Full Length Research Paper

An ecological view of the risk factors for tuberculosis in the United States

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There is scientific evidence of socio-demographic, behavioral and health risk factors associated with tuberculosis (TB) infection and TB disease. The primary objective of the study was to examine the correlation of TB risk factors at the state level in the United States (US) to obtain insights specific to the state of TB in the US. Secondary data from the centers for disease control and prevention (CDC) and US Census Bureau on line databases were used. Simple and multiple linear regressions were carried out. The model created to represent the TB rate by state included the percent of the population which was non-Hispanic white (p < 0.001), the AIDS diagnosis rate/100,000 (p = 0.067) and the percentage of the population which is foreign born. Per capita income, GINI, diabetes rates, smoking rates and alcohol abuse rates were excluded from the final model. Race/ethnicity acts as a marker for a number of risk factors, and the focus of the fight against TB in the US should be on minority communities, those populated by the foreign-born and those with high rates of AIDS particularly where a large degree of income inequality is present.

Keywords: Tuberculosis, race, ethnicity, HIV, foreign-born.

INTRODUCTION

The United States (US) has made great strides in reducing the annual incidence rate of tuberculosis (TB) over the past century. In 1945, the rate was 73/100,000; and in 1993, it was 9.0/100,000 (Snider, 1997). In 2009, the rate of TB fell to 3.8/100,000 reaching an all-time low. However, the Centers for Disease Control and Prevention's goal of eliminating TB (defined as a case rate of 1/1,000,000) appears to be a distant target (CDC, 2009). One of the great challenges in the eradication of TB is the high level of global latent TB infection (LTBI) estimated to encompass nearly 1/3 of the world population (World Health Organization, 2010). There are generally two broad approaches to fighting TB: 1) raising the standard of living; and 2) chemotherapy both for those infected with TB, as well as those with active TB disease.

Some of the risk factors which influence the incidence of TB include heavy alcohol use, smoking, drug use (injection and non-injection), homelessness, incarceration, residence in a long-term care facility, diabetes, HIV, foreign-born status in the US, and race/ethnicity in the US (CDC, 2010; Dye et al., 2009; Stead et al., 1990). In the US, not all of these risk factors play the same role as they might on the world stage due to the relatively low level of TB endemicity in the US.

With a death rate of 0.4/100,000 in 2007, TB is a disease easily ignored by the wider population (United Nations Statistics Division, 2009). This paper studies the correlation of TB risk factors in the US and derives a model for TB to sharpen our focus on the issues most likely to continue the diminution of TB in the US. The variables examined were AIDS diagnosis rates, diabetes death rates, rates of smoking, rates of alcohol abuse, percentage of the population which is foreign-born versus US born, race/ethnicity (percentage which is non-Hispanic White) and poverty (as expressed by per capita income as well as GINI).

METHODS

Data was retrieved from the CDC Online Tuberculosis Information System (OTIS), the National Center for Health Statistics (NCHS)

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Behavioral Risk Factor Surveillance Survey (BRFSS), the CDC HIV Surveillance Report and the US Census Bureau. The data was entered and merged in Microsoft Excel, and SPSS (version 18) for regression analysis of individual risk factors and the TB rate by state. The analysis examined 2008 data from all sources when available. SPSS was also used to generate an overall model.

The information on verified TB cases reported to the CDC by state health departments, the District of Columbia, New York City, Puerto Rico and seven other US jurisdictions in the Pacific and Caribbean from 1993 through 2008 is accessible in OTIS (CDC, 2010). This system was utilized to extract TB rates by each state and the District of Columbia in 2008 (Subsequent references to the states or US imply inclusion of the 50 states plus DC unless otherwise stated).

