RISK FACTORS FOR TUBERCULOSIS CONVERSION IN A STATE PRISON

by

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A THESIS

Presented to the Department of Public Health
and Preventative Medicine
in partial fulfillment of
the requirements for the degree of
Masters of Public Health
May 2003

School of Medicine
Oregon Health Sciences University

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TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

ACKNOWLEDGEMENTS

I would personally like to thank my advisor Dr. Gary Rischitelli for all his help and encouragement. I could not have completed the project without his guidance. I thank Dr. Steven Shelton, the Medical Director of the Oregon Dept. of Corrections (ODOC), for opening the door for prison research. The collaboration between the ODOC and Oregon Health Sciences University (OHSU) would not have happened otherwise. I also thank Dr. Eldon Edmundson for establishing the relationship between OHSU and ODOC and for editing my manuscript. Additional thanks go to Dr. Gary Sexton for statistical assistance, Dr. Jay Kravitz for discussions about tuberculosis, Ruth Wu for help in sorting the data, and Catherine Knox, Pam Teschner, Bob Reid, Paul Schroeder, and the TB Nurse Coordinators for providing much of the data. Finally, I appreciate all the help that Dr. Tom Becker, Dr. Katie Riley, Joketta Donaldson, and the Dept. of Public Health and Preventative Medicine have given me throughout my years at OHSU.

ABSTRACT

Objectives. Prisons are congregate institutions identified as having higher rates of tuberculosis (TB) than the general population. This study determined the prevalence, incidence, and risk factors for TB conversion among Oregon Department of Corrections (ODOC) inmates from July 2000- July 2001.

Methods. Inmates receiving anti-tuberculous drugs were identified through ODOC pharmacy records. Once identified, a database query and medical chart review were performed to obtain inmate health and demographic information. Controls were randomly selected from all 12 institutions. The case-control study (risk factor analysis) was performed using multivariate logistic regression.

Results. The prevalence of TB among ODOC inmates was 8% (826 out of 9,746) and incidence 1.4 per 100 person-years. The PPD conversion rate was approximately 0.5 per 100 person-years. Two-thirds of the converters tested positive on their second PPD skin test indicating the possibility of the booster phenomenon rather than recent conversion in prison. The converters were 6 times *more* likely to be Latino ($p < .005$) vs. Caucasian, over 19 times *less* likely to live in medium vs. minimum ($p < .001$) or maximum vs. minimum ($p < .001$) security prisons, and over 5 times *less* likely to live in a medium vs. low ($.012 < p < .031$) or high vs. low ($.002 < p < .007$) density prison. They had 1.4-1.5 times *fewer* PPD skin tests ($.002 < p < .009$) and lived in 1.5-1.7 times *fewer* prisons ($.005 < p < .017$). Age, education, county of incarceration, prior number of incarcerations, and number of visitors were not found to be significant variables.

Conclusions. The ODOC had a lower prevalence and incidence of TB compared to other prisons in the United States from July 2000- July 2001. Foreign-born inmates, particularly from Mexico, were at highest risk for conversion. Previously identified risk factors for conversion in other prison populations, namely living in densely-crowded institutions and residing for long durations were not found to be significant in this population. Prison health officials should consider performing two-step skin testing in this subset of inmates because of a possible booster effect. Future research regarding boosting and a computerized TB registry would help the ODOC track skin test prevalence and incidence.

INTRODUCTION

Tuberculosis Surveillance

Surveillance is the "ongoing systematic collection, analysis, and interpretation of outcome-specific data for use in planning, implementation, and evaluation of public health practice." (1) It is the conceptual framework and mechanism behind tuberculosis (TB) control programs. The purpose of surveillance includes quantitative estimates of the magnitude of a health problem (e.g., prevalence of latent TB infection), portrayal of the natural history of disease (e.g., progression from latent to active disease), detection of epidemics (e.g., increased incidence of infection), documentation of the distribution and spread of a health event (e.g.,. temporal and spatial clustering), evaluation of control and prevention measures (e.g., lack of two-step PPD testing at intake), and planning (ex. screening high risk inmates more often). (2) These activities fall into the three major categories: 1) assessment, 2) policy, and 3) assurance. (3) Assessment is the periodic and systematic collection and analysis of health information. Policy is the development of health standards and protocols based on the available scientific evidence. It incorporates collaboration and consensus building. Assurance is the promise and regulatory power that services will be provided. This research project assessed the magnitude of latent TB infection as determined by positive PPD reaction in the Oregon Department of Corrections (ODOC) by calculating the prevalence and incidence of latent TB infection and looking for spatial and temporal clustering. Statistical analysis was performed to obtain the risk factors for conversion. These results were then used for the planning of potential policy changes.

Effective surveillance presumes that there is an organized health care system and a stable government. In many parts of Eastern Europe, Africa, and Asia, there is an inadequate

infrastructure for surveillance. (4) Effective surveillance programs depend on infrastructure such as health clinics, research laboratories, and computer information systems. The Oregon Department of Corrections infrastructure includes health clinics, isolation rooms, and affiliations with TB research labs. They also had a Corrections Information System (CIS) with computerized inmate demographics, but no TB registry or computerized system for TB skin tests. Specific nurses were trained in TB programming and a protocol existed for contact investigation when an active case was discovered. All the resources needed to treat active and latent TB were present at the ODOC.

Passive surveillance is the reporting of health information when it occurs (e.g., case counting), while active surveillance is the initiation of protocols or procedures to obtain necessary information (e.g., case finding). An example of passive surveillance is the reporting of active TB to the local and state health departments in the U.S. An example of active surveillance is the screening of inmates for latent TB. The ODOC participated in many forms of active surveillance. They screened for latent TB with the PPD skin test and active TB with the clinical exam, chest x-ray, sputum acid-fast stain, and *Mycobacterium tuberculosis* culture. Active cases were isolated and both active and latent cases were strongly encouraged to take anti-tuberculous medications by directly observed therapy (DOT). Directly observed therapy is the observation of infected patients taking anti-tuberculous medications and the incentives built in to encourage compliances.

Tuberculosis Transmission and Pathogenesis

Tuberculosis is caused by the bacteria *Mycobacterium tuberculosis.* (5) It is not caused by *Mycobacterium bovis*, the attenuated strain used in the Bacille Calmette-Guerin (BCG) vaccine. The most common form of tuberculosis is the pulmonary form in which bacteria are spread through respiratory droplets after coughing, sneezing, or speaking. These minute particles of bacteria are inhaled by individuals within close proximity or those sharing the same ventilation. The person coughing has a sign of active infection or disease. Only active TB infection is contagious. Latent TB is the stage when the bacteria are contained but not eradicated by the body's immune system. Ninety percent of individuals with latent TB will not develop active disease. (5) A weak immune-system allows the bacteria to divide and spread to the common areas like the lungs, kidneys, brain, and bone.

The probability that TB will be transmitted depends on four factors: **1)** the infectiousness or bacteria load of the person coughing, **2)** the environment such as housing and ventilation in which the exposure occurred, **3)** the duration of exposure, and **4)** the virulence measured as the number of this particular bacteria strain needed to cause TB disease. Many administrative and environmental factors such as housing and ventilation affect disease transmission. Congregate settings such as prisons have the potential for a TB epidemic. Isolation and treatment of active cases are crucial. The completion of anti-tuberculosis medications decreases the bacteria load and infectiousness of active disease.

