incidence rate})\ddagger$
Resided in United States without authorization			
Detained first and then removed by US officials	Left United States; subgroup in this category for which most data was available	(12,16,17)	No. detainees $\times$ (183/365) $\times$ TB incidence rate for detainees $\times$ proportion removed§
All other removals meeting inclusion criteria	Left United States	(10,12,16,17)	(No. nonexpedited removals $\times$ estimated no. detained before removal) $\times$ (183/365) $\times$ (country-specific TB incidence rate)¶
MX nationals leaving United States of own volition	Left United States	(10,12,16,18,19)	No. MX nonexpedited removals $\times$ estimated % left voluntarily $\times$ (183/365) $\times$ (MX TB incidence rate)#
All other nationals leaving United States of own volition	Left United States	(10,12,16,18,19)	(Total who left voluntarily – MX left voluntarily) $\times$ (183/365) $\times$ (57/100,000 PY)**
<b>Excluded from study</b>			
Resided in the United States with authorization			
Immigrants	Permanent residents; no requirement to leave United States	(12–15)	NA
Refugees	Permanent residents	(12–15)	NA
Asylees	Permanent residents	(12–15)	NA
Resided in the United States without authorization			
Currently residing in the United States	Did not leave United States during study period	(12,16,18)	NA
Returnees and expedited removals††	Did not officially enter United States	(12,16,18)	NA
Detained but not removed	Did not leave United States during study period	(12,16,18)	NA

\*Study population is defined as those who were born outside the United States, had active tuberculosis while in the United States, and then left the United States before treatment completion was possible. I-94 card, the entry/exit form that all nonimmigrant visitors (except certain ones from MX and Canada) must fill out; MX, Mexico/Mexican; NA, not applicable; PY, person-years; TB, tuberculosis.

†These subgroups included family members. See online Technical Appendix Table 1 (<http://wwwnc.cdc.gov/EID/article/22/3/14-1971-Techapp1.pdf>) for a complete list of visas for each subgroup and their corresponding mean and median length of stay.

‡Calculated for all countries, 2008–2012. PY = no. of admissions  $\times$  (weighted mean length of stay in days/365). Weighted median length of stay was used for all these groups in sensitivity analyses, except those without an I-94 card, as only the mean was available. See online Technical Appendix Tables 3–6 for results.

§183 d, or 6 mo, of risk was assumed as the minimum amount of time for TB to be diagnosed, treatment started, and a treatment interruption caused by leaving the United States.

¶Calculated for top 12 receiving countries by using World Health Organization country-specific TB incidence rates. All other countries grouped together and multiplied by the midpoint TB incidence rate of 57 cases/100,000 PY.

#Calculated for MX nationals; they make up the majority (assumed at 90%) of this subgroup.

\*\*All other countries' nationals assumed to make up 10% of this subgroup; the midpoint incidence rate of TB burden was 57 cases/100,000 PY.

††These are 2 immigration enforcement categories with specific definitions used by US Department of Homeland Security (16).

We obtained the number of nonimmigrant visas issued in 2008–2012 from the US Department of State (15) and the number of nonimmigrant visa admissions with median and mean lengths of stay (LOS) for each country from DHS (12,13). We categorized nonimmigrant visa admissions into 7 groups, including a group of nonimmigrant visitors from Canada and Mexico without an I-94 card. DHS also provided data on the proportion of these admissions from Canada (28.5%) and Mexico (71.5%) (12,14).

We used DHS data (reported in aggregate and categorized by top receiving countries) on the number of compulsory and confirmed departures from the United States (12,16). To extrapolate the number of voluntary exits for persons from Mexico, we used previously estimated percentages (18) of Mexican nationals involuntarily returning home and mean LOS before removal. We used data reported by Schneider and Lobato (17) on TB case rates and removal rates for persons detained by US immigration officials.

We estimated the number of persons served by transnational care coordination services by using published case

management data from the 2 existing referral programs, Health Network (previously known as TBNet) and CureTB. MCN operates Health Network, which began in 1998 and provides bridge case management, care continuity, patient education and navigation, and bidirectional communication between providers on behalf of patients for high-value interventions. In 2011, Health Network managed patients returning to >50 countries and achieved an 84.7% treatment completion rate (20). CureTB, operated by the County of San Diego, started managing binational (United States and Mexico) TB cases in 1997 and recently expanded to manage cases in persons moving to Central America; CureTB reported a 79% treatment completion rate (21).

### Statistical Analysis

Some subgroups had better data available for estimating incident TB cases; therefore, we present the analyses in order of increasing complexity (Table 1) and then discuss calculations regarding the transnational care–continuity services. First, we estimated incident TB cases for authorized vis-

**Table 2.** Admissions, person-years, incident tuberculosis cases, and case rates stratified by visa group and tuberculosis burden level for persons temporarily in the United States, with authorization, 2008–2012\*

Visa group†	Admissions (%)	PY (%)	Tuberculosis		
			Total no. cases (%)	No. cases/100,000 PY (95% CI)	No. cases/100,000 admissions (95% CI)
Tourist and business traveler	201,578,207 (25)	14,431,062 (47)	6,161 (48)	43 (36–49)	3 (3–4)
High-burden countries	13,858,503 (2)	1,277,466 (4)	2,614 (20)	205 (174–235)	19 (16–22)
Medium-burden countries	126,042,138 (15)	10,733,970 (35)	3,342 (26)	31 (26–36)	3 (2–3)
Low-burden countries	61,677,566 (8)	2,419,625 (8)	205 (2)	8 (7–10)	0
Student/exchange visitor‡	9,417,888 (1)	6,293,260 (21)	3,675 (28)	58 (50–67)	39 (33–45)
High-burden countries	1,862,032	1,244,255 (4)	2,040 (16)	164 (139–189)	110 (93–126)
Medium-burden countries	4,932,913 (1)	3,296,292 (11)	1,516 (12)	46 (39–53)	31 (26–35)
Low-burden countries	2,622,943	1,752,714 (6)	118 (1)	6 (5–7)	5 (4–5)
Temporary worker‡	12,904,847 (2)	4,948,262 (16)	2,319 (18)	47 (40–54)	18 (15–21)
High-burden countries	2,154,566	826,151 (3)	1,604 (12)	194 (165–223)	74 (63–86)
Medium-burden countries	5,252,984 (1)	2,014,215 (7)	587 (5)	29 (25–34)	11 (10–13)
Low-burden countries	5,497,297 (1)	2,107,895 (7)	128 (1)	6 (5–7)	2 (2–3)
Diplomat and other representative‡	1,761,901	381,343 (1)	243 (2)	64 (54–73)	14 (12–16)
High-burden countries	332,182	71,897	167 (1)	232 (198–267)	50 (43–58)
Medium-burden countries	819,393	177,348 (1)	66 (1)	37 (31–42)	8 (7–9)
Low-burden countries	610,326	132,098	10	8 (7–9)	2 (1–2)
All other classes	2,267,465	119,836	107 (1)	90 (76–103)	5 (4–5)
High-burden countries	905,522	38,206	89 (1)	232 (197–267)	10 (8–11)
Medium-burden countries	1,107,955	46,747	18	38 (32–44)	2 (1–2)
Low-burden countries	253,988	34,884	0.8	2 (2–3)	0
Unknown visa class	1,123,438	90,579	52	57 (49–66)	5 (4–5)
High-burden countries	71,316	6,643	16	236 (200–271)	22 (19–25)
Medium-burden countries	792,676	73,838	35	47 (40–54)	4 (4–5)
Low-burden countries	259,446	10,098	2	17 (14–20)	1 (1–1)
Canada and Mexico nonimmigrant without I-94 card	592,645,430 (72)	4,266,235 (14)	371 (3)	9 (7–10)	0
Total	821,699,176	30,530,577	12,928	NA	NA
Annual average	164,339,835	6,106,115	2,586	NA	NA