The NCHS BRFSS is a state-based system of health surveys that collects information on health risk behaviors, preventive health practices, and health care access primarily related to chronic disease and injury (CDC, 2008). Diabetes death rates, adult smoking rates and heavy alcohol use rates were obtained from the BRFSS. Heavy drinkers were defined as adult men having more than two drinks per day and adult women having more than one drink per day. AIDS diagnosis rates were obtained from the HIV Surveillance Report located at: http://www.cdc.gov/hiv/surveillance/resources/reports/2008report/table20.htm.

The US Census Bureau conducts the American Community Survey (ACS) every year to collect data on social and economic issues. The information collected is combined into statistics that are used to help justify expenditures on a broad range of initiatives from school lunch programs to new hospitals (US Census Bureau, 2010). Population data, the percentage of the population which is foreign-born, per capita income, GINI and the percentage of the population which is non-Hispanic White were obtained from the ACS. GINI by state in 2006 comes from the American Community Survey (Webster and Bishaw, 2007).

RESULTS

The dominant variable in forecasting the TB rate by state was the percent of the population which was Non-Hispanic White. The forward selection process chose this as the sole variable ($p < 0.001$) to include in the model using the criteria of $p < 0.05$ for the t-test. The backward elimination process which had a criterion of $p < 0.10$ for the t-test additionally included the AIDS diagnosis rate/100,000 ($p = 0.067$). The percent of the population which is foreign-born ($p = 0.154$) was included in the model because this group is disproportionately represented in the TB rate. These variables provided the following model:

State TB Rate/100,000 = 9.012 - 0.088%NHW + 0.025 AIDS Diagnosis Rate/100,000 + 0.053%Foreign-Born

The scatter diagram showing the Pearson correlation of the percentage non-Hispanic white population versus the TB rate by state is shown in Figure 1 and for the percentage foreign-born versus the TB rate by state in Figure 2. The standardized residuals versus the predicted TB rates are shown in Figure 3, and a listing of Pearson correlation results by risk factor is in Table 1.

DISCUSSION

Whereas 1 person in 3 is estimated to be infected with TB at the global level, only 1 person in 25 is estimated to be infected in the US (Khan et al., 2008). The risk factors can be categorized in 3 ways: 1) primary risk factors which are principally associated with exposure to the *tubercle bacillus*; 2) secondary risk factors which reduce one's immunity and may enhance the risk of infection as well as act to convert Latent TB Infection to active TB; and 3) hybrid risk factors which may play an important indirect role in the exposure to the *T. bacillus* as well as contraction of the infection and progression to the active disease. The associations found between the risk factors and TB disease are examined and discussed within these 3 categories.

Primary risk factors

Being non-Hispanic white, serves as a marker for a number of factors closer to the root causes of TB. Given current immigration patterns, this risk factor largely encompasses the foreign-born population while excluding White immigrants from Western Europe who are less likely to be infected with TB. By 2007 over 80% of the foreign-born population originated from Latin America or Asia (Grieco, 2010). Other US groups not part of the Non-Hispanic White category such as African-Americans, American Indians and Native Alaskans, Asian-Pacific Islanders and Hispanics have historically had high TB rates (Cantwell et al., 1998). The circumstances of these groups are exacerbated by elevated levels of poverty characterized by overcrowding, malnutrition and lack of access to healthcare services. Given the nature of TB to sustain itself within a given community, it will be necessary to continue to focus on all groups which have historically had a high rate of TB disease and explore methods of empowering these groups to help themselves.