Every inmate that enters the ODOC has a past medical and social history. The risk factors for TB are listed in Table One. In general, the risk factors are associated with personal contact with active cases. They may be behavioral (eg. illicit drug use), structural (eg. poverty), or

environmental (eg. housing). Immigration from areas of high TB prevalence is a major cause. From 1986-2001, the number of TB cases among the foreign-born in the U.S. increased by 60%, from 4,925 cases or 22% of the national total to 7,865 cases or 49% of the national total. (6) An increased risk based on race has been postulated by some researchers. In a nursing home study, African-Americans had a relative risk of 1.9 for contracting TB compared to Caucasians. (7)

The risk factors for active disease are almost always different. They are associated with a decreased immune-system and include **1)** HIV infection, **2)** recent infection within the past two years, **3)** immuno-compromising medical illnesses such as diabetes and cancer, **4)** illicit drug use, and **5)** inadequately completing a proper course of anti-tuberculous medications. In this study, the risk factor analysis focused on incarcerated inmates. Once in prison, inmates were screened and deemed infected or not infected. Those not infected were exposed to other inmates and conditions vastly different from the outside. Previously identified risk factors for contracting TB while in prison are **1)** exposure to an active case, **2)** increased crowdedness, **3)** increased duration of stay, **4)** being housed in multiple institutions, and **5)** being incarcerated multiple times. (8-10) These variables with the exception of an exposure to active case were all studied along with the number of visitors and level of prison security. The other variables

TABLE ONE: Risk Factors for Latent TB Infection

Close contacts of a person known or suspected to have TB
Foreign-born people from areas of high TB prevalence
Residents and employees at nursing homes, prisons, mental institutions, homeless shelters, and long-term residential facilities
Medically underserved, low income populations
High risk ethnic and racial minorities such as Asian and Pacific Islanders, Latinos, African-Americans, Native Americans, migrant farm workers, and homeless individuals
Infants, children, and adolescents exposed to adults in high risk categories
Illicit drug users

commonly known to be risk factors *before* coming to prison were included in the analysis. These were: age, race, citizenship, birthplace, district of incarceration, educational assessment, and drug abuse potential.

Tuberculosis Epidemiology

In 1953, the U.S. reported 84,000 cases of active TB. Effective anti-tuberculous medications were being used and the standard of living in the U.S. was increasing. Between 1953-1985, there was a steady decline in the number of cases. In 1984, the decline reversed and there were 22,255 cases reported to the Centers for Disease Control (CDC). (11) Due to a decrease in public health funding, congregate settings became reservoirs of infection. Immigrants from areas with high TB were moving into the U.S., while the HIV epidemic was causing immuno-suppresion and rapid progression to active disease. The public health infrastructure was in disarray and many TB infection programs were lacking the resources, staff, and training to properly isolate and treat active cases.

An epidemic occurred from 1985-1992. Table Two shows the number of cases and incidence rates for 1985, 1993, and 2001. In the state of Oregon, the rate rose up to 6.0 per 100,000 person-years in 1996.

TABLE TWO: Active TB Cases in the U.S.

Year	Cases	Rate*
1985	26,673	11.2
1993	25,287	9.8
2001	15,989	5.6

* = per 100,000 person-years

There has been a steady decline since then due to increased surveillance. In 2002, the states of Hawaii and New Mexico continued to have high incidence rates of 11.9 and 14.4 (Appendix One). The rest of the nation had a rate below 10 cases per 100,000 person-years.

Table Three shows the number of cases and incidence rates in Oregon from 1997-2000. (12) The rates have decreased each year. Cases co-infected with HIV have ranged between one and twelve per year (1993-2001).

TABLE THREE: Active TB Cases in Oregon

Year	Cases	Rate
1997	161	5.0
1998	156	4.8
1999	123	3.7
2000	119	3.5

* = per 100,000 person-years

In 1998, eight percent of TB cases were co-infected with HIV. The rate was lower every other year.

U.S. Prison Epidemiology

An increasing number of people are living and working in US prisons. From 1980-94, the number of inmates in federal and state correctional facilities tripled from 319,598 to 990,147. (13) In 2001, there were 1,330,980 inmates living in prison and 731,147 on parole (Appendix 2). In 1991, over 436,991 inmates were released from state or federal prisons. Without proper screening and adequate treatment, these inmates may infect others within the prison system and outside in the community. In a survey of more than 20,000 state and federal inmates, over one-half of males and two-thirds of females reported having at least one child. Children are at increased risk when exposed to an adult with active disease. In Oregon, the number of inmates has increased from 4,431 in 1988 to over 11,000 in 2002. This was a 160% increase in population size.

During the epidemic of 1985-1992, state prisons had an average three-fold greater incidence of pulmonary TB compared to the general population. In New York (14), New Jersey (15), and California (16), the incarcerated were six to eleven times more likely to have active TB. Table Four shows the incidence rates and relative risks for active TB in these state prisons in comparison to their general state populations. In response to the epidemic, state health departments began to report incarceration status to the CDC in 1993. The reporting revealed that 4.6% of 24,361 cases were incarcerated in 1994. Prisoners comprised less than one percent (0.6%) of the general population in 1994. They were seven times over-represented, making them a high risk group for TB surveillance. (17) In Oregon, there were very few active cases in the prisons. From 1995-2001, there was one case in 1997, 1998, and 2001. (12)

TABLE FOUR: Incidence Rates for Active TB in Three State Prisons Compared to General Population in State

State	Incarcerated	Non-Incarcerated	Relative Risk
California (1991)	184	16.7	11
New Jersey (1992)	91.3	12.6	7.2
New York (1993)	139.3	21.7	6.4

Despite the low incidence in Oregon, active cases in other states were infecting the greater population of inmates. The prevalence of latent TB soared up to 28% in a California prison. (22) Over one-quarter of the inmates in six

TABLE FIVE: Prevalence of Latent TB Infection in State Prisons (18-21)

Author (year published)	State (year(s) of study)	Prevalence (mean)	Inmate Population
BEFORE EPIDEMIC			
Anderson et al. (1986)	Washington (1982)	5.4-18.1% (12.5%)	4269
DURING EPIDEMIC			
Truman et al. (1988)	New York (1987-88)	18.2%	494
Spencer et al. (1989)	New Mexico (1986-7)	6.1-21.2% (14.2%)	2240
Salive et al. (1990)	Maryland (1987)	12.7%	693
Glaser et al. (1992)	New York (1990)	27.0%	856
MMWR (1993)	California (1990-91)	24.6%	9764
MMWR (1992)	California (1991)	29.7%	2944
AFTER EPIDEMIC			
Baillargeon et al. (2000)	Texas (1997-98)	20.1%	170,215

California and one New York prison (23) were infected with latent TB as seen in Table Five. The prevalence continued to remain high in a Texas prison. (24) These alarming statistics prompted health officials in three state prisons to conduct a TB conversion study.