\*I-94 card, the entry/exit form that all nonimmigrant visitors (except certain ones from Mexico and Canada) must fill out; NA, not applicable; PY, person-years.

†High-burden countries were defined as having  $\geq 100$  TB incident cases/100,000 PY; medium-burden countries were defined as having 15–99 cases/100,000 PY, and low-burden countries were defined as having 0–14 cases/100,000 PY.

‡Corresponding spouses and children are also included in each of these categories; see online Technical Appendix Table 1 (<http://wwwnc.cdc.gov/EID/article/22/3/14-1971-Techapp1.pdf>) for full list of visas included in each subgroup.

itors in the United States stratified by visa group, country, and year and subsequently aggregated across levels of TB burden before final summation. We started by calculating a weighted mean LOS for each visa group (online Technical Appendix Table 1) and then applied the following equation (Equation 1):

$$\text{incident TB cases} = (\text{person-years for visitors with authorization}) \times (\text{country-specific TB incidence})$$

where person-years = (no. of admissions)  $\times$  (mean LOS in days/365 days per year). For example, in 2008 there were 163,845 persons from South Korea in the students and exchange visitors subgroup who stayed a mean of 244 days, resulting in 109,485 person-years (12). As a sensitivity analysis, we substituted available weighted median LOS and found 79,005 person-years (online Technical Appendix).

For the group with unknown visa type, we used mean LOS (34 days) for all visas (13). Persons from Canada and Mexico without an I-94 card had a mean LOS of 3.7 and 1.1 days, respectively (13). We used birth-country TB case rates because past studies suggested TB activation rates among non-US-born persons most closely match their TB risk at home (22,23). For admissions with no country, we applied the midpoint rate from the medium-incidence category (i.e., 57 cases/100,000 person-years) after testing it against the global average rate of 122 cases/100,000 person-years (24).

We further calculated TB cases per 100,000 person-years and 100,000 admissions, along with 95% CIs, assuming a Poisson distribution (online Technical Appendix). Another sensitivity analysis, using I-94 visa counts from US Department of State (15), provided an alternative to the 95% CI. We calculated the range within which the actual number of cases should fall by adapting equation 1. For the lower bound, we assumed 1 admission per visa (despite multiple-entry visas) and replaced admissions with visa counts. For the upper bound, we assumed each visitor had 12 months of risk, the highest possible value.

Second, we estimated TB cases for persons in the United States without authorization whom US officials removed. We began by adapting Equation 1 and multiplying by proportion (17) of persons removed postdetention (Table 1). We assumed a 6-month risk for all unauthorized subgroups because that is the minimum amount of time required to receive a diagnosis of TB infection, begin treatment, and still leave the United States before treatment completion. Sensitivity analyses included varied parameters of time at risk, TB case rate, and proportion removed (online Technical Appendix). We then estimated, again adapting Equation 1, TB cases for all remaining persons who were in the country without authorization. For these person-years, we separately calculated

removals for each year among the group of top receiving countries (i.e., Brazil, China, Colombia, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, India, Jamaica, Mexico, Nicaragua) and among the all other countries group. For the all other countries group, we used the midpoint TB case rate (57 cases/100,000 person years). In sensitivity analyses, we varied the time at risk for TB from a maximum of 9 months to a minimum represented by a weighted mean LOS in the United States before removal (i.e., 140 days) (18). This calculation was done for all 4 subgroups of persons in the United States without authorization.

Third, we estimated TB cases for persons in the United States without authorization who subsequently voluntarily left. Because most of this subpopulation consists of persons from Mexico, which is also the group for which most data were available (18), we began with the DHS-reported numbers of total nonexpedited removals of Mexican nationals (16). We applied equation 1 to the following unique person-years (Equation 2):

$$\text{person-years of unauthorized Mexican nationals leaving US on own} = ([\text{total unauthorized Mexican nationals leaving}] - [\text{Mexican, nonexpedited removals}]) \times (183/365)$$

where total unauthorized Mexican nationals leaving = Mexican nonexpedited removals/35%. We used the highest proportion of involuntary to voluntary departures (35:65) (18) because of an increase in removals in the past decade (25). A report from Mexico on migratory flows provided corroborative evidence for our estimate of total departures of Mexican nationals (19).

To obtain the final estimate of TB cases among subgroups without authorization, we assumed that persons from Mexico made up 90% of those who voluntarily left the United States because they are the documented majority of migrants (18), Mexico is a bordering nation, and local antiimmigration laws tend to target unauthorized visitors from Mexico (19,26). We then adapted Equation 2 and applied the 90% assumption.

Next, we estimated the number in the study population who were referred for transnational care-continuity services by extrapolating from and adding previously reported provider data (20,21,27,28). No evidence was found that any of these persons met 1 of 4 relevant exclusion criteria.

Last, we calculated the proportion of the study population who received transnational services to mitigate drug resistance and other negative consequences of interrupted TB treatment. To do this, we divided the number of persons receiving services by the estimated number of incident TB cases. We also estimated the proportion of referred cases included in the detained-then-removed subgroup.