Being foreign-born generated the second highest correlation coefficient of the risk factors examined. It is a very strong predictor variable of the rate of TB disease within a state. Hawaii, Alaska and DC are the greatest outliers and have distinct populations which account for their deviation. Hawaii has a large established Asian-American population which has shown a high rate of TB but is not foreign-born. As well Alaska has a large Native American population which historically has had a high rate of TB. DC is a purely urban entity that includes substantial enclaves that are economically disadvantaged. Tuberculosis rates are generally higher in urban areas and amongst groups that are economically disadvantaged. The southeastern states form a cluster of states which exhibit higher rates of TB than projected by the percentage of their population which is foreign-born. They have seen a substantial influx of foreign-born
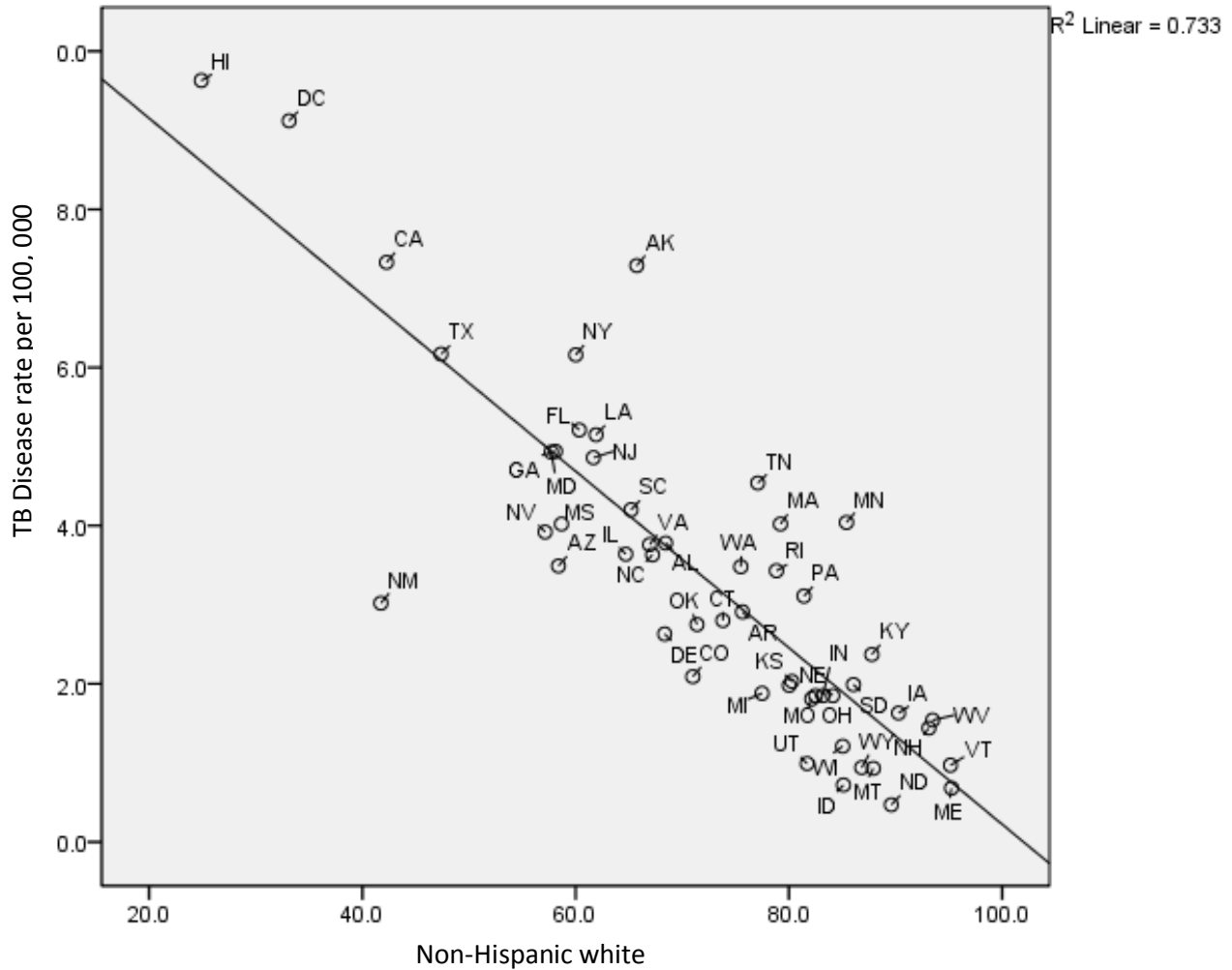
Figure 1. Simple regression of percent of the population which is Non-Hispanic White versus TB disease rates per 100,000 by state.

persons in recent years comprising 8 of the top 10 states with the greatest percentage increase in the percentage of their population which is foreign-born (Migration Policy Institute, 2011). Since TB rates among the foreign-born are almost five times higher in the first two years after entry into the US, this could partially account for these states having disproportionately high TB rates in relation to their foreign-born population (Cain et al., 2008).

