An Evaluation of Latent Tuberculosis Infections in an Ohio Prison

THESIS

Presented in Partial Fulfillment of the Requirements for the Degree Master of Public Health in the Graduate School of The Ohio State University

By

Tyler Edward Weant

Graduate Program in Public Health

The Ohio State University

2010

Master's Examination Committee:

David Murray, Advisor

Shu-Hua Wang
Copyright by

Tyler Edward Weant

2010
Abstract

The goal of this investigation was to evaluate treatment outcomes associated with tuberculosis in a correctional environment. We also conducted a case-control study to determine if social history variables such as tobacco use, alcohol use, intravenous drug abuse, and non-intravenous drug abuse were significant risk factors for tuberculosis infection.

Data on cases (individuals with positive tuberculin skin tests (TSTs)) and age-matched controls (individuals with negative TSTs) were extracted from medical charts at an Ohio Department of Rehabilitation and Correction (ODRC) facility in Orient, Ohio. Eighty-nine cases were identified and age-matched controls were randomly chosen for 88 individuals.

All 89 of the cases identified at the facility received a diagnosis of latent tuberculosis infection (LTBI), and 75 (84%) of the inmates had either completed or were receiving treatment for LTBI. Comparisons between the cases and controls revealed significantly higher rates of asthma (p=0.03) and rheumatoid arthritis (p<0.01) among cases. Conditional logistic regression determined that the social history variables we investigated were not significant predictors in this population.

Overall treatment outcomes from the study were encouraging with a majority of the infected inmates receiving and completing treatment for LTBI. No significant predictors of infection were found but more detailed information on frequency and duration of
substance abuse in future studies could prove otherwise. Some concerns were noted with regards to a lack of documentation of HIV results and treatments, however the facility demonstrates the ability of a correctional institution to detect and treat LTBI among a highly vulnerable and disadvantaged population.
Acknowledgments

I would like to thank David Murray, Shu-Hua Wang, Kevin Runyon, and the staff at Pickaway Correctional Institution for their contributions to the project which included assistance in: data collection, data analysis, record access, and epidemiological and tuberculosis consultation.
Vita

June 2002 ........................................................Francis Scott Key High School

2007.................................................................B.S. Microbiology, The Ohio State

University

Fields of Study

Major Field: Public Health
Table of Contents

Abstract............................................................................................................................. ii-iii
Acknowledgments.............................................................................................................. iv
Vita........................................................................................................................................ v
List of Tables .................................................................................................................... vii
List of Figures .................................................................................................................... viii
Chapter 1: Introduction .................................................................................................... 1-3
Chapter 2: Methods .......................................................................................................... 4-6
Chapter 3: Results ........................................................................................................... 7-12
Chapter 4: Discussion .................................................................................................... 13-19
Chapter 5: Summary ...................................................................................................... 20
References ....................................................................................................................... 21-22
List of Tables

Table 1. Results from annual TB surveillance testing of incarcerated individuals ........ 6
Table 2. Descriptive statistics of inmates with positive TST reactions and their resulting medical examinations.................................................................................................................. 8
Table 3. Treatment outcomes for inmates diagnosed with latent tuberculosis infection (LTBI).................................................................................................................................................. 9
Table 4. Results of baseline medical history comparison between inmates with TB infection and uninfected individuals............................................................................................................. 10
Table 5. Results of conditional logistic regression for social history of inmates .......... 11
List of Figures

Figure 1. Distribution of induration results from TB infected inmates receiving tuberculin skin tests........................................................................................................................................... 12
Chapter 1: Introduction

One-third of the world’s population is believed to be infected with *Mycobacterium tuberculosis*\(^1\). While most of these infections occur in the developing world, there is a disproportionately high prevalence of Tuberculosis (TB) among prison inmates in the United States\(^2\). Approximately 10% of patients with latent TB infection (LTBI) develop active TB infection. Incarceration itself has been described as a risk factor for infection by the causative agent, *M. tuberculosis*. Many inmates are confined to housing which exposes them to crowded conditions, increasing their risk of contracting the infection\(^3\). Inmates also experience greater risk of TB due to several factors prior to their incarceration including decreased access to healthcare, lower socioeconomic status, and substance abuse.