**Table 3.** Estimated number of incident tuberculosis cases for all subgroups at risk for treatment interruption due to voluntary or involuntary departure from the United States, 2008–2012\*

Study subgroup	No. cases, by year					Yearly average (%)
	2008	2009	2010	2011	2012	
<b>Resided in United States with authorization</b>						
Tourist and business traveler	1,099	987	1,219	1,403	1,454	1,232 (44)
Student and exchange visitor†	696	657	785	791	745	735 (26)
Temporary worker‡	474	394	473	503	475	464 (16)
Diplomat and other representative‡	47	46	50	50	49	49 (2)
All other NIV classes	24	22	21	21	20	21 (1)
Unknown NIV class	10	9	15	10	8	10
Canada residents, no I-94 card	21	19	15	15	15	17 (1)
Mexico residents, no I-94 card	64	60	54	52	55	57 (2)
<b>Resided in United States without authorization</b>						
Detained then removed	173	175	166	196	218	186 (7)
Nondetained, removed	6	6	6	6	6	6
Mexico resident, voluntary departures	35	42	39	40	39	39 (1)
All other voluntary departures	10	12	11	11	11	11
<b>Total</b>	<b>2,659</b>	<b>2,430</b>	<b>2,853</b>	<b>3,099</b>	<b>3,094</b>	<b>2,827</b>

\*I-94 card, the entry/exit form that all nonimmigrant visitors (except certain ones from Mexico and Canada) must fill out; NIV, nonimmigrant visa.

†Corresponding spouses and children were included in each of these categories; see online Technical Appendix Table 1

(<http://wwwnc.cdc.gov/EID/article/22/3/14-1971-Techapp1.pdf>) for full list of visas included in each subgroup.

## Results

The cumulative number of incident TB cases among the study population was 14,134, and the annual average incidence was 2,827 cases (95% CI 2,440–3,213; Table 3) among an estimated annual population of 6.9 million. The sensitivity analysis using available median LOS resulted in 1,544 annual cases (95% CI 1,249–1,840; online Technical Appendix Tables 3–6). Further sensitivity analysis using visa count data produced an annual range of 1,352–4,637 cases.

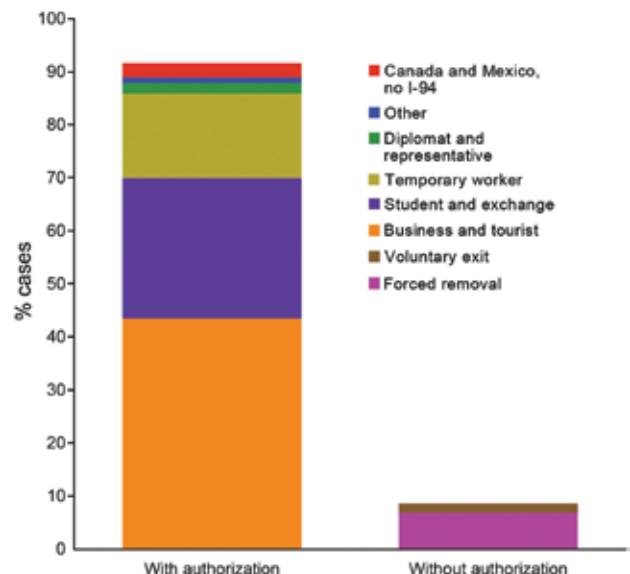
For the authorized subpopulations, we calculated a total of 30,530,577 person-years and 12,928 cases during 2008–2012. Tourist and business travelers represented 47% (14,431,062) of these person-years; students and exchange visitors, 21% (6,293,260); temporary workers, 16% (4,948,262); diplomats, 1.2% (381,343); and persons from Canada and Mexico without an I-94 card 14% (4,266,235). Tourist and business travelers from medium-incidence countries accounted for most cases (3,342; 26%). However, students and exchange visitors from countries with a high TB incidence had the highest number of cases per 100,000 admissions (110, 95% CI 93–126), followed by temporary workers from high-incidence countries (74, 95% CI 63–86), diplomats from high-incidence countries (50, 95% CI 43–58), and students and exchange visitors from medium-incidence countries (31, 95% CI 26–35).

Among the subpopulations without authorization, we calculated a total of 1,206 incident TB cases, representing an annual average of 241 (Table 3). Persons removed by US officials and those who left voluntarily represented 958 and 259 cases, respectively. These subpopulations represented 8.5% (241/2,827) of annual cases (Figure). Sensitivity analyses showed an annual range of 180–324 cases (6.4%–11.5% of total).

We estimated CureTB and Health Network managed 510 and 599 TB cases, respectively, for a collective annual average of 222 cases during the study period (Table 4). Thus, 7.9% (222/2,827) of persons leaving the United States before treatment completion received transnational care–continuity services. We further estimated that 67% (124/186) of persons who received transnational services belonged to the subgroup that was detained before removal.

## Discussion

We estimated that, during 2008–2012, a substantial number of TB-infected persons were at risk for drug resistance



**Figure.** Estimated percentage of incident tuberculosis cases among authorized and unauthorized visitors to the United States who were at risk for treatment interruption due to voluntary or involuntary departure from the country, 2008–2012. Key indicates subgroups of visitors by visa status.

**Table 4.** Estimated number of persons with tuberculosis referred for transnational care–continuity services to prevent treatment interruption due to voluntary or involuntary departure from the United States, 2008–2012

Variable	Total no. estimated cases among study population*	No. cases managed by CureTB†	No. cases managed by Health Network
Year			
2008	2,659	90	106
2009	2,430	111	95
2010	2,853	108	109
2011	3,099	111	134
2012	3,094	90	155
Annual average (% referred)	2,827 (8)	102	120
Total incident cases from detained and removed subgroup (% referred)	928 (67)	180	442
Annual average for subgroup	186	36	88

\*Study population was defined as nonimmigrants, nonrefugees who were born outside of the United States had active tuberculosis while in the United States, and then left the United States before treatment completion was possible.  
†Numbers for 2008 and 2009 were extrapolated by using previously reported data from 2010–2012 (27,28).

because of treatment interruption due to departure from the United States. During that time, 14,134 cases of incident TB occurred among visitors to the United States, representing a yearly average of 2,827 cases (2,586 and 241, respectively, among persons with and without authorization). Approximately 10% of these persons received transnational care–continuity services (from Health Network or CureTB). Thus, ~90% of infected persons departed the country without such services, a finding that highlights a neglected public health area and the feasibility of scaling up intervention.

Pathogens that cause TB are transmitted via breathing, and the disease has a high death rate if untreated (29), thereby incurring severe negative externalities for the public's health and economic wellbeing (30). A single untreated case can lead to hundreds of new infections (31,32). If treatment is interrupted, the situation is worsened because of the risk for poorer outcomes (29). Our findings contribute to TB control efforts by elucidating characteristics of an understudied population at risk for acquiring and spreading drug-resistant TB (6) and by highlighting opportunities to prevent this serious threat to the public's health and the corresponding fiscal consequences. Moreover, our findings contribute to previously identified needs for improving screening practices for migrants (33) and for understanding how best to target TB prevention and control efforts (7). Our findings build on those of Liu et al. (11), particularly the finding that temporary residents contribute appreciably to illness in the United States caused by TB; the reported number of TB cases in 2012 was 9,945, of which 6,274 were among foreign-born persons (8). Our estimate of 2,827 yearly cases among visitors to the United States does not entirely overlap with the number from that report because we counted persons with <90 days of treatment (34) and we captured undiagnosed cases.