Secondary risk factors

Diabetes death rates and smoking rates showed no association with TB disease rates across the states. It is recommended that those at risk of developing diabetes should be encouraged to take steps both to preclude diabetes as well as undertake isoniazid prevention therapy (IPT). Anyone who is in a high risk group to be infected or already infected with TB should take steps

toward cessation of smoking and in the case of LTBI subscribe to a protocol of IPT.

Hybrid risk factors

Alcohol usage involves both a social factor as well as an immunological issue. Poverty is a risk factor for TB disease although a positive relationship was found between per capita income by state and TB rates by state. This seeming contradiction points out both the hazards of an ecological study and the need to measure poverty in a more meaningful way at the state level. TB typically flourishes in areas with overcrowding, malnutrition and poor access to healthcare, all of which are indicative of poverty. A positive relationship was found between poverty and GINI by state suggesting that income inequality has a negative effect on TB health outcomes.
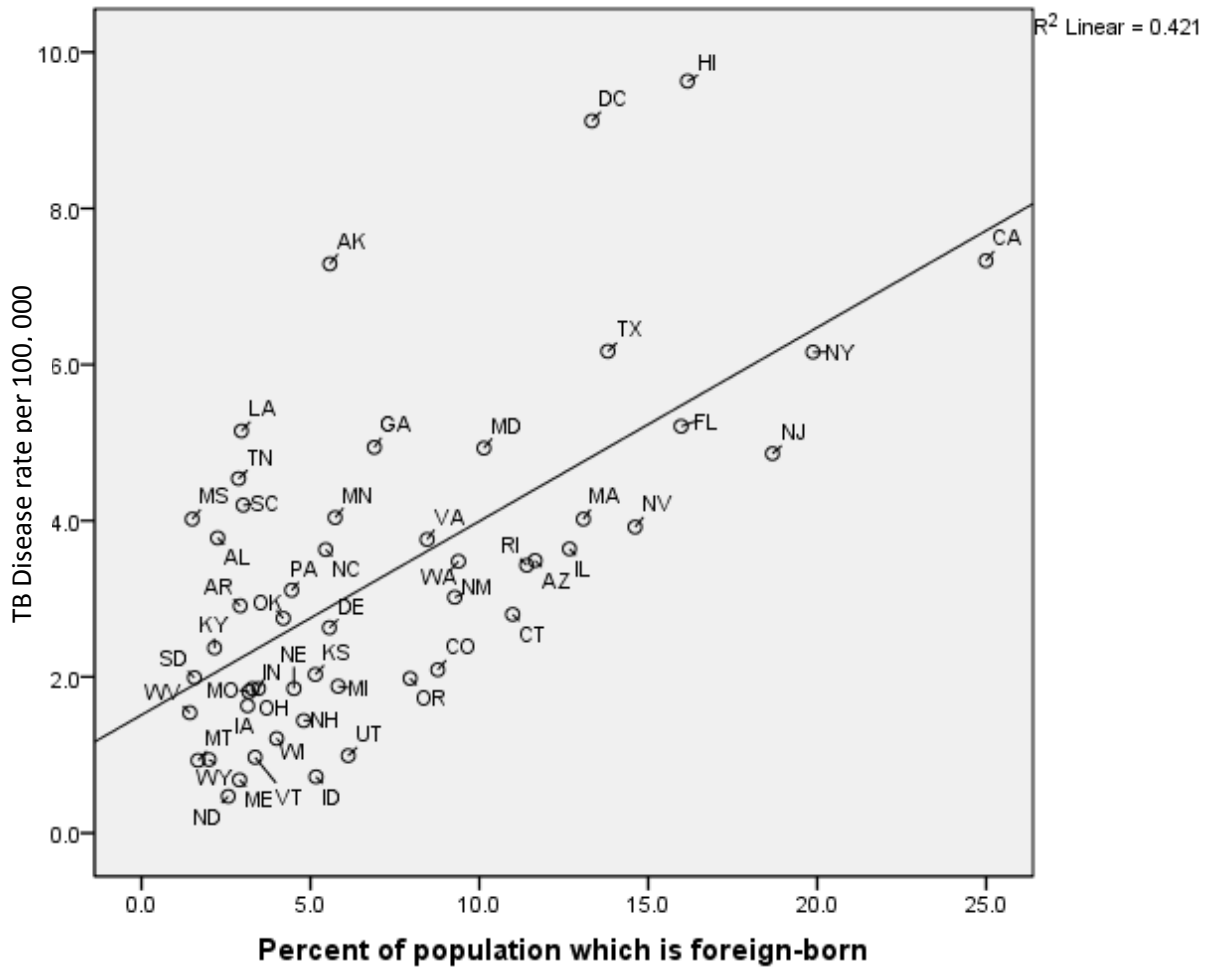
Figure 2. Simple regression of percent of the population which is foreign-born versus TB disease rates per 100,000 by state.