The transient nature of this high-risk population can adversely impact the public health of the general population when inmates are released\(^4\). If an infection is not properly detected or treated during incarceration, the prison inmate may develop active TB disease and transmit the mycobacteria to fellow inmates, staff, or to other members of the community outside of the correctional facility. In order to improve and maintain a high standard of healthcare for both prison inmates and the communities they will ultimately inhabit, it is vital that correctional institutions incorporate and uphold policies to address issues regarding TB.
Because of the problematic nature of *M. tuberculosis* in the prison setting, the Centers for Disease Control and Prevention (CDC) released updated guidelines in 2006 developed to enhance screening, prevention, and treatment in correctional facilities\(^5\). These guidelines highlight the opportunity to diagnose and treat individuals that otherwise might not have access to proper care.

The goal of our study was to evaluate treatment outcomes as well as identify risk factors for infection associated with the social history of inmates in an Ohio correctional institution. By evaluating the prison’s implementation of TB protocols, we can assess how successful the policies are in addressing infections and determine if there are any areas for improvement. Identification of significant risk factors for TB in the prison setting would not only help staff to identify those who are most vulnerable, it would also give prison personnel the opportunity to educate inmates on behaviors that increase their risk of infection.

Our investigation of social history focused on tobacco use, alcohol use, intravenous drug abuse (IVDA), and non-IVDA. The potential of these 4 variables as risk factors for TB has been previously described\(^6-8\). Tobacco use, specifically smoking, can cause damage to lung tissue which can lead to bacterial infections. The cumulative effects of alcohol abuse can also prove detrimental to the body, especially the immune system. With impaired immune functions, an individual can be more susceptible to infections and diseases. The social nature of IV drugs as well as non-IV drugs can increase the risks of TB among users.
The Ohio Department of Rehabilitation and Correction (ODRC) consists of 32 prisons throughout the State of Ohio. The ODRC houses approximately 51,000 inmates with an estimated 37,000 additional offenders that continue to be monitored under ODRC supervision among communities in the state as well. In 2004, the ODRC implemented an annual TB surveillance program. Under this program, prison facilities in the state conduct mass TB testing once a year on individuals currently incarcerated who have not had a positive tuberculin skin test (TST) before. Under this policy, from 2004 to 2007 the ODRC had 499 (0.3%) of 165,802 tests result in positive TSTs.
Chapter 2: Methods

Data used in the investigation were collected from the Pickaway Correctional Institution (PCI) located in Orient, Ohio. PCI is a moderate security, male prison which housed approximately 2,400 inmates while the study was being conducted. PCI also participates in the annual mass testing program in the ODRC. Data from the testing which was compiled from 2004 to 2007 found 26 (0.36%) of the 7,188 tests conducted had positive TST results (Table 1).

Prison personnel identified cases which were inmates that had a documented TST result of ≥ 10mm. Data on cases were extracted from medical charts during July 2009. A prison transfer sheet was used to determine if the incarcerated individual had a history of previously positive TST or if this was their first positive test result. Three of the inmates were found to have positive TST reaction without induration measurements in their medical charts. After reviewing the charts, we determined that the inmates had completed isoniazid (INH) for LTBI during their current incarceration. We included these three cases in our analysis.

Clinical features for cases were determined according to results from examinations performed at the Tuberculosis Chronic Care Clinic on site. These data were also obtained from annual TB screening exams when available. Information on past medical history was extracted from a baseline medical exam administered upon incarceration. Results for chronic infectious diseases (i.e. Human immunodeficiency
virus (HIV), hepatitis C) were obtained from laboratory testing. Social history was
determined according to a mental health examination in which data were self-reported.
Due to inconsistent reports on frequency of substance use for several inmates, these
variables were measured dichotomously as having ever used the substance, or never used
the substance.