Little is known about TB cases among subpopulations living in the United States without authorization. The attribution of only 8.5% of cases to this subgroup contradicts widespread opinion that TB in the United States is primarily due to illegal immigration. Moreover, 8.5% is consistent

with the finding in a multinational study (35). A county-level study found 25% of TB cases in the unauthorized population (36), but it is difficult to generalize from a single county's data. A related and somewhat encouraging finding was that 67% (124/186) of persons receiving transnational services were among the most vulnerable subgroup (those detained before removal). Ideally, no one would be forcibly relocated until after treatment completion (35), but assuring all who are removed receive transnational services is another way to avoid treatment interruption and development of drug-resistant TB. Our findings suggest that scaling up transnational care–continuity services is feasible and desirable, given the likely return on investment (9,30). Furthermore, removal of unauthorized visitors from the United States has been increasing over the past decade (25), suggesting incident TB cases among this subgroup will remain at estimated levels or decrease in future years. The Obama administration's executive action in November 2014 to provide immigration relief to specific persons without authorization to enter the United States may slightly reduce this estimate because it temporarily halts deportation.

The authorized subgroups differ from each other, just as the unauthorized subgroups differ in risk and migratory profiles. Therefore, here we consider program and policy implications separately by subgroup. First, we concur with the suggestion by Liu et al. (11) to prescreen only subgroups that have the highest case rates per 100,000 admissions and are in the United States long enough to make postarrival medical follow-up feasible and worthwhile. This policy would affect students, exchange visitors, and temporary workers from countries with high TB incidences and expand the successful prescreening–plus–follow-up policy for immigrants and refugees (37). If persons in these subgroups do not stay in the United States long enough to complete treatment, they should be referred for transnational care–continuity services. Any compulsory screening program must be accompanied by regard for civil liberties and medical ethical principles (6). In addition, some persons with TB who leave the country complete treatment

without the aid of transnational services; however, case management increases the likelihood of completion, and US-based providers would have more data should a patient return, a probable occurrence for many (9).

Second, diplomats and other representatives from high-incidence countries also had a relatively high TB case rate, but the number of admissions was not sufficient to make prescreening a high-yield activity. Political calculus also weighs heavily for this group of visitors, and diplomats tend to have preexisting mechanisms for health emergencies. Therefore, further intervention is impractical or unnecessary.

Third, when a large volume of admissions to the United States and relatively low TB case rates are combined, referral to transnational care—continuity services after TB diagnosis is more rational than prescreening. Subgroups falling into this category are tourist and business travelers; persons from Canada and Mexico entering without an I-94 card; and any authorized visitor from a country with medium or low TB incidence, except for diplomats.

Last, subgroups without authorization to enter the United States have little interaction with formal systems that would help to identify and treat their TB infections in a timely manner. This situation is especially true in the wake of the Affordable Care Act of 2010, which prohibited such persons from purchasing private health insurance (38). The best option in this circumstance is to refer unauthorized visitors for transnational services immediately after they are diagnosed with TB. Persons who are detained by immigration officials are typically screened for TB (17); this practice should continue, as it increases the chances of referral for transnational care—continuity services.

Our study had limitations. First, there were time lags in DHS data (16), thus, where available, we used postadjustment numbers for removal totals. Also, in 2010, DHS started counting all visa admissions separately rather than counting multiple entries for 1 person as 1 admission. An increase resulted, particularly among admissions from Canada and Mexico (12), suggesting that estimates from 2009 and earlier were biased toward undercounting. This change also represents the second biggest factor in the difference between our estimate and those from previous studies (11). Nevertheless, given the affected subgroups, the policy implications do not change.

Second, there was uncertainty around the time at risk for TB. However, our sensitivity analyses varied this input in both directions for the unauthorized subpopulations, and the findings remained robust. For the authorized subpopulations with an I-94 card, substituting median LOS for mean LOS dramatically reduced time at risk. The overall estimate was nearly halved, but the order of magnitude was the same, as do intervention recommendations,

with the exception that prescreening for temporary workers from high-incidence countries might no longer be a high-yield intervention. Furthermore, the available LOS data are highly suggestive of smooth skews rather than random outliers with problematic influence (13); thus, the best way to statistically account for those days at risk is by using mean LOS.

Third, a conservative bias was introduced by global TB underreporting (39), which affected the estimated number of cases and corresponding CIs. A countervailing bias was introduced by not adjusting for visitor socioeconomic status or age upon US entry because of insufficient data. Moreover, data from our sources were consistent with those in similar studies (11). Additional bias toward overcounting occurred due to lack of data on visitors who adjusted status to permanent residency, for whom TB screening is required. Because most of those who adjust status come from the group for whom we recommended preentry screening and postentry follow up, our recommendation remains unchanged and would aid visitors who adjust their status, because they will have completed their TB screening early.

The 2,827 annual cases would include some drug-resistant TB cases, depending on the strain contracted. Drug-resistant and MDR TB lend urgency to achieving treatment completion; however, without additional mechanisms besides the international referral form, US clinicians and health departments rarely know outcomes for patients exiting the country. In contrast, CureTB and Health Network have documented completion rates, approaching the WHO target of 85% (20,21,24). Therefore, our recommendation to refer these patients for transnational services is justified in order to reduce the number and spread of these deadly and costly conditions.

In summary, TB in mobile persons in the United States is not well understood and represents a particular challenge to global TB control (6), as well as a key opportunity to reduce development and spread of drug-resistance. Our findings provide new epidemiologic evidence that will inform an effective TB control strategy (6). Because many mobile persons with TB may return to the United States (9) and the global prevalence of MDR TB is increasing (4,24), scaling up transnational care—continuity services would benefit the US directly and bolster international TB control efforts (40). Use of such services would reduce suffering, save lives, build goodwill with receiving countries, improve global TB surveillance data, and bolster economic productivity. Access to healthcare varies among subgroups of mobile, TB-infected persons; however, programs like CureTB and Health Network are able to serve all subgroups. The most complete policy response may be to make these services available to public and private clinicians alike.