AIDS diagnosis rates showed a significant association with TB disease rates. The degree to which HIV is concentrated in specific communities such as the African-American, Hispanic and Gay communities, particularly those of lower income, may contribute to a social environment that sustains the spread of TB. Someone already infected with TB is much more likely to progress to the active TB disease stage if they contract HIV. Vigilance and aggressive medical treatment for either TB infection and/or HIV is imperative to preclude the often deadly combination of these two infections. As the TB rate in the US falls, it is important that measures to protect everyone, especially HIV patients, from TB infection are maintained.

THE MODEL

The two greatest outliers, New Mexico and Alaska, pose interesting questions. Why does New Mexico have a

much lower TB rate than that projected and Alaska a much higher TB rate? Alaska has a larger percentage American Indian/Alaskan Native population (15.2%) compared to New Mexico (9.7%). Alaska also proportionately has a larger Asian population (5.0%) than New Mexico (1.5%) (US Census Bureau, 2010). Additionally the largest minority in New Mexico, Hispanics (45.6%), forms a plurality of the population and has substantial political power holding the governor, speaker of the house and senate majority posts in 2010 (Jennings, 2010). Alaskan Natives and American Indians on the other hand while of political importance in their state do not have the numerical strength to control the government. Further research into how political power and ownership of health issues contributes to the health of a community is warranted.

