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Nancy Morisseau Date

Tuberculosis Screening Among Immigrants Entering the United States: An Analysis of Radiographic Findings of China, Mexico, Nepal, Philippines and Vietnam

By

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Degree to be awarded: MPH
Global Health

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By

Nancy Morisseau
B.S. The Pennsylvania State University, 2008

Thesis Committee Chair: Kenneth Castro, MD, FIDSA

An abstract of
A thesis submitted to the Faculty of the Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health in Global Health
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Abstract

Tuberculosis Screening Among Immigrants Entering the United States: An Analysis of Radiographic Findings of China, Mexico, Nepal, Philippines and Vietnam

By Nancy Morisseau

Background
Tuberculosis (TB) is a closely monitored disease by the U.S. Centers for Disease Control and Prevention (CDC). Individuals applying for immigration or refugee visas are required to undergo a pre-arrival medical screening that includes an explicit TB screening component. In 2015, twice as many TB cases were identified in foreign-born persons than U.S.-born.

Methods
An analysis was conducted of deidentified data from 2010-2016 collected by CDC's Division of Global Migration and Quarantine. The data was provided by panel physicians and only included individuals classified as either Class A TB or B1 TB under CDC TB Technical Instructions (TI). The screening data were analyzed to determine the association between chest x-ray (CXR) findings and Class A TB (i.e. active TB disease) designation.

Results
Among the 98,350 individuals included in the study, 9.7% were classified as Class A TB. Fifty-three percent were female, 47% male. Of the individuals included in the study, 5,617 (51%) were from the Philippines, 23% (23,127) from Vietnam, 15% (14,991) from Mexico, 5789 (6%) from Nepal and 3826 (4%) from China. All possible CXR findings, age, gender, and country of screening were included in the model. It was found that gender, age, country of origin and several CXR findings (infiltrate or consolidation, the presence of any cavitary lesion, nodule(s) or mass with poorly defined margins (such as tuberculoma), pleural effusion, miliary findings, discrete linear opacity (fibrotic scar) were predictive of Class A TB classification of those applying for immigrant status.

Conclusions
CXR is an important component of pre-arrival medical screening of those applying for immigration visas. Additional studies should be conducted among applicants to examine the influence of other c-morbid conditions known to be associated with TB disease among applicants applying for immigrant visa to the United States.

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Introduction

Tuberculosis (TB) has plagued humanity since before recorded history. Traces of bacterial ancestors of *Mycobacterium tuberculosis* as early as 3 million years ago (Daniel TM, 2006). Modern *M. tuberculosis* can be documented farther than 5000 years ago in Egypt (Daniel TM, 2006). With the migration of man from ancient Africa came the migration of disease, including TB. During the middle ages, it is likely that the disease known as scrofula, was a form of TB (Daniel TM, 2006). In 1882 the mist surrounding the disease that had plagued humanity for centuries began to dissipate with 'Die Aetiologie der Tuberkulose' by Hermann Heinrich Robert Koch. Koch presented this paper to the Berlin Physiological Society – TB was caused by a bacteria (additionally he laid out what would come to be known as Koch's postulates) (Daniel TM, 2005). For centuries public health workers have been working towards the prevention and elimination of TB.

TB did not become a major problem until the Industrial Revolution created conditions that favored its spread. The crowded living conditions present in the 17th and 18th centuries led to such a spread of the disease as to cause 25% of all adult deaths in Europe (Bennett JE, 2015). Since 1944, the discovery of multiple drugs that could treat TB led to a decrease in TB deaths. Those drugs include streptomycin (STM), isoniazid (INH), rifampin (RMP) – all of which are still used in TB treatment today.

Tuberculosis disease is caused by the bacterium *Mycobacterium tuberculosis.* The disease is spread through airborne droplets that remain suspended in the air. When an infected person expels infected droplets through speech, coughs, sneezes or any other method, uninfected

persons exposed to these bacteria are at risk of inhaling and contracting infection, and possibly, disease. Crowded living conditions, weakened immune system, and institutionalization are some of the risk factors for contracting TB (Bennett JE, 2015). Once TB is contracted, it is either active or latent TB. Latent TB occurs when a person with TB infection does not exhibit any symptoms of feel sick. Those with latent TB are not infectious. In active TB, the person feels ill and displays signs and symptoms of disease which may include coughing, fever, night sweats, weight loss, chest pain and hemoptysis. Multidrug resistant TB is when an *M. tuberculosis* strain is resistant to at least isoniazid (INH) and rifampin (RMP) (Bennett JE, 2015).