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# Use of Transnational Services to Prevent Treatment Interruption in Tuberculosis-Infected Persons Who Leave the United States

## Technical Appendix

### Median Length of Stay versus Mean Length of Stay

The primary reason for our estimates of incident TB cases being greater than similar studies (*1*) is our methodological choice to use mean length of stay (LOS) rather than the median LOS. The challenge was to balance legitimate concern about the influence of very long stays with the desire to capture all time-at-risk for as accurate an estimate of TB cases as possible. The main limitation to using median LOS is that it does not use the data at the end of a skewed distribution. The main limitation to using mean LOS is that outliers can create noise in one's calculations. We compared the means versus medians (Appendix Table 1), as well as the frequency distributions (i.e., stays for <six months, 6–12 months, and >one year) for all the visa categories where data was available (*2*). There is some variation in the ratios between the means and medians, but the evidence is most supportive of smooth distributions with a skew rather than outliers with undo influence. For example, the B-2 visa class (i.e., temporary visitors for pleasure) was weighted using 5.6 million records. The mean LOS was 48 days and the median was 13. While that represents a dramatic ratio of nearly 4:1, there were 7.2% that stayed between 6 months to a year, or significantly longer than 13 days. Moreover, nearly 1%, or 45,000 persons, stayed for over a year, representing  $\approx 45,000$  person-years that would not be captured by the use of the median LOS.

Finally, the calculations involve aggregates of 202,766 to 12,199,633 records per subgroup. This large volume is protective against noise introduced by outliers. Therefore, we maintain that the best statistical approach to our person-year calculations was to use mean LOS, as this allowed us to capture the impact of the notable proportions of people staying substantially

longer than their peers in each visa category. Nevertheless, we are very cognizant that our estimates seem high, particularly those familiar with the U.S. TB surveillance system. Thus, we recalculated every estimate for which a weighted median LOS was available (see next section).

We also investigated another aspect as to why our estimates are higher than Liu et al., specifically the impact of the Department of Homeland Security's 2010 change in counting admissions methodology. In short, more admissions were counted, rather than being obscured by the fact that some visas allow multiple entries, and therefore, multiple times at risk for TB activation. For example, the "tourists and business travelers" (with a visa) subgroups had a weighted median LOS of 6.7 and 11.2 days, respectively in our calculations, and 7 days in those of Liu and colleagues. This led to 203 (199 TB and 4 MDR TB) annual cases from 552,984 person-years at risk in their estimates, while we calculated 379 for 1,006,560 person-years at risk. In contrast, for the "diplomats and other representatives" subgroup – predominantly unaffected by the change in counting methodology – we found 13 TB cases and Liu et al. estimated 11.

### **Sensitivity Analyses for Subgroups with Authorization**

Our first sensitivity analyses for subgroups residing in the U.S. with authorization involved replacing the weighted mean LOS with a weighted median LOS where available (see Appendix Table 1 for a complete list) and holding all other methodology constant. The result was a total of 7,722 TB cases and an annual average of 1,544 cases (95% CI: 1,249–1,840). This means that TB cases among those without authorization would make up 15.6% (241/1,544) and those that received transnational care continuity and management services represented 14% (222/1,544) of total estimated cases (Appendix Tables 3–6).

We conducted another set of sensitivity analyses using visa count data from the U.S. Department of State (DOS). This provided an alternative to the 95% CI by calculating the range within which the actual number of incident cases should fall by adapting our primary person-years equation (equation 1, Table 1). For the lower bound, we assumed an average of only one admission per visa (despite multiple-entry visas) and replaced admissions with visa counts, stratified by country and year. For the upper bound we assumed each visa-holder had 12 months of risk, the highest possible value. When using the mean LOS for the visas, we found a

cumulative range of 6,761–23,186 cases, for an annual range of 1,352–4,637. After substituting median LOS where available, the annual range shifted to 649–4,637. The upper bound did not shift because in both cases, the maximum time-at-risk was 12 months. Both of these ranges are confirmatory of our findings.

### **Sensitivity Analyses for Subgroups without Authorization**

Passel and Cohen provided data on the amount of time Mexican nationals spent in the U.S. before being removed by U.S. officials (3). We took the midpoints and percentages of their three categories (i.e., greater than a year, between 1 year and 1 week, and less than a week) and calculated a weighted mean length of stay of 122 days. We then assumed that people from other nations would have a greater proportion staying in the U.S. longer because they invest more to arrive in the U.S. and immigration enforcement trends strongly discourage returning to one's home country for any reason other than by force (3–5). Thus, we assumed 50% were here more than a year and 50% were here less than a week, resulting in an estimated weighted mean stay of 186 days. We then combined these two means into a single value and multiplied the proportion of 2010 removals involving Mexicans versus all other countries (6). This weighted mean, i.e., 140 days, served as the time-at-risk for all persons being removed by U.S. officials. These three estimates of time-at-risk were then substituted in for the base-case assumption of 6 months (i.e., 183 days) at risk among all unauthorized visitors. We also estimated TB incident cases at 9 months of risk as a further sensitivity analysis, because it is possible that someone suffered a delay in diagnosis or a treatment interruption, began again, and then left the U.S. It is also possible that if the patient's TB is complex in any way, the treatment course will be closer to 9 months, increasing the time-at-risk for treatment interruption.

The American Civil Liberties Union of Massachusetts (ACLU) and the Transactional Records Access Clearinghouse (TRAC) Immigration tools provided key data on those detained by U.S. immigration officials (4,7,8). We expected to use their estimates of average time detained (for various portions of those detained) to adjust the time-at-risk parameter for our sensitivity analyses involving those present without authorization. Ultimately, there was not enough data to provide a viable substitute for additional sensitivity analyses.

There was limited evidence that the removal rate of those with TB who were first detained by immigration officials was closer to 69% (7) rather than our base case of 80%. Applying the 69% rate, we estimated 165 fewer cases among that subgroup (i.e., 763 over the same 5-year period). However, the data was too limited, i.e., it applied to only 1 month's worth of data for this subgroup, to report this removal rate rather than the one used from Schneider & Lobato (9).

The TB case rate among those detained by U.S. immigration officials held some uncertainty as well. Schneider and Lobato reported a "TB case rate" of 83 per 100,000 person-years in 2004 and 122/100,000 in 2005 (9), giving a weighted mean of 108/100,000. However, in the article text, it seemed that the case rate might have been a prevalence rate rather than an incidence rate, which is what we needed for our estimate of incident TB cases. We estimated a new case rate based on the equation of [prevalence = incidence x duration]. The duration of untreated TB is typically cited at 2 years (10), although there is some evidence of duration of 3 years in non-HIV-infected persons (11). The sensitivity analysis for this subgroup involved a TB case rate range of 36–64 per 100,000 person-years, yielding an estimated 339–496 incident TB cases, which was unrealistically low based on actual cases referred for transnational care-continuity services (i.e., an estimated 622 cases). Therefore, we proceeded with the weighted mean of 108/100,000.