Information regarding treatment for TB, both during and prior to incarceration,
required documentation for treatment to be considered complete. The diagnosis of LTBI
was based on positive TST, no clinical signs or symptoms consistent with active TB
disease, and negative chest radiograph or computed tomography chest scan (when
necessary) examinations. Prison protocols recommended a regimen of 900 mg of INH
administered twice weekly for a period of 9 months for LTBI. An alternative treatment of
daily rifampin for 4 months was recommended to inmates who were intolerant of INH.
Treatments were administered by nurses using directly observed therapy (DOT).

A reference population of inmates with negative TST reactions was randomly
chosen from the prison inmate population at PCI during October 2009. The data for the
selected individuals were extracted from medical charts four weeks later. Because the
sample size was small, the population was matched on age to rule out the possibility of
the variable acting as a confounder during analysis. An age-matched control was selected
for each case according to year of age (i.e. each 26 year old control was chosen for each
26 year old case in the study). This resulted in the loss of one of the cases when
conditional logistic regression was performed due to the inability to locate a control with
the same age. Information on medical and social history for this population was collected using the same forms indicated for the cases.

Institutional review board approval for the investigation was obtained from both the Ohio State University and Ohio Department of Rehabilitation and Corrections.

Descriptive statistics from the evaluation were calculated using STATA 10. SAS 9.2 was used for Fisher’s exact tests which were utilized for comparisons regarding medical history between the cases and controls. This statistical package was also employed for the conditional logistic regression investigation of measured social history variables. An $\alpha$ of 0.05 was used to determine statistically significant results.

<table>
<thead>
<tr>
<th>Year</th>
<th>ODRC</th>
<th>PCI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tests Conducted</td>
<td>Positive TST (%)</td>
</tr>
<tr>
<td>2004</td>
<td>39,090</td>
<td>159 (0.41)</td>
</tr>
<tr>
<td>2005</td>
<td>39,448</td>
<td>132 (0.33)</td>
</tr>
<tr>
<td>2006</td>
<td>42,452</td>
<td>117 (0.28)</td>
</tr>
<tr>
<td>2007</td>
<td>44,812</td>
<td>91 (0.20)</td>
</tr>
<tr>
<td>Total</td>
<td>165,802</td>
<td>499 (0.30)</td>
</tr>
</tbody>
</table>

Table 1. Results from annual TB surveillance testing of incarcerated individuals$^a$.

$^a$ Inmates with previously positive TST were not tested
Chapter 3: Results

A total of 89 inmates were found to have positive TSTs at PCI. Cases ranged in age from 23 to 66 with a mean age of 40 years (Table 2). Approximately 9% of inmates with a positive TST who were examined experienced one or more symptoms consistent with TB disease (fever, fatigue, night sweats, unintentional weight loss). However, chest radiographs showed no evidence of active TB disease and these individuals were ultimately diagnosed with LTBI. Among cases receiving examinations, there was no evidence of inmates exhibiting other symptoms of active TB including cough, productive cough, chills, or hemoptysis. Unintentional weight loss (4.5%) along with fatigue (3.2%) and night sweats (3.2%) were the most frequent symptoms reported.
Table 2. Descriptive statistics of inmates with positive TST reactions and their resulting medical examinations.

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>No. Receiving Examination</th>
<th>% (No.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fever</td>
<td>62</td>
<td>1.6 (1)</td>
</tr>
<tr>
<td>Cough</td>
<td>62</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Productive Cough</td>
<td>62</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Unintentional Weight Loss</td>
<td>66</td>
<td>4.5 (3)</td>
</tr>
<tr>
<td>Fatigue</td>
<td>63</td>
<td>3.2 (2)</td>
</tr>
<tr>
<td>Night Sweats</td>
<td>62</td>
<td>3.2 (2)</td>
</tr>
<tr>
<td>Chills</td>
<td>62</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Hemoptysis</td>
<td>62</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Any</td>
<td>66</td>
<td>9.1 (6)</td>
</tr>
</tbody>
</table>