Previous estimates suggested that one third of the world population is infected with *M. tuberculosis*. However, more recent modeling have resulted in revised estimates suggesting that in 2014, 1.7 billion persons had latent TB infection, or 23% of the global population (Houben & Dodd, 2016). In its most recent report, the World Health Organization (WHO) stated that TB is responsible for about 1.4 million deaths annually (WHO, 2016a). According to the Centers for Disease Control and Prevention (CDC), TB cases in the U.S. have been on the decline since 1975, with a rate of 3 cases per 100,000 population in 2015 compared to 15.7 cases per 100,000 in 1975 (CDC, 2016b). From 1953 – 1985 the annual average rate of decline was 5.8% (Rieder, Cauthen, Comstock, & Snider, 1989). However, between 1985 and 1992 rates of TB cases increased 20% (Cantwell, Snider, Cauthen, & Onorato, 1994; Rieder et al., 1989). Foreign-born persons saw a 48% increase in cases during this time and accounted for 60% of the total increase of U.S. cases. Prior to 2007, overseas TB screening used a smear-based algorithm that did not identified smear-negative but culture-positive TB, and that rates of infection are higher in the country of birth among immigrants contributed to increased risk. HIV/AIDS contributed to the

case rate increase as well: 1985 – 1992 was the height of the HIV/AIDS epidemic in the U.S. In their report, Cantwell et al. concluded that the rise in TB cases and morbidity during this time was due to HIV, increased foreign-born cases and increased transmission in congregate settings such as hospitals and prisons (Cantwell et al., 1994).

HIV is a strong risk factor for TB; it not only increases the risk of activating latent TB, it increases the "risk of rapid TB progression soon after infection or reinfection with *M. tuberculosis* (Bucher et al., 1999; Daley et al., 1992; Shafer, Singh, Larkin, & Small, 1995). In settings where there is a higher prevalence of HIV infection among smear-positive TB cases (up to 7.5%), there is a greater impact of HIV to TB transmission. Thirty-one percent of adult TB cases in the WHO Africa region are attributable to HIV, 5.1%, 1.5%, 2.6%, 2.7%, 1.1% in the Americas, Eastern Mediterranean, Europe, South-East Asia and Western Pacific regions respectively; 9% globally (Corbett et al., 2003). The weakened immune system of HIV infected individuals has been associated with accelerated progression from latent to TB disease. Also, HIV and TB share similar risks factors such as poverty, socioeconomic status (SES), poor nutrition, drug use and lack of access to health care (Bennett JE, 2015). Some studies suggest TB incidences are more strongly associated with national SES than other indicators such as national TB program performance (Dye, Lönnroth, Jaramillo, Williams, & Raviglione, 2009; Oxlade et al., 2009). Smoking, undernutrition, diabetes and alcohol abuse are also identified as TB risk factors (15.8%, 26.9%, 7.5% and 9.8% population attributable risk respectively) (Lönnroth et al., 2010). Tuberculosis is a common opportunistic infection in HIV infected individuals and HIV infection is the most significant factor associated with latent TB becoming active TB (Castro, 1995; Lönnroth et al., 2010). In 2014 12.5% of new TB cases were among those coinfected with

HIV (WHO, 2016b). Approximately 6% of TB cases in the U.S. are also HIV infected (CDC, 2016c).

Globally, WHO reports an estimated 10.4 million TB cases. The highest burden of TB cases have been in Asia and Africa – accounting for 61% and 26% of new cases respectively. The hardest hit nations are India, Indonesia, China, Nigeria, Pakistan, and South Africa (WHO, 2016b). With over 1 million immigrants entering the U.S. in 2015 alone, cases of TB in foreign-born persons remains an ongoing public health problem (DHS, 2015). Twice as many TB cases are diagnosed in foreign-born persons than U.S.- born (CDC, 2016a). Immigrants from Mexico, Philippines, Vietnam, India and China account for 57% of cases among foreign-born persons (CDC, 2016a) .