TABLE SIX: Incidence of Latent TB Conversion in State Prisons

Author (year published)	State (year(s) of study)	Conversion Rate* (mean)
Spencer et al. (1989)	New Mexico (1986-87)	0–6.8% (3.9%)
Johnsen, C. (1993)	New York (1991)	5.5 – 7.4 (6.7%)
MacIntyre et al. (1997)	Maryland (1991-93)	0-53% (6.3%)

* = per 100 person-years

In New Mexico, the average conversion rate was 3.9%. In some New Mexico prisons, up to 6 inmates per 100 were contracting TB while being incarcerated for one year. In Maryland (8), one intake center had a conversion rate of 53 per 100 inmate-years. Active cases were spreading the bacteria and true conversion was occurring. In New York (25), the conversion rate ranged from 5.5 to 7.4 per 100 inmate-years.

Latent TB Screening in Prisons

True conversion is differentiated from pseudo-conversion. Active TB is confirmed with a bacteria culture for *Mycobacterium tuberculosis*, but latent TB is dependent on the validity and interpretation of the PPD skin test. The Centers for Disease Control (CDC) has no published results on the sensitivity and specificity of the tuberculin skin test. A study of 250 patients in India revealed a sensitivity ranging from 20-81% and a specificity ranging from 71-97%. (26) A German study on 642 patients revealed a sensitivity of 95%. (27) There are false positives that may have reacted to *Mycobacterium avium* or other species. This can be determined with

laboratory studies, but it is not cost-effective to determine the species in every case. One study showed variability in the interpretation of skin test readings. Health care workers had a sensitivity of 87% and a specificity of 97% when reading calibrated models. This translated to a false positive rate of 3%. (28) At the minimum, there must be about 6% false positives due to lab and interpreting error alone. One study revealed a 40% increase in false positives due the brand of tuberculin administered. Aplisol tuberculin caused more false positives than Tubersol (29). At the ODOC, every converter is encouraged to take anti-tuberculous medications. These medications are highly effective, but have side effects such as hepatitis and must be taken for at least 6 months. Only symptomatic patients are cultured to verify true conversion.

The major concern at the ODOC revolves around the phenomenon of boosting. Boosting occurs when an inmate has a decreased immune response, called delayed hypersensitivity, to the tuberculin skin test. These inmates test negative even when though they were infected with latent TB. Their immune response gets "boosted' from their first test allowing them to test positive on their second test. They are pseudo-converters that make it difficult to assess true conversion. One solution is implementing two-step skin testing where a second test is given 1-3 weeks after the first. Two negative tests indicate an absence of infection, but a negative followed by a positive test strongly suggests a past positive and the boosting phenomenon. The risk factors for boosting have not been studied in the prison population according to the author's literature searches. Research on health care workers, school children, and young adults showed older age, previous BCG vaccination, and sensitivity to atypical Mycobacterium to be risk factors. (30-35) Older age decreases the immune response to tuberculin and previous a vaccination or sensitivity to atypical Mycobacterium elicits a weaker response respectively. In one state prison, the rate of boosting

was 1%. (36) The health officials did not think it was cost-effective to initiate two-step skin testing. When the boosting rate was higher at 5%, a hospital in California initiated two-step skin testing for all employees and patients. (37) This study evaluated the extent of boosting in the Oregon prisons.

Boosting is different from anergy which is the lack of an immune response due to an immune-compromising disease like HIV. Immuno-compromising individuals have a lower threshold for a positive skin test. A HIV positive individual with a skin test reaction 5 mm + is considered positive, while an inmate at 10 mm+ is considered positive. The general population is positive at 15 mm+. The CDC developed the thresholds based on the expected risk of exposure in the three groups. By decreasing the threshold from 15 to 10 mm in high risk groups such as inmates, the sensitivity was increased and specificity was decreased meaning that more infected inmates were detected at the cost of increasing the number of false positives.

The CDC developed guidelines for correctional facilities in 1989 and 1995. (38-39) In the first guideline, the increased risk for active TB due to co-infection with HIV was highlighted. In the second guideline, the principles of screening, containment, and assessment were emphasized. The basic principles revolved around yearly skin testing, treatment with prophylactic medications, containment of active cases, and periodic assessments. An outline summary of the manual is shown in Table Seven.

TABLE SEVEN: Guidelines to Controlling TB in Correctional Facilities

Screening	Containment	Assessment
1) Identify active TB cases. 2) Identify latent TB cases. 3) Screen by: a) symptoms b) chest x-ray c) PPD skin test d) Two-step skin testing if boosting is prevalent 4) Interpret skin test- 10 mm or greater induration is positive for inmates. 5) Follow-up Screening- Annual PPD skin test. 6) Report all active cases.	1) Isolate and treat all active TB cases. Place in isolation rooms. 2) Offer preventative therapy to all latent TB cases. 3) Use engineering controls such as UV lights and HEPA filters.* 4) Use personal respirators when working with active cases 5) Initiate contact investigations. Skin test all contacts with the infectious cases. 6) Use directly observed therapy 7) Monitor drug therapy and side effects	1) Maintain up-to-date records for risk assessment and program review 2) Evaluate skin test data for evidence of transmission 3) Assess completion of therapy and preventative therapy 4) Collaborate and consult with health departments for training and education

* UV = ultra-violet HEPA = High Efficiency Particulate Filtration

The ODOC followed all of these guidelines with the exception of employee skin testing. A correctional employee union decided that they wanted no mandatory testing for their employees. They had the legal right to ignore the recommendations for annual skin tests. With the low rate of TB in the Oregon prisons, no political mandates were warranted. Structurally, the ODOC had isolation rooms and the latest in environmental controls. In addition, they used High Efficiency Particulate Air (HEPA) filters and UV lights in the rooms. This technology reduces the concentration and spread of TB by filtering the air or directly killing the bacteria by irradiation. The ventilation systems are both single pass and recirculating. A single pass system does not mix contaminated room air with air from the outside and is preferred over the recirculating system. When working with an active case, the health care workers wear personal respirators with HEPA

filters. This protects them from contracting TB. Since 1993, these are required by the Occupational Safety and Health Administration (OSHA). At the minimum, they had to filter particles one micrometer in size with an efficiency of 95% (type C allowing only 5% leakage) and flow up to fifty liters of air per minute. Type B respirators were 99% efficient while type A were nearly 100% efficient (99.97%) and had the highest quality. The equipment was very expensive and prompted much debate over the cost-effectiveness of the technology. One hospital did not find HEPA filters to be cost-effective. (40)

Eliminating Tuberculosis

In May 2000, the Institute of Medicine (IOM) issued a report entitled, "Ending Neglect: The Elimination of Tuberculosis in the United States". (41) The report detailed the multi-factorial strategies necessary to prevent resurgence and decisively eradicate TB in the United States. Eradication is defined as < 1 case per 10,000 person-years. The basic principles revolved around surveillance, applied research, prevention and control, and infrastructure. A shift from active to latent TB screening was emphasized. High risk groups such as inmates, immigrants, and HIV+ individuals should be targeted. To adapt to these changes, the financing and management of services would have to be coordinated. More managed care and private providers would be involved. Research in vaccine development and improved screening tests would be encouraged and funding for public education crucial to maintain the political impetus to eliminate TB. The infrastructure would evolve and the surveillance would remain vigilant.

To treat latent TB with prophylactic medications, improved screening tests are necessary.