Of the 89 total cases, 37 (42%) tested positive for the first time during their current incarceration (Table 3). Among the newly infected individuals, 73% were found to have either completed treatment or were currently receiving the medication regimen. Of those treated at the prison, 3 (11%) inmates experienced adverse reactions during treatment with INH. These adverse events included chills, headaches, and nausea. Treatment was interrupted for 2 of these cases, with 1 inmate continuing and completing the regimen while the other inmate refused any further treatment. An adverse reaction was documented for one case treated prior to incarceration and the inmate completed an alternative regimen of rifampin. Ninety-two percent of the 52 inmates who were infected prior to their current incarceration were receiving treatment or had completed treatment for LTBI.
<table>
<thead>
<tr>
<th>Variable</th>
<th>LTBI diagnosed during current incarceration</th>
<th>LTBI diagnosed prior to current incarceration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases</td>
<td>42 (37)</td>
<td>58 (52)</td>
</tr>
<tr>
<td>Currently under care or completed treatment</td>
<td>73 (27)</td>
<td>92 (48)</td>
</tr>
<tr>
<td>Experienced adverse reaction</td>
<td>8.1 (3)</td>
<td>1.9 (1)</td>
</tr>
<tr>
<td>Treatment Interrupted</td>
<td>5.4 (2)</td>
<td>1.9 (1)</td>
</tr>
<tr>
<td>HIV tested</td>
<td>97 (36)</td>
<td>90 (47)</td>
</tr>
<tr>
<td>Co-infected with HIV</td>
<td>0 (0)</td>
<td>3.8 (2)</td>
</tr>
<tr>
<td>Received HIV treatment</td>
<td>0 (0)</td>
<td>3.8 (2)</td>
</tr>
</tbody>
</table>

Table 3. Treatment outcomes for inmates diagnosed with latent tuberculosis infection (LTBI).

HIV test results were documented for 83 prison inmates. Two (2.4%) of these inmates were found to be co-infected with TB and HIV. Both of these individuals were receiving highly active antiretroviral therapy (HAART).

Results of the comparative analysis between cases and controls are displayed in Table 4. Inmates with LTBI had significantly higher rates of asthma (p=0.03) and rheumatoid arthritis (p<0.01) compared to the reference population. Cases were also found to have higher rates of hepatitis C, however this result was only marginally significant (p=0.09). We also analyzed the following diseases in our comparison which were found to be insignificant: diabetes, arthritis, hepatitis B, cancer, hypertension, sexually transmitted diseases, mental health disorders, and HIV.
<table>
<thead>
<tr>
<th>Disease</th>
<th>Cases % (No.)</th>
<th>Controls % (No.)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asthma</td>
<td>21 (18)</td>
<td>8 (7)</td>
<td>0.03</td>
</tr>
<tr>
<td>Cancer</td>
<td>0 (0)</td>
<td>3 (3)</td>
<td>0.25</td>
</tr>
<tr>
<td>Diabetes</td>
<td>5 (4)</td>
<td>2 (2)</td>
<td>0.68</td>
</tr>
<tr>
<td>Hepatitis B</td>
<td>3 (3)</td>
<td>0 (0)</td>
<td>0.25</td>
</tr>
<tr>
<td>Hepatitis C</td>
<td>20 (18)</td>
<td>10 (9)</td>
<td>0.09</td>
</tr>
<tr>
<td>Arthritis</td>
<td>18 (16)</td>
<td>15 (13)</td>
<td>0.69</td>
</tr>
<tr>
<td>Rheumatoid Arthritis</td>
<td>11 (10)</td>
<td>1 (1)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Hypertension</td>
<td>19 (17)</td>
<td>16 (14)</td>
<td>0.69</td>
</tr>
<tr>
<td>STD&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10 (9)</td>
<td>14 (12)</td>
<td>0.49</td>
</tr>
<tr>
<td>Mental Health Disorder</td>
<td>7 (6)</td>
<td>14 (12)</td>
<td>0.14</td>
</tr>
<tr>
<td>HIV</td>
<td>3 (2)</td>
<td>1 (1)</td>
<td>0.60</td>
</tr>
<tr>
<td>Any</td>
<td>57 (51)</td>
<td>52 (46)</td>
<td>0.55</td>
</tr>
</tbody>
</table>

Table 4. Results of baseline medical history comparison between inmates with TB infection and uninfected individuals.