In the United States, reported TB cases in 2015 were highest among Asians (33%), followed by Hispanic/Latinos (28%) (CDC, 2016a). The National Tuberculosis Surveillance System reports that the national average TB case rate of 3/100,000 population is surpassed in New York, New Jersey, Washington D.C. Georgia, Texas, California, Alaska and Hawaii. While there is a general decline in case rates, since 2001, number of TB cases in foreign-born persons has remained relatively stable and surpasses the number of cases in U.S. born persons. The proportion of total TB cases among foreign-born persons has been steadily inclining. The TB case rates in foreign-born persons has dramatically increased in the 10 years between 2005 and 2015. This contributes to the large proportion of Asian and Hispanic/Latino TB cases reported in the U.S. – the majority of these are foreign-born persons (of TB cases in foreign-born persons, 48% and 32% are from

Asians and Hispanic/Latinos respectively compared to 4% and 21% respectively of ethnicity in U.S.-born TB cases) (CDC, 2016a).

One measure that is in place to reduce the number of foreign-born cases of tuberculosis is a comprehensive TB screening program as part of the medical exam for persons who apply to the United States for immigration or refugee (nonimmigrants) visa (CDC, 2009). This program is overseen by the CDC Division of Global Migration and Quarantine (DGMQ). "Because tuberculosis is a challenging disease to diagnose, treat, and control … designed to detect and treat tuberculosis disease among applicants and to reduce the risk of spread of tuberculosis among the U.S. population after immigration" (CDC, 2009). The TB screening is a part of the medical screening that all persons applying for U.S. immigration visa overseas must undergo. Revised in 2007, the technical instructions (TI) are in place to ensure uniform screening in all countries and to reduce the importation of tuberculosis into the United States (CDC, 2009). The objective of this analysis is to assess association between chest -x-ray findings and the classification of U.S. visa applicants as Class A TB.

Methods

This thesis will describe the association between chest x-ray (CXR) findings and medical findings of tuberculosis disease during the screening of persons (applicants) seeking to enter the United States (applicants) as immigrants or nonimmigrants who are required to have an overseas medical examination such as refugees, and provide recommendations for continued implementation of this program.

Overseas Screening Process

The United States requires an overseas medical examination for all persons overseas applying for an immigration visa. As part of that examination, individuals are required to undergo TB screening to reduce the risk of importing tuberculosis and spreading it in the United States. Applicants aged ≥ 15 years require medical history, given a physical examination, and chest x-ray (CXR) evaluation by designated panel physicians in their countries of origin/residence. If CXR is suggestive of TB, or the applicant has signs and symptoms of TB or is HIV infected, three sputum specimens must be provided for microscopic examination and culture to detect the presence of *M. tuberculosis* (CDC, 2009). [Appendix]

For applicants aged <14 years in a country where the World Health Organization (WHO) estimates TB incidence rates at ≥ 20/100,000 population/year, tuberculin skin testing (TST) or interferon gamma release assay (IGRA) and a physical examination are required. Additionally, a medical history must be provided by "a parent or responsible adult who know the child best" [Figure 1]. If test results of TST or IGRA are positive, a CXR should be performed. If CXR indicates possible TB, or the applicant has signs and symptoms of TB or is HIV infected, three sputum specimens must be provided for microscopic examination and culture of M. tuberculosis (CDC, 2009).

Radiograph Findings and Classifications

The CXR "should consist of a standard posteroanterior view for all applicants >10 years of age. Applicants <10 years of age who receive a CXR should have a standard anteroposterior or

standard posteroanterior view and should also have a lateral view. If a child receives a posteroanterior view, the CXR should be labeled "PA" for the benefit of radiologist's review." CXR are interpreted by radiologists and findings should be available within 1 week (CDC, 2009).

For those with CXR suggestive of TB, 3 sputum smears are obtained to undergo microscopy for acid fast bacilli (AFB) examination and culture for *M. tuberculosis.* If these results come back positive, the cultures are tested for drug susceptibility. "Positive *M. tuberculosis* cultures that are resistant to isoniazid and rifampin shall undergo drug susceptibility testing on second-line tuberculosis medications. At a minimum, second-line testing should include testing for resistance against ethionamide, a fluoroquinolone (e.g., ofloxacin, levofloxacin, moxifloxacin), amikacin, capreomycin, and para-aminosalycilic acid (PAS)." Once individuals complete the medical evaluation, panel physicians assign a TB classification, and issue a travel clearance. Those without any TB findings and not infected with HIV are given no TB classification. Those with smears or cultures that are positive for TB, have to undergo treatment, are not cleared for travel to the U.S. and are classified as Class A TB. After they complete overseas TB treatment, they are reclassified as Class B1 TB and are allowed to travel to the United States. Those with a positive TST or IGRA, but with no clinical findings of TB, normal CXR, and are negative for HIV are classified as Class B2 TB, LTBI Evaluation and cleared for travel to the U.S. Those who are smear- and culture-negative but the CXR and clinical findings are suggestive of tuberculosis disease are cleared for travel and they are classified as Class B1 TB. (CDC, 2009) [Table 1]