In 2001, the Quantiferon test for TB was approved by the U.S. Food and Drug Administration. (42) It is an example of applied research that may benefit society. Known as the interferon-gamma blood test, it was shown to have sensitivity of 90% and a specificity of 98%. (43) In another study, it was comparable to the to the tuberculin skin test (PPD). (44) The overall agreement between the tuberculin and Quantiferon test was 83%. The good news was that the test was more specific for *Mycobacterium tuberculosis*. There were less false positives due to BCG vaccination or sensitivity to *Mycobaterium avium*. A positive tuberculin and negative Quantiferon test was associated with BCG vaccination. In unvaccinated individuals, one-fifth of the false positives (7 of 33) on the tuberculin skin test were due to sensitivity to *Mycobacterium avium*. The ODOC may consider using the Quantiferon test in the near future. It would be half the cost of the tuberculin skin test ($10 vs. $20) and decrease the number of false positive and negatives. (45)

METHODS

Study Population

The Oregon Department of Corrections (ODOC) consisted of twelve institutions and one intake center during the study period (Appendix 3). The inmate population ranged from n = 166 at the Oregon Women's Correctional Center to n = 2,794 at the Snake River Correctional Institution and were often in flux. One study by the DOC showed that less than 50% of inmates resided in the same institution for a six month period. The Oregon Correctional Intake Center is in Oregon City and houses the main TB screening site upon entering the prison system. All inmates were skin tested at the Intake Center. Subsequent skin testing occurred in their respective institutions. Men comprised 95% (n = 9,746) of the inmates population and women 5% (n = 573). The

women were housed in three institutions while the men were spread out in all twelve. One-third of the inmates were between the ages of 18-30, forty-five between 31-45 and one-fifth between 45 and 70. Due to the demographic preponderance of men, women were excluded from the study. Three-quarter of the inmates were Caucasian, 11% Latino, 11% Black, and 3% other.

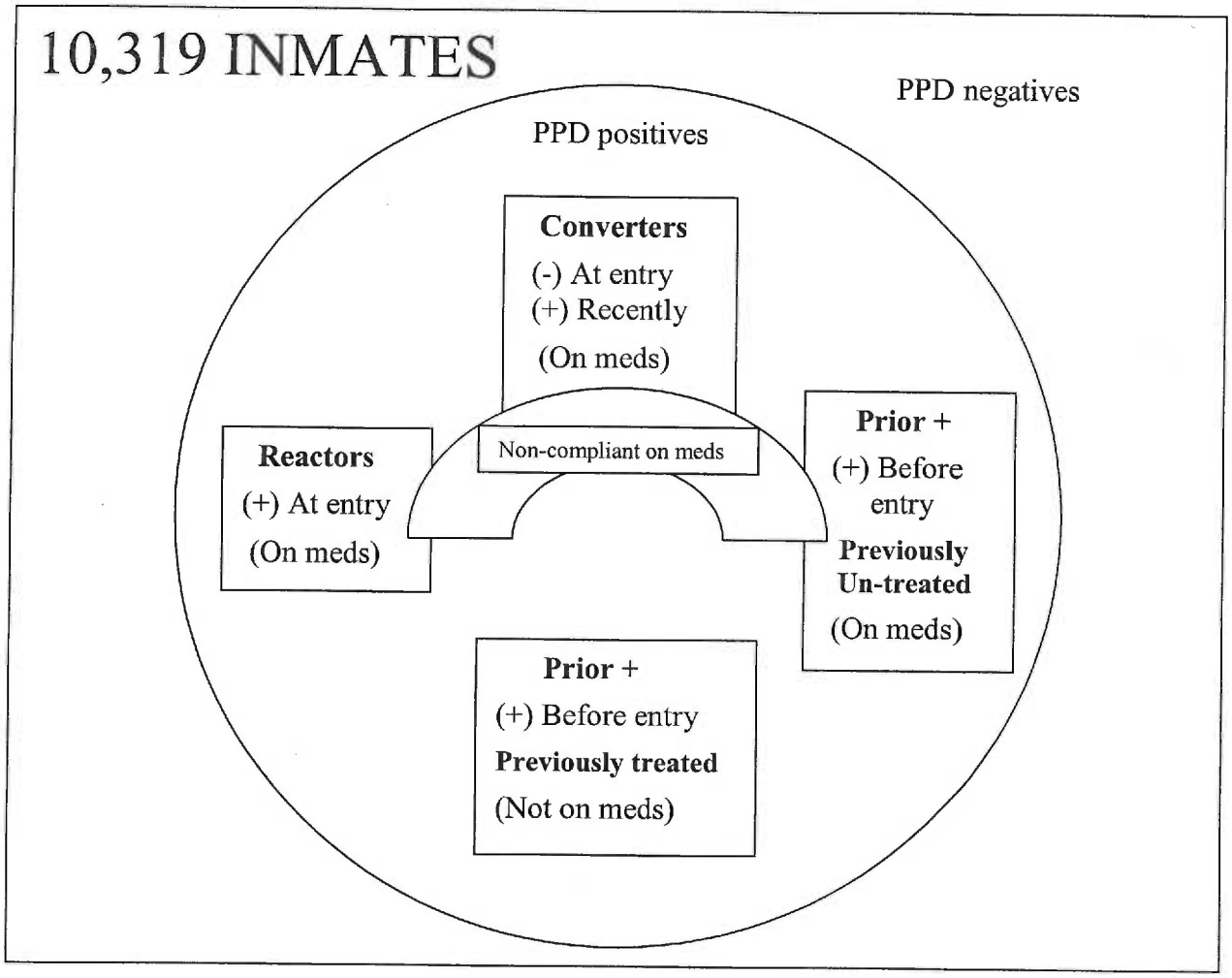
Confidentiality

As a student researcher at Oregon Health Sciences University (OHSU), Institutional Review Board (IRB) approval was obtained. Inmate records were viewed with the names removed and given a unique identifier. The student researcher was subsequently hired as a volunteer of the Oregon Department of Corrections (ODOC) at a later point in the study and gained full access to the data. All inmate records were kept in a locked file cabinet and the records destroyed after the research was completed.

Case Definitions

The TB records contained the information necessary to separate the converters, reactors, and prior positives (previously treated or untreated). "Converters" were inmates who tested negative upon entrance and positive during an annual skin test. They were on TB meds at some point during July 00-01. "Reactors" tested positive upon entrance while "previously untreated prior positives" were started on medications in prison. A fourth group consisted of inmates who were positive in the past and treated before incarceration. These "previously treated prior positives" were estimated from the control sample. A final group was composed of PPD positive inmates who refused to take medications. They were classified as "non-compliant on meds". The figure below displays the different groups.

FIGURE ONE: Venn Diagram of Converters, Reactors, and Prior Positives



Study Design

Pharmacy database search for cases

In order to capture the cases, inmates receiving anti-tuberculous medications during a one year period from July 1, 2000 – June 30, 2001 were identified through the pharmacy database. The association between infection and the immediate use of anti-tuberculous medications was verified by the Monthly TB Statistics. Ninety-nine percent of PPD positive inmates during the one year were placed on drug therapy (Appendix Four).

Medical chart review of cases

The PPD skin test information was recorded in the TB section of the medical records. For all the cases, the medical charts were reviewed in order to separate the converters from the reactors and previously untreated prior positives. This was necessary for the prevalence and incidence study.