Limitations

This is an ecological study which carries inherent
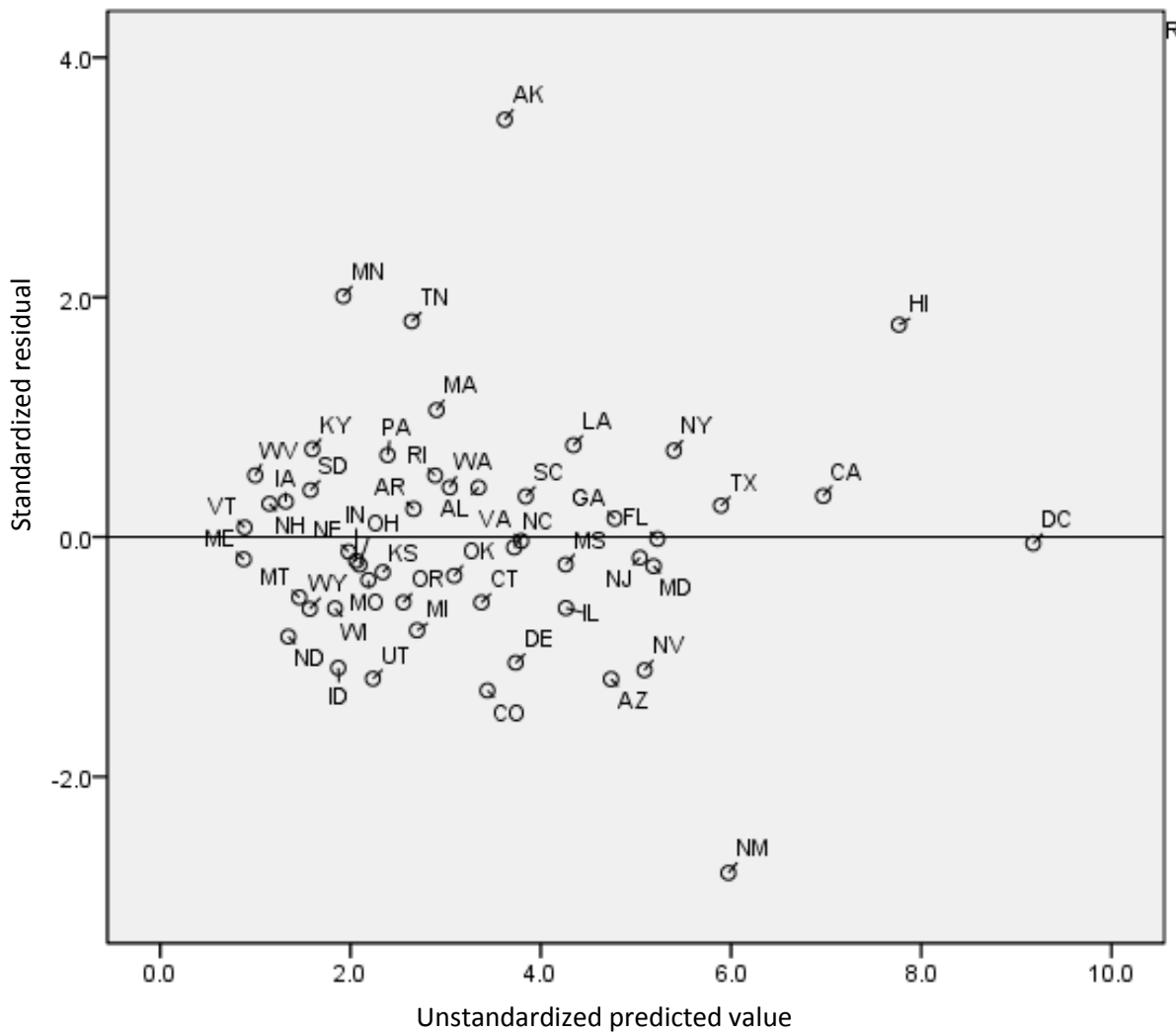
Figure 3. Standardized residuals versus predicted TB rates for the proposed model.

Table 1. Summary of simple regression results.

Risk factor	Correlation with TB disease rates at the state level	
	R	p value
AIDS diagnosis rates/100K	0.579	<0.001
Diabetes deaths per 100K	-0.053	0.71
Percent of adults who smoke	-0.157	0.27
Percent of adults who drink heavily	0.019	0.9
Percentage of population foreign-born	0.649	<0.001
Per capita income	0.46	0.001
GINI	0.588	<0.001
Percent of population non-Hispanic White	-0.856	<0.001

limitations regarding the conclusions one may draw. The study was limited by the use of secondary data in terms of extensibility and reliability.

Conclusion

This study reviewed seven known risk factors associated

with TB and provided evidence that the primary focus of the fight against TB in the US should be on minority communities, those populated by the foreign-born and those with high rates of AIDS particularly in conjunction with disadvantaged communities in areas of income inequality. This is consistent with the assertion by Coberly and Chaisson (2007) that the risk of TB infection is a function of exposure (Coberly and Chaisson, 2007). In a low endemicity environment, such as the US, the issues of exposure and infection predominate in an ecological study at the state level. While aggressive identification and treatment of LTBI and TB cases must continue, we should not ignore the sociodemographic aspects driven by factors such as income inequality and healthcare access for all including immigrants, the homeless and prisoners that serve as a breeding ground for this insidious disease and which can be improved at the federal, state and local levels.