Study Population

The data were collected electronically by CDC's DGMQ and provided by designated panel physicians who complete the DS 3030 form (i.e., Department of State form 3030). We analyzed data collected between 2010 and 2016 from 5 selected countries – China, Mexico, Nepal, Philippines, and Vietnam. The applicants included in the study were applicants applying for immigration visas that were classified with Class A TB or Class B1 TB. The study protocol was submitted to Emory University IRB for review and it was determined that the study does not meet the definition of "research" with "human subjects" or "clinical investigation" as set forth in Emory policies and procedures and federal rules, if applicable. The protocol was also reviewed by a CDC DGMQ human subjects advisor and designated as non-research under CDC policy, and therefore outside the scope of CDC IRB review requirements. The analysis sought to determine the relationship between certain CXR findings, and the finding of active TB as validated by microscopy and culture.

Statistical Analysis

The data were analyzed using SAS 9.4. P-values of less than 0.05 were considered statistically significant. The variables of interest include the various CXR findings suggestive of tuberculosis: infiltrate or consolidation, the presence of cavitary lesions, nodule(s) or mass with poorly defined margins (such as tuberculoma), pleural effusion, hilar/ mediastinal adenopathy, other (such as miliary findings), discrete linear opacity (fibrotic scar), discrete nodule, discrete linear opacity, volume loss or retraction, other (such as bronchiectasis); age; gender, and country.

Discrete linear opacity (fibrotic scar) with volume loss or retraction and volume retraction variables were excluded from the analysis because the 2014 DS 3030 update removed and introduced them respectively.

Using logistic regression and backward selection, a model was built to examine the relationship between the remaining CXR findings and Class A TB. Only significant variables remained in the statistical model.

Results

A total of 98,350 applicants from five select countries who were medically screened between 2010 and 2016, and classified with Class A TB or Class B1 TB were included in the analysis. The Philippines accounted for 50,617 (51.5%), Vietnam 23,127 (23.5%), Mexico 14,991 (15.2%), Nepal 5,789 (5.9%) and China 3,826 (3.9%) [Table 4]. Applicants were mostly female: 52.9% female, 47.1% male. The ages of applicants ranged from <1 to 112 years old. Mean age was 51 with a median of 55 and mode of 60 (interquartile range 24). Class A TB accounted for 4.2% of applicants from China, 1.5% from Mexico, 7.7% from Nepal, 11.0% from Philippines and 13.4% from Vietnam.

The majority of applicants were not classified with Class A TB, but with Class B1 TB: China – 95.8%, Mexico – 98.5%, Nepal – 92.4%, Philippines – 89.0%, Vietnam – 86.6%; overall, 9.7% of applicants were Class A TB [Table 3]. Most of those classified as Class A TB were >15 years old at 95.5%.

It was found that Class A TB (active TB) was significantly associated with gender, infiltrate or consolidation, the presence of any cavitary lesion, nodule(s) or mass with poorly defined margins (such as tuberculoma), pleural effusion, miliary findings, discrete linear opacity (fibrotic scar), age and country of screening Class A TB classification of those applying for immigrant status. Odds ratio (OR) of infiltrate or consolidation: 3.0 (95% Confidence Interval [CI] 2.8, 3.2), the presence of any cavitary lesion: 6.0 (95% CI 5.2, 6.9), nodule(s) or mass with poorly defined margins (such as tuberculoma): 1.79 (95% CI 1.64, 1.96), pleural effusion: 1.97 (95% 1.53, 2.54), miliary findings: 0.31 (0.28, 0.34), discrete linear opacity (fibrotic scar): 0.55 (0.52, 0.58) with the reference for all CXR findings being a finding of 'no' for each possible finding. With 'Less than 2 years old' as the reference, ages 2-4 have an odds ratio (OR) of 11.68 and age 15 and older an OR of 1.46. The OR for Class A TB classification for China, Mexico, Philippines and Vietnam were 1.35, 0.18, 1.46, and 3.18 respectively; with Nepal as the reference.