Database Search for demographic information

The patient demographics were obtained from two computerized databases.

Case-control study for the risk factor analysis

Cases that converted before July 1, 2001 were used in the risk factor analysis. The controls were randomly selected from all the institutions except the Oregon Woman's Correctional Center. The controls were male and not on anti-tuberculous medications. Matching was not performed because every demographic variable was of interest. A pre-hoc power analysis was performed as shown in the Table Eight below.

It was estimated that 2% of the population or 200 inmates would be converters. A pre-planned number of controls doubling the cases would be used. The null hypothesis was that the Odds Ratio between cases and controls was 1.0. The anticipated Odds Ratio for the known risk factors ranged from 1.9-2.5 based on previous studies.[8-10] (8-10)

The level of significance signified by alpha indicates the probability of a type one error. With an alpha set at .05, there is a 1 in 20 chance that random error can result in a false positive.

Choosing a wide prevalence of exposure ranging from 10-35% and the corresponding OR's and sample sizes, the power or ability to detect a difference if one truly existed ranged from 71% to 99%.

TABLE EIGHT: Pre-hoc Power Analysis

Prevalence of exposure in the controls	.10	.10	.25	.25	.35	.35
Odds Ratio	1.9	2.5	1.9	2.5	1.9	2.5
Sample Size of Cases	200	200	200	200	200	200
Sample Size of Controls	400	400	400	400	400	400
Power	.71	.97	.93	.99	.95	.99

Tuberculin Testing Procedure

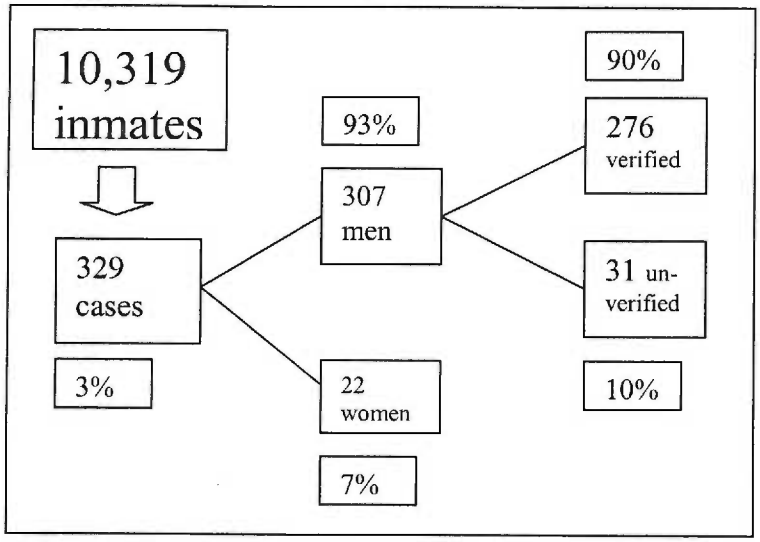
Testing was performed and read by licensed nurses by means of the Mantoux method. A 0.1 ml sample of tuberculin containing 5 TU was used. A positive reaction was defined as one greater or equal to 10 mm. For those with HIV, a reaction greater or equal to 5 mm was considered positive.

Data Sources and Collection

Pharmacy Records for Controls

All the inmates on anti-tuberculous medications from July 1, 2000 – June 30, 2001 were reported from the pharmacy database. These 329 inmates were presumed cases. Ninety-three percent were men and seven percent women. Ninety percent of the male records were reviewed to confirm a positive PPD skin test. Ten percent of the records (n = 31) were not reviewed and accounted for a potential of 8 missing converters. Figure Two displays the number of cases.

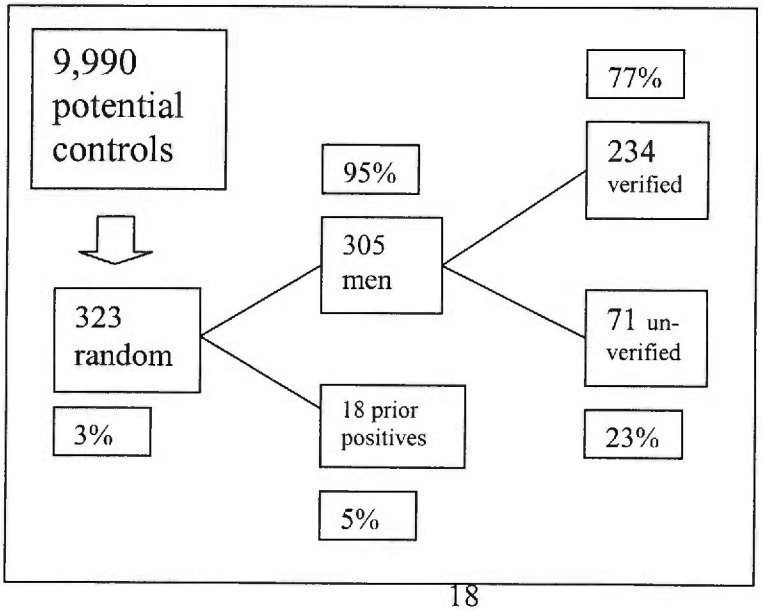
FIGURE TWO: Flow Diagram of the Number of Cases



Computer Database for Controls

A database manager at the ODOC randomly selected 329 inmates (326 males, 6 females inadvertently) who were never on anti-tuberculous medications. All of these inmates resided in the ODOC from July 1, 2000 – June 30, 2001. Five percent of these inmates were found to be prior positives (before July 2000) and were not used in the data analysis. Seventy-seven percent of the male controls were verified through a medical chart review. Figure Three displays the numbers.

FIGURE THREE: Flow Diagram of the Number of Controls



Medical Charts for TB information

From Dec. 00–Dec. 02, the TB Nurse Coordinators across the state were contacted three times via e-mail and asked to send a copy of the TB records to the student investigator. Forty, fifty, and sixty percent of the data were collected during each wave of data collection. Between Jan.02–Nov. 02, the student investigator visited the central records department twice to collect information on paroled inmates. In Dec. 02, the investigator visited several prison sites to obtain further records. Ninety percent of the case records and seventy-seven percent of the controls records were obtained.

Computer databases for demographic information

The demographic variables were collected from two sources. All the variables were derived from the Correctional Information System (CIS) database except for "drug abuse potential" that came from the mental health computer database. Inmate psychiatric assessments provided the data for that variable. ODOC staff provided all the demographic information for the cases and controls.

Variable Selection

The known risk factors for intramural conversion in other state prisons were: **1)** exposure to an active case, **2)** increased crowdedness, **3)** increased duration of stay, **4)** being housed in multiple institutions, and **5)** being incarcerated multiple times. These variables with the exception of an exposure to active case were all studied along with the number of visitors and level of prison security. The other variables commonly known to be risk factors *before* coming to prison were included in the analysis. These were: age, race, citizenship, birthplace, district of incarceration, educational assessment, and drug abuse potential (Appendix Five).

Several variables were created from preexisting information. For example, the level of security and density of the prison was coded once the inmate locations were collected. The inmate population was divided into low (< 260 inmates), medium (> 260 but < 950 inmates), and high (> 950 but less than 2800 inmates) density based on the January 2001 population census. The "AOC District" variable was created once the county of incarceration data was obtained. The Association of Oregon Counties (AOC) is a formal grouping of counties based on social and economic similarities. The "institution" variable was the prison site that an inmate lived in the longest. The housing history was used to determine this information.