REFERENCES

Cain KP, Benoit SR, Winston CA, MacKenzie WR (2008). Tuberculosis Among Foreign-Born Persons in the United States. JAMA. pp. 405-412.

Cantwell MJ, McKenna MT, McCray E, Onorato IM (1998). Tuberculosis and Race/Ethnicity in the United States Impact of Socioeconomic Status. Am. J. Respir. Crit. Care. Med., pp. 1016-1020.

CDC (2008). About the BRFSS [Internet]. Behavioral Risk Factor Surveillance System. Available from: http://www.cdc.gov/brfss/about.htm

CDC (2009). Division of Tuberculosis Elimination Strategic Planning [Internet]. Available from: http://www.cdc.gov/tb/about/StrategicPlan.pdf

CDC (2010). Decrease in Reported Tuberculosis Cases --- United States, 2009 [Internet]. Available from: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5910a2.htm

CDC (2010). Online Tuberculosis Information System (OTIS) Data [Internet]. CDC WONDER. Available from: http://wonder.cdc.gov/tb.html

Coberly JS, Chaisson RE (2007). Tuberculosis. In: Infectious Disease Epidemiology. Jones and Bartlett Publishers. pp. 653-697.

Dye C, Lönnroth K, Jaramillo E, Williams B, Raviglione M (2009). Trends in tuberculosis incidence and their determinants in 134 countries. Bulletin World Health Organization,pp. 683-691.

Grieco E (2010). Race and Hispanic Origin of the Foreign-Born Population in the United States: 2007 [Internet]. Washington, D.C. US Census Bureau. Available from: http://www.census.gov/prod/2010pubs/acs-11.pdf

Jennings T (2010). Economics, demographics and political culture explain divide between NM and AZ immigration policies [Internet]. New Mexico Independent. Available from: http://newmexicoindependent.com/54783/economics-demographics-and-political-culture-explain-divide-between-nm-and-az-immigration-policies

Khan K, Wang J, Hu W, Bierman A, Li Y, Gardam M (2008). Tuberculosis Infection in the United States, National Trends over Three Decades. Am. J. Respir. Crit. Care. Med.,pp. 455-460.

Migration Policy Institute (2011). 2009 American Community Surveyand Census Data on the Foreign Born by State [Internet]. Available from: http://www.migrationinformation.org/datahub/acscensus.cfm#

Snider GL (1997). Tuberculosis Then and Now: A Personal Perspective on the Last 50 Years. Annals of Internal Medicine,pp. 237-243.

Stead WW, Senner JW, Reddick WT, Lofgren JP (1990). Racial differences in susceptibility to infection by Mycobacterium tuberculosis. New England Journal of Medicine, pp. 422-427.

United Nations Statistics Division (2009). Tuberculosis death rate per year per 100,000 population (mid-point) [Internet]. UN Data A World of Information. Available from: http://data.un.org/Data.aspx?d=MDG&f=seriesRowID%3A647

US Census Bureau (2010). About the American Community Survey [Internet]. American Community Survey. Available from: http://www.census.gov/acs/www/about_the_survey/american_community_survey/

US Census Bureau (2010). State and County QuickFacts [Internet]. Available from: http://quickfacts.census.gov/qfd/index.html

Webster JB, Bishaw A (2007). Income, Earnings, and PovertyData From the 2006 AmericanCommunity Survey [Internet]. Available from: http://www.census.gov/prod/2007pubs/acs-08.pdf

World Health Organization (2010). Tuberculosis [Internet]. Nov;Available from: http://www.who.int/mediacentre/factsheets/fs104/en/