<sup>a</sup> Sexually transmitted diseases

Our investigation of several social history variables revealed that they were not significantly associated with TB infection among the prison population after matching for age (Table 5). Increased odds of infection were found for tobacco use (OR=1.08, 95% CI, 0.49 – 2.37), alcohol use (OR=1.44, 95% CI, 0.62 – 3.38), and IVDA (OR=1.44, 95% CI, 0.62 – 3.38) after matching for age, however these results were statistically insignificant. Alternatively, we found decreased odds of TB infection for non-IVDA (OR=0.50, 95% CI, 0.23 – 1.07) after matching for age. Although this result was only marginally significant (p=0.07), it suggests a protective effect for non-IVDA among inmates.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobacco</td>
<td>1.08 (0.49 – 2.37)</td>
<td>0.84</td>
</tr>
<tr>
<td>Alcohol</td>
<td>1.44 (0.62 – 3.38)</td>
<td>0.40</td>
</tr>
<tr>
<td>IV Drug Abuse</td>
<td>1.44 (0.62 – 3.38)</td>
<td>0.39</td>
</tr>
<tr>
<td>Non-IV Drug Abuse</td>
<td>0.50 (0.23 – 1.07)</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Table 5. Results of conditional logistic regression for social history of inmates.

During data collection, we noticed a large number of TST results taken upon incarceration with terminal digits of “5” or “0”. We investigated this and found that approximately 80% of test results exhibited this terminal digit tendency (Figure 1). Moreover, 30% of the tests recorded during current incarceration resulted in induration measurements of 10 mm. This signified that almost one-third of the inmates diagnosed with LTBI had results on the cutoff value for positive tests. Meanwhile, all of the randomly selected inmates from the reference population were non-reactive or had measurements of 0 mm for their test results.
Figure 1. Distribution of induration results from TB infected inmates receiving tuberculin skin tests\textsuperscript{a,b,c}.

\textsuperscript{a} Inmates with TSTs <10 mm had previously tested positive for TB infection

\textsuperscript{b} One test result was listed as 17-20 mm and was input at 17 mm in this distribution

\textsuperscript{c} One test result was listed as >20 mm and was input at 20 mm in this distribution
Chapter 4: Discussion

In this investigation of 89 cases of LTBI, treatment outcomes were assessed and it was determined that the outcomes were favorable for this population, however there is room for improvement. The prison’s impact on public health can directly be viewed by noting the 37 cases diagnosed upon their current incarceration. Without the screening process implemented by the institution, it is likely that these cases would have gone unnoticed and without treatment, which could lead to activation of the disease and increased rates of infection in inmates’ neighborhoods. We were able to locate documentation of completed or current treatment for a majority of the individuals in the study, regardless of the time of diagnosis. Documented HIV results were also found for most of the cases, which is vital to the success of a TB treatment program since co-infected individuals have a substantially higher probability of converting from a latent to active infection over their lifetime\textsuperscript{10}. The two inmates at the facility who were co-infected with HIV and TB had completed INH therapy and were currently receiving HAART treatment, which is consistent with CDC recommendations. Adverse reactions among cases treated at PCI were approximately twice the rate found in an international investigation into the side effects of a similar LTBI treatment regimen among a non-incarcerated population\textsuperscript{11}. This increased rate of adverse events could be due to factors other than the INH treatment, such as a desire to be removed from work or the general prison population. While the number of adverse reactions experienced by patients treated
at the prison was surprisingly high, it was encouraging to see that most of those patients were able to continue on with the prescribed treatment regimen.