Double Checking Data Entry

The demographic information obtained from the ODOC database was re-coded for both the cases and controls. Double data entry was conducted on 10% of the data. For each variable, the threshold for recoding was 5% of error.

Data Analysis

Prevalence

Table Nine shows the calculations for the prevalence on treatment and prevalence for all inmates.

TABLE NINE: Equations for Prevalence Estimations

Prevalence of PPD positive inmates on treatment	Prevalence of PPD positive inmates
$\frac{\text{(Converters +Reactors + Previously untreated prior (+))}}{\text{(Estimated population size in the ODOC)}}$	$\frac{\text{(All PPD positives)}}{\text{(Estimated population size in the ODOC)}}$

Incidence Rate

Table Ten shows the calculation for the incidence estimation.

TABLE TEN: Equation for Incidence Rate Estimation

Incidence
$\frac{\text{(Converters + Reactors from July 00 – July 01)}}{\text{(Estimated person-years in the ODOC)}}$

Conversion Rate

Table Eleven shows the calculation for the conversion rate.

TABLE ELEVEN: Equation for Conversion Rate Estimation

Conversion Rate
$\frac{\text{(Converters from July 00 – July 01)}}{\text{(Estimated person-years in the ODOC)}}$

Booster Phenomenon

The distribution of the skin test conversions will be graphed according to sequence.

Case-control study

The risk factor analysis was performed with the Statistical Package for the Social Sciences (SPSS). All twenty one variables were coded or translated into numbers. For example, the variable race was coded into: 0 for Caucasian, 1 for Latino, 2 for African-American, and 3 for other (Appendix Six). Multiple trials were made to code the variables to obtain a balance between too many categories and insufficient numbers and too much grouping with loss of

detail. Univariate analysis was performed with the use of chi-square for categorical variables and the student t-test for continuous variables. Multivariate analysis was performed with logistic regression. Pearson's correlation was used to choose variables for the logistic model. Variables that were heavily correlated were grouped together and only the most significant ones entered into the main effects model. Double and triple interaction terms, transformations, and goodness of fit were evaluated as well. The best models were presented with Odd Ratios (OR) and 95% confidence intervals.

RESULTS

Cases and Controls

The demographic breakdown of the cases and verified controls are shown in Table Twelve below. Each study variable is listed with its components. Numbers that appear elevated or large in value are bolded for visual effect. By simply viewing the table, one can see differences that will become statistically significant later in the analysis.

Thirty percent of the cases (n = 22) were Latino, while only seven percent (n = 16) of the controls were of the Latin race. More of the cases had Mexican citizenship (n = 12 or 17% versus n = 4 or 1.7% for the controls) and were born in a non-U.S. country (n = 32 or 44% vs. n = 14 or 6%). The cases were less likely to be incarcerated in the district containing Polk, Marion, and Yamhill counties (n = 17 or 24% vs. n = 87 or 37%), more likely to live in minimum security prisons (n = 51 or 71% vs. n = 19 or 8%), and less likely to live in high density prisons (n = 38 or 53% vs. n = 180 or 77%).

TABLE TWELVE: BASELINE CHARACTERISTICS OF CASES AND CONTROLS

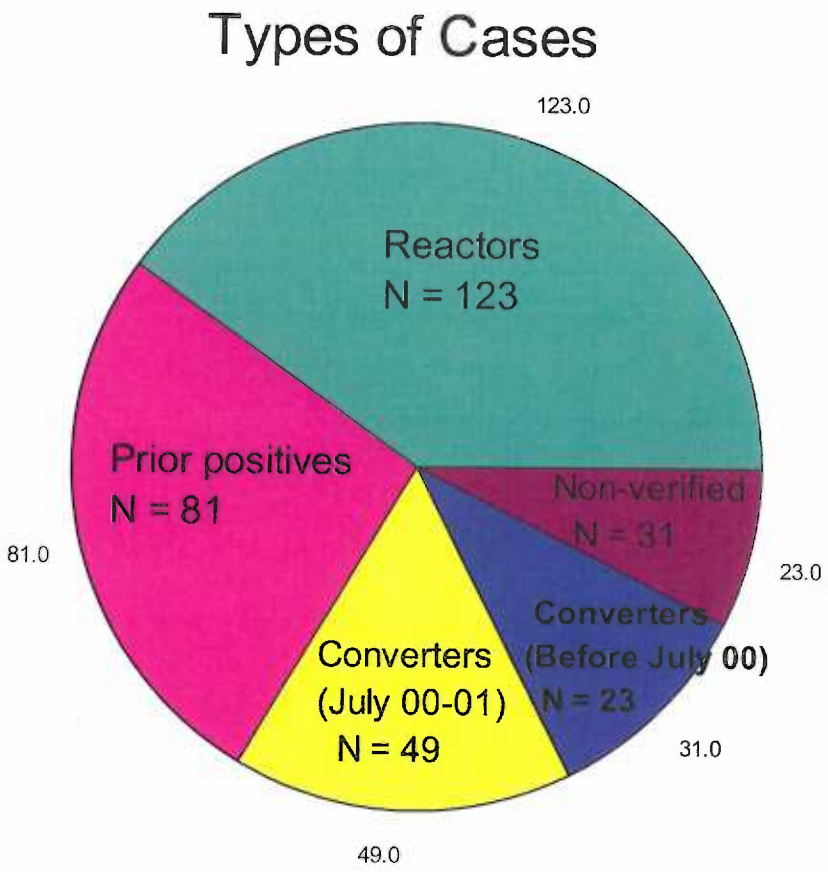
Characteristic Variables	Cases N = 72	Verified Controls N = 234
Age- mean (SD- standard deviation)	33 (11)	38 (11)
20-29 – no. (%)	20 (27.8)	53 (22.7)
30-39	23 (31.9)	83 (35.5)
40-49	18 (25.0)	62 (26.5)
50-59	9 (12.5)	29 (12.4)
60-69	0 (0)	6 (2.6)
70-79	2 (2.8)	1 (.43)
Race or ethnic group – no. (%)		
Caucasian	42 (58.3)	186 (79.5)
Latino	**22 (30.6)**	**16 (6.8)**
African-American	5 (6.9)	23 (9.8)
Asian, Native American, other	3 (4.2)	9 (3.8)
Citizenship		
United States	57 (79.2)	229 (97.9)
Mexico	**12 (16.7)**	**4 (1.7)**
Other	3 (4.2)	1 (0.4)
Birthplace		
Oregon	11 (15.3)	77 (32.9)
Other state or country	**61 (84.7)**	**157 (67.1)**
Unknown	0	0
Birthplace		
United States	40 (55.6)	220 (94.0)
Non-U.S.	**32 (44.4)**	**14 (6.0)**
Unknown	0	0
County of Incarceration		
AOC District 1	1 (1.4)	8 (3.4)
AOC District 2	6 (7.8)	7 (3.0)
AOC District 3	3 (8.3)	4 (1.7)
AOC District 4	8 (4.2)	27 (11.5)
AOC District 5	6 (8.3)	26 (11.1)
AOC District 6	12 (16.7)	37 (15.8)
AOC District 7	4 (5.6)	8 (3.4)
AOC District 8 (Tri-County)	26 (36.1)	92 (39.3)
Unknown	6 (8.3)	25 (10.7)
Final Educational Assessment		
Un-testable	0	7 (3.0)
Obtained GED	20 (27.8)	90 (38.5)
No GED	**52 (72.2)**	**137 (58.5)**
Location of the main institution of Incarceration		
AOC District 1	44 (61.1)	138 (59.0)
AOC District 2	0	0
AOC District 3	0	0
AOC District 4	3 (4.2)	1 (0.4)
AOC District 5	0	0
AOC District 6	**17 (23.6)**	**87 (37.2)**