Discussion

As of September 2014, there were 10 categorizations of CXR findings that could suggest tuberculosis and the need for smear and cultures in the screening as listed above. Of those possible findings, volume loss or retraction was not included in model selection because this categorization was created when the DS 3030 form was updated September 2014 – thus many data points were missing from these variables. The CXR finding with the highest OR was the presence of any cavitary lesion; having a positive finding rather than no finding of any cavitary lesion increases the odds of a Class A TB classification. Vietnam had the greatest odds of the 5 countries examined at 3.18 (95% CI 2.84, 3.56) compared to Nepal. Children aged 2-14 years old

were almost 12 times as likely as children under 2 years old to be classified Class A TB where those 15 years old and older were only 1.4 times as likely.

Liu, et al. observed a reduction in annual number of reported TB cases among foreign-born persons within 1 year of arrival, 2007-2012 – the improved screening mechanisms of CXR combined with smear and cultures are leading to the detection of more TB cases prior to arrival in the U.S. (Liu, Posey, Cetron, & Painter, 2015). This highlights the need to continue to improve TB screening mechanisms among those seeking immigration visas to the U.S. As Binkin et al. state, because CXR are sensitive, but not highly specific, smears and cultures are a necessary part of medical screening (Binkin, Zuber, Wells, Tipple, & Castro, 1996). The results of this study support this finding as several other CXR findings did not serve as predictors of Class A TB designation. As global migration continues to grow, TB pre-arrival TB screenings serve as one effective mechanism for reducing the global burden of TB (White et al., 2017). While symptom based screenings can be used to identify TB in low resource settings [symptoms and signs being: fever of more than one week duration, cough of more than two weeks duration, night sweats, weight loss, and hemoptysis (WHO, 2013)] CXR increases the sensitivity of screening, improving the numbers of TB cases identified for treatment (Schepisi et al., 2013).

Strengths of this study are the nature of the dataset (coming from required screening of those applying for immigration status) few variables were missing, allowing for robust analysis. Additionally, this study is a timely analysis of revised regulations that provides confirmation that new screening mechanisms are predictive of Class A TB and Class B1 TB findings. Also, the dataset covered a long period of time (2010-2016) from countries with high TB incidence is another strength of the study.

One limitation of the study is that it is limited to only 5 countries. The U.S. issues visas to applicants from every country and this is but a limited sample of that universe with 617,752 visas issued in 2016 alone (State, 2017). During this time period, the United States received applicants with Class A TB and Class B1 TB from 183 countries. Additionally, the study excluded India, which accounts for 9% reported TB among foreign-born persons; and is one of the top 5 countries of birth of reported TB among foreign-born persons accounting for 57% of cases (along with Mexico, 20%; Philippines, 13%; Vietnam, 8%; and China 7%). The data that were analyzed are not representative of the proportions of TB burden of foreign-born persons from those countries.

Another limitation of the study is that the CXR finding of "volume loss or retraction" was not analyzed. Finally, this study did not account for several risk factors for TB: (1) in country incidence rates of TB, (2) rates of HIV co-infection among applicants, (3) those with other medical conditions that weaken the immune systems such as: diabetes mellitus, severe kidney disease, and low body weight; and (4) country of origin of applicants (data is from country of application). Also, this analysis does not have a normal distribution of ages, thus the study can't be generalized to the overall population.

Studies such as this are necessary to evaluate the positive predictive value, negative predictive value, sensitivity and specificity of medical screening programs. The indicated CXR findings and being female are not strong predictors for the Class A TB and B1 classifications which can impact future screening recommendations.

Recommendations

Additional studies should be conducted among applicants to examine the influence of other co-morbid conditions known to be associated with TB disease among applicants applying for immigrant visa to the United States. Applicant data that were screened and classified as 'no tuberculosis' should ideally be included in future studies as a source of reference. Because of the reliance on CXR, Panel Physicians should undergo uniform radiology trainings to optimize and standardize CXR readings. Although not examined as part of this study, as global immigration continues to expand, it might be worth reevaluating pre-arrival TB screenings in low incidence countries and pilot test the evaluation of short term visitors from high incidence countries to determine the potential value of expanded screening and treatment for TB as a way to further reduce the incidence of this disease (Alvarez et al., 2011).