Although the treatment situation at the institution was generally favorable, the missing HIV, TB examination, and treatment records could be cause for concern. As previously mentioned, co-infection with HIV has increased risks associated with activation among those with latent infections. Without documented results, it would be difficult to determine which inmates have an increased likelihood of activation, which could be particularly troublesome if they are living in a high density area of the prison. This undesirable situation could also arise if an individual with active infection is not examined for symptoms prior to imprisonment. The TB chronic care exams and chest radiographs are necessary components to reducing infectivity among the general prison population and it is vital that these protocols be adhered to. While a lack of documentation in a medical chart does not necessarily signify the test or treatment was never conducted, it could result in an unnecessary duplication of the act. Duplicate examinations or HIV tests are not intensely time consuming or expensive, however a duplicate course of LTBI treatment for an inmate can be costly to both the staff and the patient. An INH regimen lasts 9 months and requires administration by a nurse to comply with DOT protocol, which can be cumbersome for staff. Additionally, as evidenced by our investigation, the medication can cause side effects with several inmates experiencing adverse effects. These issues can be addressed and avoided simply by improving documentation practices in the treatment program.
We also found differences, both significant and of marginal significance, in medical history between the cases and controls in the study. Incarcerated individuals with TB infection had significantly higher rates of asthma and rheumatoid arthritis. The increased prevalence of asthma is somewhat surprising. A previous study on the relationship between TB infection and asthma found that there was an inverse association present among children\textsuperscript{12}. The investigators suggested that infection with \textit{M. tuberculosis} during childhood could modify immunogenic responses which would act to reduce the incidence of atopic disorders. This reasoning for an inverse association may not be valid under the circumstances of our investigation considering that our study included only adults aged 23 or older and the age at which they were infected is unknown. The retrospective nature of our case-control investigation also complicates issues regarding temporality. It is unknown whether inmates included in the study were infected with TB before or after developing asthma.

The higher prevalence of rheumatoid arthritis among cases could be due to a number of factors. In research regarding the association between TB infection and rheumatoid arthritis, one investigation conducted in Japan found a significant 10-fold increased risk of TB disease among males with rheumatoid arthritis compared to males without the disease\textsuperscript{13}. While this suggests a positive relationship between the disease and \textit{M. tuberculosis} infection, the reason for the correlation is uncertain. Japan has a higher rate of TB compared to the US. With an increased likelihood of exposure to the bacteria, results in this Japanese study population may not be generalized to Western nations. Rheumatoid arthritis patients may be receiving immunosuppressive agents that increase
the likelihood of developing active TB disease\textsuperscript{14}. The increased prevalence of rheumatoid arthritis could also be due to the higher rate of hepatitis C among cases. The rate of hepatitis C in the TB infected population was found to be marginally higher compared to the control group. This finding is consistent with a previous study of US Veterans Affairs hospitals which identified a significantly higher prevalence of tuberculosis among hepatitis C infected patients in the study population\textsuperscript{15}. Since a higher prevalence of arthritis has previously been identified with hepatitis C infection, our detection of an increased prevalence of rheumatoid arthritis is not entirely unexpected\textsuperscript{16}.

Hepatitis C has also been linked to the presentation of rheumatoid-like symptoms\textsuperscript{17}. While these characteristics do not represent true rheumatoid arthritis, they could complicate diagnostic accuracy when classifying the disease. Our data collection process may have also inadvertently classified some of the inmates with arthritis as having rheumatoid arthritis. Any misclassification that may have occurred would result in an inaccurate measurement of disease prevalence.

In our investigation we did not identify tobacco use, alcohol use, non-IVDA, or IVDA as significant risk factors for TB infection. Although increased odds of infection were found for tobacco, alcohol, and IV drug users, these associations were not significant after matching for age. These results were not particularly surprising in studying this specific population due to the high prevalence of substance abuse among prison inmates and small sample size. We were somewhat surprised to find an inverse relationship between non-IVDA and TB infection among the inmates, but again this relationship was only determined to be marginally significant.
While we did not detect any significant risk factors in our investigation, a larger sample size and more detailed history of substance abuse could provide increased accuracy when analyzing these variables. We were only able to generate a match at a frequency of 1:1 in the study. A larger number of age-matched controls for each case could aid in detecting any significant relationship that might exist. During our data collection, we were also restricted to categorizing substance abuse as “ever used” or “never used”. Incorporating frequency and duration of use would be desirable and yield more flexibility in performing the analysis. It would also be advantageous to investigate certain types of substance abuse by more detailed categories. For instance, non-IVDA is a broad category that encompasses several different forms of drug use such as cocaine, marijuana, and oxycontin. By partitioning the category, we could conduct a more thorough analysis on certain drugs which can be shared using cigarettes or pipes, to determine if there is an increased risk of infection.