## **Calculating Confidence Intervals**

There were multiple steps to calculate our 95% confidence intervals (CI), which we describe here in greater detail. First, we calculated the initial estimate of incident TB cases among the population present in the U.S. with authorization for each country, year, and visa grouping. We then aggregated the TB cases into subtotals according to low-, medium-, and high-burden levels within each visa grouping (plus the Canadian/Mexican without an I-94 category) for each of the 5 years, 2008–2012. We then assumed a Poisson distribution to each subtotal, which equated those incidence numbers with the mean of the distribution. They also equaled the variance since, for a Poisson distribution, the mean is equal to the variance. Taking the square root of the variance gave the standard deviation. With the standard deviation, we calculated the

CI for each subtotal by adding and subtracting to the mean the product of 1.96 times the standard deviation.

The next step was to add the distributions, since adding two Poisson distributions creates another Poisson distribution. Practically speaking, this meant we added the incident TB cases (i.e., the means), the lower bounds of TB cases (i.e., the means minus 1.96 times standard deviations), and the upper bounds of TB cases (i.e., the means plus 1.96 times standard deviations) for an estimated number of incident TB cases with 95% CIs for each year. By adding all the lower bounds together and all the upper bounds together, we obtained a conservative (i.e., wide) CI, which we thought appropriate given the large number of assumptions in our study.

At this point, we did not add the 5 year totals together since another underlying assumption of the Poisson distribution is that the events are independent, and the WHO's TB incidence rates for each country are related year-to-year. Therefore, we opted to apply the 2010 proportion of the CI width of the mean to the final 5-year annual case estimate for the entire study population (Appendix Table 2). This step again required adding the lower bound of the authorized subpopulation to the lower bound of the unauthorized subpopulation and adding the two upper bounds. The result was a wider CI, which we felt would better serve public health officials as they consider the response that might be needed for this new surveillance population we investigated. It is worth noting that the lower and upper bound estimates for the unauthorized population were not calculated using a Poisson distribution due to the fragmented nature of the available data. Rather, we obtained a realistic range through the sensitivity analyses described above, specifically, by varying the time-at-risk.

## **U.S.–Mexico Border Flow**

In general our study subgroups represent a comprehensive and mutually exclusive set of categories with regard to foreign-born individuals spending time in the U.S. There was one additional group that may have had overlap with one or more of our subgroups, specifically those that cross the U.S.-Mexico border multiple times a year. This category should generally only affect those without authorization, since the visa holders and the Mexican visitors without an I-94 card likely accounted for all of those that “flow” across the border with authorization. That being the case, we expected the number to be very small given the increased militarization of the

border since the Illegal Immigration Reform and Immigrant Responsibility Act of 1996. Due to the expected small numbers and the paucity of data, we did not attempt to calculate TB cases for that subgroup separately. We also did not include the possible contributions of various bi-national programs along the U.S.-Mexico border, e.g., Los Dos Laredos and Grupo Sin Fronteras (12). This is because they predominately deal with cases that do not leave the U.S. so much as cross back and forth or cases that remain in one country but had contacts located in the other. Furthermore, the estimated 30 (range, 0–60) cases that would fit into the current study's definition do not change the 8% proportion receiving transnational care-continuity services.

### **Accounting for Differences in Socio-economic Status and Age**

For the subgroups in the U.S. with authorization, there was the concern that applying the country TB incidence rate to all nonimmigrant visitors would overestimate the TB case rates among the visitors with higher socio-economic status (SES) (13). For example, Buskin et al. found that having one indicator of low SES led to 3.0 times the odds of having TB (14). While it is true that TB has long been associated with poverty, the pathways are more complicated than simply having higher income or more education. Davidow and colleagues discussed how many TB cases in New Jersey were found among those who were educated, employed, and living in an affluent locations (15). Nahid and colleagues compared TB risk between Blacks and Whites and found that SES did not explain the racial disparity in TB (16), which contradicts earlier findings that SES factors accounted for more than half of the increased risk for TB among minority groups in the U.S (17). Holtgrave & Crosby found social capital to be the strongest predictor variable in analyses that included poverty and inequality (18). Lonroth and colleagues suggested that the causal pathways have more to do with links between SES and proximate risk factors, i.e., those factors that increase exposure to infected droplets or decrease the host's defense against infection (13). Urbanization is a particularly potent risk factor for TB, which would impact people from most SES levels (13). Mitnick et al. found that TB risk based on origination from a high-income country was modified by conditions related to SES, particularly crowded living quarters (19); similarly, risk based on origination from a low-income country was mitigated by indicators of social support and access (19). This suggests that our chosen TB rates are both consistent with the literature (1), and that the biases due to SES differences may balance

out since those with low SES from low-burden countries would cause some undercounting and those with high SES from high-burden countries would cause some over-counting.

A similar situation arose from that fact that we did not have enough data to account for age upon U.S. entry. Cain et al. found different incident TB case rates among distinct age cohorts, with increasing rates as age grew (20). If the admissions data had been aggregated by age as well, then the estimated TB case rates here would likely be slightly lower. Nevertheless, we do not think this had a substantial impact on the findings because the majority of our study population was made up of business visitors, tourists, students, and temporary workers, thus the overwhelming majority fell into the 18–45 year-old range. This age range showed the most constant TB case rates in the Cain et al. study (20). Furthermore, our study implications and recommendations are robust whether the actual number of TB cases is somewhat greater or less than our estimate.

## **Other notes**

The majority of TB morbidity in the U.S. is imported because TB is still endemic in most of the world (21), while the U.S. has pursued TB control aggressively. However, since the majority of foreign visitors and residents to the U.S. also enter legally, the majority of imported TB follows that migratory pattern.

For any of the subgroups studied here, enrolling the patients in programs like Health Network or CureTB also has implications for domestic and global TB surveillance efforts. For example, Health Network updates the referring clinician after a final TB treatment outcome has been confirmed with the patient and the final treating clinician. An expansion of cases being managed after leaving a nation should make more data available regarding the magnitude and dynamics of TB on the move. Domestically, Health Network's services are also available for any TB case mobile within the U.S., and could serve as the necessary link between the clinician first identifying each case and public health officials (22).

The reported number of TB cases in 2012 was 9,945, of which 6,274 were foreign-born (23). Our yearly estimate of 2,827 would not entirely overlap with CDC's reported number because of the policy of not counting cases with fewer than 90 days of treatment (24), and our calculations capture undiagnosed cases. It is worth noting that a 2010 revision to the CDC report



form may improve surveillance data for those who leave the U.S. before completing 90 days of treatment once all jurisdictions utilize the revised portions fully (24).