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Tables and Figures

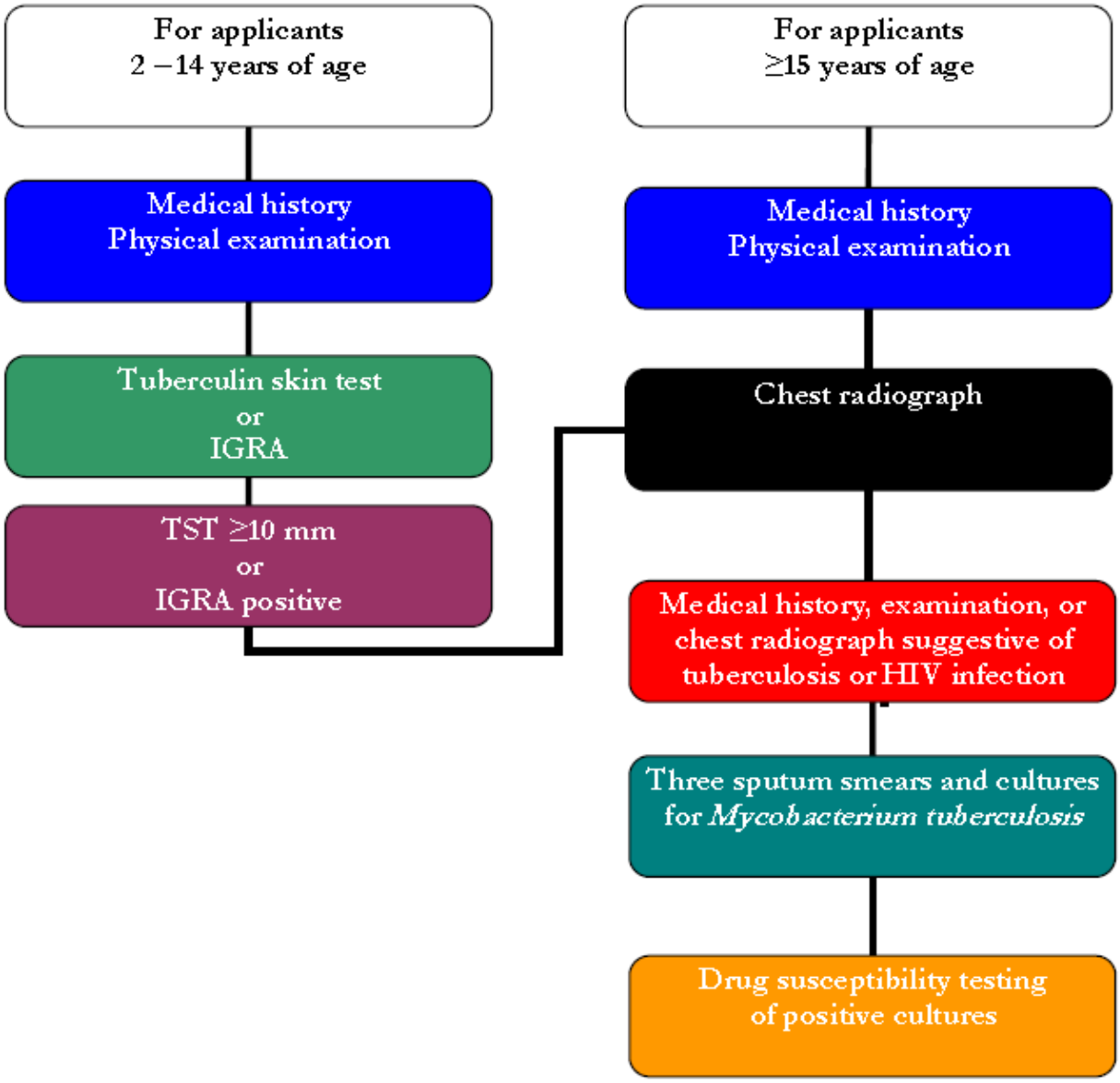

Figure 1: Tuberculosis screening medical examination for applicants ≥ 2 years of age in countries with a WHO-estimated tuberculosis incidence rate <20 cases per 100,000 population. (CDC, 2009)