AOC District 7	0	2 (0.9)
AOC District 8 (Tri-County)	1 (1.4)	3 (1.3)
Unknown	7 (9.7)	3 (1.3)
Level of Security		
Maximum	8 (11.1)	58 (24.8)
Medium	**6 (8.3)**	**154 (65.8)**
Minimum	**51 (70.8)**	**19 (8.1)**
Unknown	7 (9.7)	3 (1.3)
Institutional Density		
High	**38 (52.8)**	**180 (76.9)**
Medium	22 (30.6)	46 (19.7)
Low	5 (6.9)	5 (2.1)
Unknown	7 (9.7)	3 (1.3)
Drug abuse potential		
Low	**28 (38.9)**	**123 (52.6)**
High	34 (47.2)	104 (44.4)
Unknown	10 (13.9)	7 (3.0)
Prior number of incarcerations- mean (SD)	0.92 (2.25)	1.20 (2.28)
Number of visits in one year- mean (SD)	10 (18)	20 (37)
Number of visitors in one year- mean (SD)	21 (36)	35 (61)
Number of PPD skin tests- mean (SD)	**2.7 (1.2)**	**4.4 (2.3)**
Duration of incarceration prior to conversion or July 2001 in days- mean (SD)	**609 (539)**	**1278 (1071)**
Number of institutions inhabited- mean (SD)	2.5 (1.1)	2.4 (1.5)
Number of relocations to other prisons- mean (SD)	1.6 (1.1)	1.7 (1.9)

Prevalence

Of the 307 PPD positive inmates, ninety percent (n = 276) were confirmed with medical records. Ten percent of the cases (n = 31) were not confirmed. The exact breakdown of the cases is shown in Figure Four below.

FIGURE FOUR: Pie Chart of the Different Types of Cases



Forty percent (n = 123) of the cases tested positive at the intake center, while twenty three percent (n = 72) were potential converters who have a previous negative skin test. Two-thirds of the potential converters tested positive from July 00 – July 01. Twenty six percent (n = 81) of the controls were positive in past and ten percent (n = 31) were not verified by medical records. Table Thirteen contains the prevalence calculations.

TABLE THIRTEEN: Prevalence Calculations

Definition	Number of Cases	Estimated number of inmates	Prevalence***
All PPD positive inmates on medications	123 (reactors) + 72 (converters) + 81 (prior positives, previously untreated) + 31 (unverified)	9,746	3.15%
All PPD positive groups	123 (reactors) + 72 (converters) + 81 (prior positives, previously untreated) + 31 (unverified) + 11* (max number non-compliant with meds) + 487**	9,746	8.26%

*Maximum # PPD positive inmates who refused to take medications. Most of them took medications later.

** (5%) (Inmate population) = estimated number of previously treated prior positives in the ODOC

The prevalence of PPD positive inmates on anti-tuberculous medications was 3%. The estimated prevalence of all PPD positive inmates in the ODOC is 8% and much lower than the prevalence (up to 30%) seen in other state prisons.

Incidence rate

There were forty-nine converters and eight three reactors from July 00-01. With inmates in constant flux, the estimated person-years during the study period were calculated. The incidence rate is shown in the Table Fourteen below.

TABLE FOURTEEN: Incidence Estimation

Number of Converters and Reactors	Estimated person-years**	Incidence Rate
49 (converters) + 83 (reactors)	9,746 person-years	1.35 per 1,00 person-years

* July 00 – July 01 ** Estimated population size times one year

The incidence rate in the ODOC was 1.4 per 100 person-years, much lower than the rates seen in other state prisons.

Conversion rate

There were forty-nine converters from July 00-01. With inmates in constant flux, the estimated person-years during the study period were calculated. The conversion rate is shown in the Table below.

TABLE FIFTEEN: Conversion Rate Calculation

Number of Converters	Estimated person-years**	Incidence Rate
49	9,746 person-years	.50 per 1,00 person-years

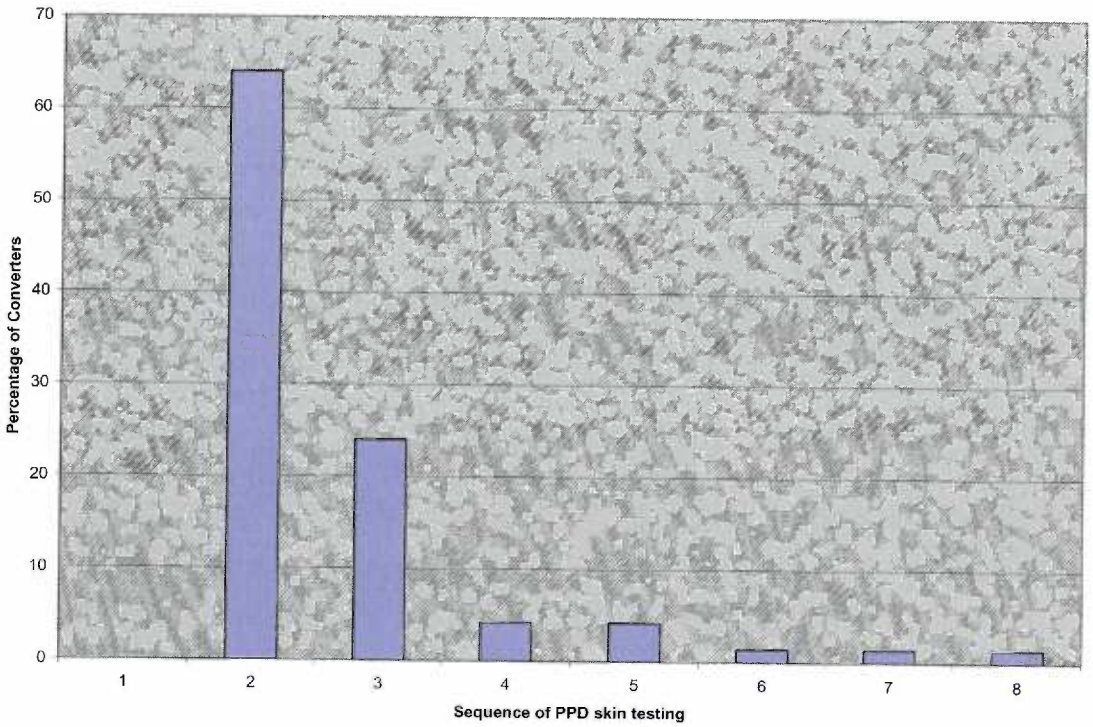
* July 00 – July 01 ** Estimated population size times one year

The conversion rate in the ODOC was .50 per 100 person-years, much lower than the rates (3.9-6.7 per 100 person years) seen in other state prisons.