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**Technical Appendix Table 1.** Weighted Median and Mean Lengths of Stay and Ratios for Nonimmigrant Visa Types by Visa Grouping\*

Visa type	No. † with visa type	Median LOS for visa type (days)	Weighted median LOS (days)	Mean LOS for visa type (days)	Weighted mean LOS (days)	Ratio, wt. mean to wt. median
<b>Visa waiver</b>						
GB	1,201	4	0.0	4	0.0	1.0
GMB	n/a	n/a	n/a	n/a	n/a	n/a
GT	87,697	3	0.0	4	0.0	1.3
GMT	n/a	n/a	n/a	n/a	n/a	n/a
WB	1,827,070	5	0.7	8	1.2	1.6
WT	10,283,665	7	5.9	11	9.3	1.6
<b>Subgroup total</b>	<b>12,199,633</b>		<b>6.7</b>		<b>10.5</b>	
<b>Business and tourist travelers</b>						
B-1	1,889,980	6	1.5	15	3.8	2.5
B-2	5,622,514	13	9.7	48	35.9	3.7
<b>Subgroup total</b>	<b>7,512,494</b>		<b>11</b>		<b>39.7</b>	
<b>Students and exchange visitors</b>						
F1	329,844	224	116.4	316	164.2	1.4
F2	21,729	199	6.8	260	8.9	1.3
J1	248,321	110	43.0	148	57.9	1.3
J2	29,213	196	9.0	253	11.6	1.3
M1	5,022	101	0.8	147	1.2	1.5
M2	602	29	0.0	85	0.1	2.9
<b>Subgroup total</b>	<b>634,731</b>		<b>176.1</b>		<b>243.9</b>	
<b>Temp workers and families</b>						
CW1	n/a	n/a	n/a	n/a	n/a	n/a
E1	36,489	60	2.2	114	4.1	1.9
E2	101,435	56	5.6	110	11.0	2.0
E3	n/a	n/a	n/a	n/a	n/a	n/a
H1B	262,880	91	23.7	173	45.0	1.9
H1B1	n/a	n/a	n/a	n/a	n/a	n/a
H1C	18	120	0.0	189	0.0	1.6
H2A	8,095	139	1.1	154	1.2	1.1
H2B	45,963	170	7.7	171	7.8	1.0

Visa type	No. † with visa type	Median LOS for visa type (days)	Weighted median LOS (days)	Mean LOS for visa type (days)	Weighted mean LOS (days)	Ratio, wt. mean to wt. median
H2R	n/a	n/a	n/a	n/a	n/a	n/a
H3	1,997	99	0.2	158	0.3	1.6
H4	70,597	198	13.8	268	18.7	1.4
I1	27,403	9	0.2	49	1.3	5.4
L1	247,850	37	9.1	83	20.4	2.2
L2	100,294	128	12.7	177	17.6	1.4
O1	20,469	30	0.6	76	1.5	2.5
O2	4,139	10	0.0	41	0.2	4.1
O3	2,618	98	0.3	166	0.4	1.7
P1	31,296	11	0.3	41	1.3	3.7
P2	1,463	21	0.0	82	0.1	3.9
P3	7,247	14	0.1	35	0.3	2.5
P4	1,065	109	0.1	144	0.2	1.3
Q1	1,250	164	0.2	194	0.2	1.2
R1	12,240	94	1.1	169	2.0	1.8
R2	2,716	110	0.3	179	0.5	1.6
TD	4,068	326	1.3	293	1.2	0.9
TN	18,983	311	5.8	246	4.6	0.8
<b>Subgroup total</b>	<b>1,010,575</b>		<b>86.6</b>		<b>140.0</b>	
<b>Diplomat and other representatives</b>						
A1 to A3	111,359	10	5.5	74	40.6	7.4
G1 to G5	82,450	32	13.0	80	32.5	2.5
N1 to N7	8,957	58	2.6	128	5.7	2.2
<b>Subgroup total</b>	<b>202,766</b>		<b>21.1</b>		<b>78.8</b>	
<b>All other classes</b>						
K1	3,889	161	1.5	220	2.0	1.4
K2	658	95	0.1	168	0.3	1.8
K3	1,546	98	0.4	136	0.5	1.4
K4	228	129	0.1	153	0.1	1.2
N8 to N9	52	39	0.0	105	0.0	2.7
T1 to T4	449	111	0.1	132	0.1	1.2
U1 to U4	134	114	0.0	153	0.0	1.3
V1 to V3	12,763	302	9.0	249	7.4	0.8
C1	168,222	1	0.4	8	3.1	8.0
C2	1,637	63	0.2	134	0.5	2.1
C3	8,496	1	0.0	4	0.1	4.0
C4	230,410	1	0.5	2	1.1	2.0
Q2 to Q3	373	148	0.1	172	0.1	1.2
<b>Subgroup total</b>	<b>428,857</b>		<b>12.5</b>		<b>15.4</b>	

Source: Grieco EM. Length of visit of nonimmigrants departing the United States in 2003: U.S. Department of Homeland Security, Office of Immigration Statistics; 2005.

\*Groupings according to Table 28 of the 2009–2013 Yearbooks of Immigration Statistics published by the U.S. Department of Homeland Security, Office of Immigration Statistics.

† LOS is length of stay; No. is number, wt. is weighted

‡ Weighted LOS was calculated by dividing the number of a given visa type by the total for the visa group and multiplying by the mean or median LOS for that specific visa. The sum of the weighted LOS gave the weighted mean or median LOS for the visa subgroup.

**Technical Appendix Table 2.** Overall Calculation of 95% Confidence Interval for Average Annual Incident TB Cases in Study Population

Group	Best estimate, TB* cases	Lower bound	Upper bound	Width	1/2 Width	Proportion, 1/2 width to incident TB†
Subpopulation with authorization, 2010	2,631	2,309	2,956			
Subpopulation without authorization, 2010	222	165	298			
Total study population, 2010	2,853	2,474	3,254	780	390	0.137
Total study population, 5-year annual average	2,827	2,440‡	3,213§			

\* TB is tuberculosis.

† Proportion used to calculate the overall study lower and upper bounds; TB is tuberculosis.

‡ The lower bound of the 95% confidence interval, calculated as [incident TB - (incident TB \* proportion)].

§ The upper bound of the 95% confidence interval, calculated as [incident TB + (incident TB \* proportion)].