Medical History	Physical Exam	Chest Radiograph	TST or IGRA	Sputum Smears	Culture for Mycobacterium	Travel Clearance	Action or TB Classification
Normal	Normal	Normal	Negative	NA	NA	6 months	No TB classification
Normal	Normal	Normal	Positive	NA	NA	6 months	Class B2 TB, LTBI Evaluation
Normal	Normal	Normal	Negative	Negative	Negative	3 months	No TB classification
Normal	Normal	Normal	Positive	Negative	Negative	3 months	Class B2 TB, LTBI Evaluation
Normal	Normal	Normal	Positive or Negative	Either Positive		No	Class A, Treatment
Any Component Suggestive of TB			Positive or Negative	Negative	Negative	No	Use Clinical Judgment
Any Component Suggestive of TB			Positive or Negative	Either Positive		No	Class A, Treatment
Any Component Suggestive of TB			Positive or Negative	Negative	Negative	No	Use Clinical Judgment
Any Component Suggestive of TB			Positive or Negative	Either Positive		No	Class A, Treatment
Completed Therapy for Tuberculosis			Positive or Negative	Positive or Negative	Negative	3 months	Class B1 TB, Pulmonary
Completed Therapy for Tuberculosis			Positive or Negative	Positive or Negative	Negative	3 months	Class B1 TB, Pulmonary

Table 1: Tuberculosis screening results, travel clearance, and actions.(CDC, 2009)

	Class A TB (N=9551) n (%)	Class B1 TB (N=88799) n (%)	Chi-square* Value (p-value)
Gender			
Male	5131 (11.1)	41191 (88.9)	186.23 (< 0.0001)
Female	4420 (46.3)	47608 (53.6)	
Country of Origin			
China	159 (4.2)	3667 (95.8)	1780.28 (< 0.0001)
Mexico	229 (1.5)	14762 (98.5)	
Nepal	443 (7.6)	5346 (92.4)	
Philippines	5618 (11.1)	44999 (88.9)	
Vietnam	3102 (13.4)	20025 (86.6)	
Age Category			
Less than 2 years old	47 (3.9)	1146 (96.1)	902.30 (< 0.0001)
2-14 years old	379 (36.6)	658 (63.5)	
15+ years old	9125 (9.5)	86995 (90.5)	

Table 2: Characteristics of tuberculosis patients classified as Class A or Class B1 TB included in the study (N=98,350)

Country	**Class A TB N (%)**	**Class B1 TB N (%)**	**Total N (%)**
China	159 (4.2)	3,667 (95.8)	3,826 (3.9)
Mexico	229 (1.5)	14,762 (98.5)	14,991 (15.2)
Nepal	443 (7.6)	5,346 (92.4)	5,789 (5.9)
Philippines	5,618 (11.1)	44,999 (88.9)	50,617 (51.5)
Vietnam	3,102 (13.4)	20,025 (86.6)	23,127 (23.5)
Total	9,551 (9.7)	88,799 (90.3)	98,350 (100)

Table 3: Persons applying for U.S. immigrant visa identified as Class A TB or Class B1 TB (2010-2016)

(N=98350)	Class A TB (N=9551) n (%)	Class B1 TB (N=88799) n (%)	Chi Square	Chi Sq. p-value	Crude Odds Ratio (OR)	95% Confidence Interval	OR p-value
Gender			156.6	< 0.0001	0.75	0.72, 0.79	< 0.0001
Male	5131 (11.1)	41191 (88.9)			Reference		
Female	4420 (46.3)	47608 (53.6)					
CXR Findings ('no' as reference)							
Infiltrate or consolidation	7459 (13.8)	46658 (86.2)	1281.42	< 0.0001	3.0	2.8, 3.2	< 0.0001
Cavitary lesion	383 (32.1)	812 (67.9)	606.77	< 0.0001	6.0	5.2, 6.9	< 0.0001
Discrete linear opacity (fibrotic scar)	3513 (6.4)	51782 (93.6)	538.8	< 0.0001	0.55	0.52, 0.58	< 0.0001
Miliary findings	662 (10.7)	5536 (89.3)	543.88	< 0.0001	0.31	0.28, 0.34	< 0.0001
Nodule(s) or Mass with poorly defined margins (such as tuberculoma)	686 (11.5)	5303 (88.5)	161.18	< 0.0001	1.79	1.64, 1.96	< 0.0001
Pleural effusion			27.19	< 0.0001	1.97	1.53, 2.54	< 0.0001
Age (years)			824.70	< 0.0001			
Less than 2	47 (3.9)	1146 (96.1)			Reference		
2-14	379 (36.5)	658 (63.5)			11.68	8.05, 16.95	< 0.0001
15+	9125 (9.5)	86995 (90.5)			1.46	1.32, 1.63	0.0329
Country			1919.77	< 0.0001			
Nepal	443 (7.6)	5346 (92.4)			Reference		
China	159 (4.2)	3667 (95.8)			1.35	1.09, 1.68	0.0068
Mexico	229 (1.5)	14762 (98.5)			0.18	0.15, 0.21	< 0.0001
Philippines	5618 (11.1)	44999 (88.9)			1.46	1.32, 1.63	< 0.0001
Vietnam	3102 (13.4)	20025 (86.6)			3.18	2.84, 3.56	< 0.0001