Our findings of a potential terminal digit bias were noteworthy. This bias has been described before and is not particularly concerning when referring to its accuracy in predicting future likelihood of disease. However, the large percentage of individuals with test results of 10 mm, right on the cutoff for a positive result, could be cause for alarm. If staff are rounding up results of 8 or 9 mm to 10 mm, then there could be an issue with false positives among the inmate population. A false positive would be problematic for the same reasons stated earlier with regards to duplicate treatment of individuals: the treatment is long, time consuming, and potentially difficult to endure. It is also not cost effective as every positive TST result needs a chest radiograph, medical
examination, treatment, and follow-up for 4 to 9 months. There is also potential for adverse drug reactions and unnecessary risk if the diagnosis was inaccurate. Borderline results such as the ones found in our study could benefit from the use of an interferon-γ release assay (IGRA), a blood-based assay approved by the Food and Drug Administration for screening of LTBI. Commercialized tests include QuantiFERON-TB-Gold-In-Tube (QFT-GIT) (Celestis Inc, Australia) and T.SPOT TB Test (Oxford Immunotec, United Kingdom). Although no gold standard exists to determine specificity and sensitivity for TB screening, the use of an added blood-based assay could assist in distinguishing true positives from false positives, especially since it is not prone to the same subjectivity that could lead to false positive results. ODRC does have an electronic medical record (EMR) system. If information regarding tuberculosis screening, diagnosis, and treatment were available in EMR, it may improve follow-up of inmates who have multiple incarceration episodes in the ODRC system. An EMR would also improve the quality of research data collected. Starting in 2009, the ODRC has begun implementing QFT-GIT for inmates with positive TST or history of positive TST. The QFT-GIT laboratory results will be in the EMR and should improve the follow-up and treatment completion rates for LTBI.

Aside from the recommendations stated earlier to enhance our regression analysis, there were several areas that our investigation could have improved upon, and that future research on TB infection in the prison environment should take into account. We were unable to study several potential predictors of TB infection that we had originally intended to investigate. Additional TB risk factors which were not consistently
documented include: inmate’s employment history prior to incarceration such as a healthcare worker or congregate, use of a homeless shelter, country of origin, and history as a TB contact. However, information on these variables was not available in medical charts and would have only been collected through a prospective study interviewing prison inmates directly. Another way to improve the study would have been gained through access to records for inmates who were no longer incarcerated. Our investigation could only describe the population that was incarcerated at PCI while investigators were on-site. Collecting data on former convicts who had undergone treatment during imprisonment would give us a more comprehensive evaluation of the treatment process. There is also the potential for bias in the study due to the delay in data collection. Information on controls was extracted from charts 4 months after data was collected for cases. This delay was caused by the need for an IRB addendum to add the control population to the study protocol. It is unlikely that the makeup of the prison population changed dramatically over the 4 month holdup, however, if this did occur, our results would be affected.
Chapter 5: Summary

Through an analysis of 89 cases of TB infected prison inmates and an age-matched reference population, we were able to conduct an evaluation of LTBI at an Ohio correctional institution. From our results, we determined that social history factors such as tobacco use, alcohol use, IVDA, and non-IVDA were not significant predictors of TB infection among this study population. However, future studies should account for frequency and duration of substance abuse, as enhanced detail during data collection could yield different results. Our evaluation of the treatment program at the facility found encouraging outcomes associated with LTBI treatment completion, HIV testing and treatment, and continuation of the medicinal regimen after adverse reactions had been experienced. There were however issues regarding a lack of documentation in certain instances and a potential terminal digit bias in TST results. But these concerns are minor in comparison to the problem that TB can present in the correctional institution. This facility has demonstrated the enormous potential that exists in the prison environment, and in public health, to treat a highly vulnerable population for an infection that might otherwise go unnoticed, ultimately leading to increased morbidity and mortality in the nation.
References