**Technical Appendix Table 3.** Sensitivity Analysis of Admissions, Person-years, Incident Tuberculosis Cases, and Case Rates Stratified by Visa Group and Burden Level for Persons Temporarily in U.S. with Authorization†, 2008–2012

Visa group	Admissions (%)	PY* (%)	No. cases (%)	TB*	
				No./100,000 PY (95% CI)	No./ 100,000 admissions (95% CI)
Tourist and business traveler	201,578,207 (25)	5,034,802 (29)	1,893 (29)	38 (32–43)	1 (1–1)
High burden countries	13,858,503 (2)	390,778 (2)	771 (12)	197 (168–227)	6 (5–6)
Medium burden countries	126,042,138 (15)	3,415,731 (20)	1,017 (16)	30 (25–34)	1 (1–1)
Low burden countries	61,677,566 (8)	1,228,294 (7)	105 (2)	9 (7–10)	0 (0–0)
Student/exchange visitor‡	9,417,888 (1)	4,543,757 (27)	2,653 (41)	58 (50–67)	28 (24–32)
High burden	1,862,032 (0)	898,357 (5)	1,473 (23)	164 (139–189)	79 (67–91)
Medium burden	4,932,913 (1)	2,379,935 (14)	1,095 (17)	46 (39–53)	22 (19–26)
Low burden	2,622,943 (0)	1,265,466 (7)	86 (1)	7 (6–8)	3 (3–4)
Temporary worker‡	12,904,847 (2)	3,063,082 (18)	1,435 (22)	47 (40–54)	11 (10–13)
High burden	2,154,566 (0)	511,406 (3)	993 (15)	194 (165–223)	46 (39–53)
Medium burden	5,252,984 (1)	1,246,843 (7)	363 (6)	29 (25–34)	7 (6–8)
Low burden	5,497,297 (1)	1,304,833 (8)	79 (1)	6 (5–7)	1 (1–2)
Diplomat and other representative‡	1,761,901 (0)	101,852 (1)	65 (1)	64 (54–73)	4 (3–4)
High burden	332,182 (0)	19,203 (0)	45 (1)	232 (198–267)	13 (11–16)
Medium burden	819,393 (0)	47,368 (0)	618 (0)	37 (31–42)	2 (2–3)
Low burden	610,326 (0)	35,282 (0)	3 (0)	8 (7–9)	0 (0–1)
All other classes	2,267,465 (0)	83,339 (1)	87 (1)	104 (89–120)	4 (3–4)
High burden	905,522 (0)	31,011 (0)	72 (1)	232 (197–267)	8 (7–9)
Medium burden	1,107,955 (0)	37,944 (0)	14 (0)	38 (32–44)	1 (1–2)
Low burden	253,988 (0)	14,385 (0)	1 (0)	5 (4–5)	0 (0–0)
Unknown visa class	1,123,438 (0)	21,313 (0)	12 (0)	57 (49–66)	1 (1–1)
High burden	71,316 (0)	1,563 (0)	4 (0)	236 (200–271)	5 (4–6)
Medium burden	792,676 (0)	17,374 (0)	8 (0)	47 (40–54)	1 (1–1)
Low burden	259,446 (0)	2,376 (0)	0 (0)	17 (14–20)	0 (0–0)
Canadian and Mexican nonimmigrant without an I-94	592,645,430 (72)	4,266,235 (14)	371 (3)	9 (7–10)	0 (0–0)
<b>Total</b>	<b>821,699,176</b>	<b>17,114,381</b>	<b>6,516</b>		
<b>Annual average</b>	<b>164,339,835</b>	<b>3,422,876</b>	<b>1,303</b>		

\* CI is confidence interval; PY is person-years; TB is tuberculosis.

† High burden countries were defined as having ≥100 TB incident cases per 100,000 PY; medium-burden countries as having a case rate of 15–99, and low-burden countries, 0–14. Weighted median length of stay was used for all these groups, except those without an I-94 form, as only the mean was available.

‡ Corresponding spouses and children are also included in each of these categories; See Appendix Table 1 for full list of visas included in each subgroup.

**Technical Appendix Table 4.** Sensitivity Analysis for Estimated Incident Tuberculosis Cases for All Subgroups at Risk of Treatment Interruption Due to Leaving U.S.

Study subgroup	2008	2009	2010	2011	2012	Yearly average (%)
Resided in U.S. with authorization						
No.* cases, tourist & business traveler	337	305	374	430	446	378 (25)
No. cases, student & exchange visitor†	503	475	567	571	538	531 (34)
No. cases, temporary worker‡	293	244	293	311	294	287 (19)
No. cases diplomat & other representative‡	13	12	13	13	13	13 (1)
No. cases, all other NIV classes	19	18	17	17	16	17 (1)
No. cases, unknown NIV class	2	2	3	2	2	2 (0)
No. cases, Canadian non-I-94s	21	19	15	15	15	17 (1)
No. cases, Mexican non-I-94s	64	60	54	52	55	57 (4)
Resided in U.S. without authorization						
No. cases, detained then removed	173	175	166	196	218	186 (12)
No. cases, non-detained, removed	6	6	6	6	6	6 (0)
No. cases, MX voluntary departure	35	42	39	40	39	39 (3)
No. cases, all other voluntary departure	10	12	11	11	11	11 (1)
<b>Total</b>	<b>1,476</b>	<b>1,370</b>	<b>1,558</b>	<b>1,664</b>	<b>1,653</b>	<b>1,544</b>

\* MX is Mexican; NIV is nonimmigrant visa; No. is number.

† Corresponding spouses and children were included in each of these categories; See Appendix Table 1 for full list of visas included in each subgroup.

**Technical Appendix Table 5.** Sensitivity Analysis for Estimated Incident Tuberculosis Cases Referred for Transnational Care Continuity Services

Year	Study total estimated cases*	CureTB-managed cases†	Health Network–managed cases
2008	1,476	90	106
2009	1,370	111	95
2010	1,558	108	109
2011	1,664	111	134
2012	1,653	90	155
Annual average (% referred)	1,544 (14)	102	120
Total incident TB cases from detained & removed subgroup (% referred)	928 (67)	180	442
Annual average for subgroup	186	36	88

\*Study population was defined as nonimmigrants, nonrefugees who were born outside of the U.S., had active tuberculosis while in the U.S., and then left the U.S. before treatment completion was possible, 2008–2012, inclusive. TB cases estimates included use of weighted median lengths of stay.

† 2008 and 2009 numbers were extrapolated using previously reported data from 2010–2012 (25, 26).

**Technical Appendix Table 6.** Sensitivity Analysis for Overall Calculation of 95% Confidence Interval for Average Annual Incident TB Cases in Study Population

Group	Best estimate, TB* cases	Lower bound	Upper bound	Width	1/2 Width	Proportion, 1/2 width to incident TB†
Subpopulation with authorization, 2010‡	1,336	1,106	1,569			
Subpopulation without authorization, 2010	222	165	298			
Total study population, 2010	1,558	1,271	1,867	596	298	0.19
Total study population, 5-year annual average	1,544	1,249§	1,840¶			

\* TB is tuberculosis.

† Proportion used to calculate the overall study lower and upper bounds; TB is tuberculosis.

‡ Estimates for incident TB cases included the use of both weighted mean and median lengths of stay.

§ The lower bound of the 95% confidence interval, calculated as [incident TB - (incident TB \* proportion)].

¶ The upper bound of the 95% confidence interval, calculated as [incident TB + (incident TB \* proportion)].