Table 4: Findings of Statistically Significant Variables in Study Analysis

U.S. Department of State

TUBERCULOSIS WORKSHEET

For Use with DS-2054

OMB No. 1405-0113
EXPIRATION DATE: 09/30/2017
ESTIMATED BURDEN: 20 MINUTES
(See Page 2 - Back of Form)

Photo

Name *(Last, First, MI)* | Age

Birth Date *(mm-dd-yyyy)* | Passport Number | Alien *(Case)* Number

1. Test for Cell-Mediated Immunity to Tuberculosis
Required for applicants 2 through 14 years of age where WHO-estimated TB rate ≥ 20 per 100,000 and contacts; perform one type only.

☐ TST Date applied *(mm-dd-yyyy)* _____
Results *(mm)* _____

☐ QFT NII Value: IU _____
TB Response: TB minus nil IU/ml _____

☐ IGRA Date drawn *(mm-dd-yyyy)* _____
☐ Positive
☐ Negative
☐ Indeterminate, Borderline, or Equivocal

☐ T-Spot NII Value: Number of cells _____
TB Response: Higher of Panel A or Panel B minus nil value _____

2. Chest X-Ray Indication *(Mark all that apply)*

☐ Chest X-Ray not indicated
☐ Age ≥ 15 years
☐ Signs or symptoms of tuberculosis
☐ Known HIV infection
☐ TST ≥ 10 mm or IGRA positive
☐ Contact: TST ≥ 5 mm or IGRA positive

Date Chest X-Ray Taken *(mm-dd-yyyy)*

3. Chest X-Ray Findings

☐ Normal Findings ☐ Abnormal Findings *(Indicate category and finding, checking all that apply in the tables below)*

Can Suggest Tuberculosis ***(Need Smears and Cultures)***

☐ Infiltrate or consolidation
☐ Cavitary lesion
☐ Nodule(s) or mass with poorly defined margins *(such as tuberculoma)*
☐ Pleural effusion *(perform lateral or decubitus radiograph or ultrasound, if needed)*
☐ Hilar/mediastinal adenopathy
☐ Miliary findings
☐ Discrete linear opacity
☐ Discrete nodule(s) without calcification
☐ Volume loss or retraction
☐ Other

No Sputum Specimens Required

Mark as Class B Other on DS-2054
☐ Cardiac
☐ Musculoskeletal
☐ Other, specify in Remarks

Do Not Mark as Class B Other on DS-2054
☐ Pleural thickening
☐ Diaphragmatic tenting
☐ Calcified pulmonary nodule(s)
☐ Calcified lymph node(s)

Remarks

Radiologist's Name *(Printed)* | Radiologist's Signature *(Required)* | Date Interpreted *(mm-dd-yyyy)*

4. Sputum Smears and Cultures Decision

☐ No, not indicated -Applicant has no signs or symptoms of TB, no known HIV infection, and:
☐ X-ray Normal or 'No specimens required' and test for cell-mediated immunity to TB negative *(if performed)*
☐ X-ray Normal or 'No specimens required' and test for cell-mediated immunity to TB positive *(if performed)*
☐ Yes, are indicated - Applicant has *(Mark all that apply)*:
☐ Signs or symptoms of TB
☐ Chest X-ray suggests TB
☐ Known HIV infection
☐ End of treatment cultures

5. Sputum Smears and Cultures Results

Sputum Smear Results	Date specimen obtained *(mm-dd-yyyy)*	Date specimen reported *(mm-dd-yyyy)*	Positive	Negative
	1.			
	2.			
	3.			

Sputum Culture Results	Date specimen obtained *(mm-dd-yyyy)*	Date specimen reported *(mm-dd-yyyy)* *Date of exam on DS 2054	Positive	Negative	NTM	Contaminated
	1.					
	2.					
	3.					

DS-3030
09-2014

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DS 3030 TB screening form