Booster Phenomenon

Over 60% of the cases converted on their second PPD skin test. The numbers and percentages are shown in Figure Five below. This is different than the distribution seen in the control group (Appendix Seven)

FIGURE FIVE: Bar Graph of the Percentage of PPD Positive Skin Tests by Sequence in the Case Sample



Sixty-four percent (n = 46) converted on their second PPD skin test, while 24% (n = 17) tested positive on their third, 4.2% (n = 3) on their fourth, 4.2% (n=3) on their fifth, and 1.4% (n = 1) on their sixth, seventh, and eighth skin test.

Therefore, one can presume that the majority of the 46 converters are really "boosters". The rate of boosting in the ODOC is only 0.47% (46 of 9,746 inmates) based on this data. Two-step skin testing may not be cost-effective in this population.

Risk Factor Analysis

Validity of the Controls

Seventy-seven percent of the controls (n = 234) were verified by medical records. Twenty-three percent (n = 71) were not verified. The two samples were compared using chi-square for categorical variables and the t-test for continuous variables. There was no statistically significant difference between the two samples (chi-square, $p < .36$ to .99; t-test, $p < .35$ to .73) (Appendix Eight).

Univariate Analysis

Of the eleven categorical variables, seven were significant and one borderline by chi-square ($p < .05$, $p < .07$). The cases were more likely to be non-white ($p < .001$), to have foreign citizenship ($p < .001$), and to be born outside of Oregon ($p < .001$) or in a foreign country ($p < .004$). They tended to live in different districts ($p < .048$) from the controls. They lived in different security prisons ($p < .001$) and resided in different density institutions ($p < .003$). Their age, county of incarceration, and drug abuse potential was no different from the controls, but they were of borderline significance for not having a GED ($p < .07$) (Appendix Nine).

Of the six continuous variables, three were significant and one borderline according to the student t-test ($p < .05$, $p < .07$). The cases had fewer visitors ($p < .07$) and visits ($p < .02$), fewer PPD skin tests ($p < .001$), and a shorter duration of stay ($p < .001$) than the controls. The number of prior incarcerations and number of institutions for the duration of stay were no different from the controls (Appendix Nine).

Logistic regression revealed more specific information as seen in Table Sixteen and Table Seventeen below. The cases were more likely to be Latino ($p < .001$) and have a Mexican ($p < .001$) or non-U.S. and non-Mexican citizenship ($p < .032$). They were more likely to be born outside of Oregon ($p < .005$) and in a foreign country ($p < .001$). They were arrested more often in Crook, Deschutes, Harney, Jefferson, Klamath, and Lake County ($p < .064$) and of borderline significance *not* have a GED ($p < .071$) They tended not to live in medium ($p < .001$) and high ($p < .001$) density prisons, nor in maximum security prisons ($p < .018$). Their age, institutional housing by AOC district, and drug abuse potential were no different from the controls. This analysis differed from the chi-square regarding the institutional housing and county of incarceration. This is not alarming since the logistic regression is more robust.

The logistic regression was similar to the t-test for the continuous variables. The cases had fewer visitors ($p < .074$) and visits ($p < .027$), fewer PPD skin tests ($p < .001$), and a shorter duration or stay ($p < .001$). The number of prior incarcerations and number of institutions for the duration of stay were no different from the controls.

TABLE SIXTEEN: Univariate Logistic Regression on Categorical Variables

Categorical Variables	Univariate logistic (p-value)	Meaning
Age	P < .381 (30-39 vs. 20-29 y/o) P < .484 (40-49 vs. 20-29 y/o) P < .673 (50-59 vs. 20-29 y/o) P < .671 (60-69 vs. 20-29 y/o) P < .183 (70-79 vs. 20-29 y/o)	No difference
Race	**P < .001 (Latino vs Caucasian)** P < .942 (Black vs. Caucasian) P < .572 (Other vs. Caucasian)	**Cases were more likely to be Latino (OR = 6.09)**
Citizenship	**P < .001 (Mexican vs. U.S.)** **P < .032 (Other vs. U.S.)**	**Cases were more likely to have Mexican (OR = 12.1) and other citizenship (OR = 12.1)**
Birthplace (Oregon)	**P < .005 (non-OR vs. OR)**	**Cases were more likely to be born outside of Oregon (OR = 2.72)**

Birthplace (US)	**P < .001 (non-U.S. vs. U.S.)**	**Cases were more likely to be born in a foreign country (OR = 12.6)**
County of incarceration	P < .453 (District 1 vs. Tri-county) **P < .064 (District 2 vs. Tri-county)** P < .220 (District 3 vs. Tri-county) P < .918 (District 4 vs. Tri-county) P < .688 (District 5 vs. Tri-county) P < .730 (District 6 vs. Tri-county) P < .381 (District 7 vs. Tri-county) *** See Appendix Six for Legend**	**Cases were of borderline significance to live in Crook, Deschutes, Harney, Jefferson, Klamath, and Lake County (OR = 3.03)**
Final Educational Assessment (GED)	**P < .071**	**Cases were of borderline significance to not have a GED (OR = 1.71)**
Institution by AOC district	P < .970 (District 1 vs. Tri-county) P < .178 (District 4 vs. Tri-county) P < .652 (District 6 vs. Tri-county) P < .746 (District 7 vs. Tri-county) *** See Appendix Six for Legend**	No difference
Level of Security	**P < .001 (Medium vs. Minimum)** **P < .001 (Maximum vs. Minimum)**	**Cases were less likely to live in medium (OR = .015) or maximum security prisons (OR = .051)**
Density of Institution	P < .281 (Medium vs. Low) **P < .018 (High vs. Low)**	**Cases were less likely to live in high density prisons (OR = .211)**
Drug Abuse Potential	P < .209	No difference

TABLE SEVENTEEN: Univariate Logistic Regression on Continuous Variables

Continuous Covariates	Logistic Regression	Meaning
Prior incarcerations	P < .355	No difference
Number of visitors in one year	**P < .074**	**Cases had FEWER visitors (OR = .994)**
Number of visits in one year	**P < .027**	**Cases had FEWER visits (OR = .985)**
Number of PPD skin tests	**P < .001**	**Cases had FEWER skin tests (OR = .503)**
Duration before censorship or a positive skin test	**P < .001**	**Cases had SHORTER stays in prison (OR = .998)**
Number of Institutions for the duration of stay	P < .633	No difference

Correlation Analysis

Ten of the seventeen variables were places into four correlation groups as shown in Table Eighteen. For each variable, all the cases and controls were

TABLE EIGHTEEN: Correlations Groups

Correlation Groups
1) Race, Citizenship, Birthplace (Oregon vs. other), Birthplace (U.S. vs. other)
2) Level of Security, Institutional Density
3) Number of Visits, Number of Visitors
4) Number of PPD skin tests, Duration of residence

grouped together and compared with their respective variables. The Pearson's correlation coefficients and p-values are all listed in Appendix Ten.

Race, citizenship, and birthplace were positively correlated ($p < .001$-$.005$). Many Latinos were Mexican citizens born in Mexico. The level of security was positively correlated with the institutional density ($p < .001$). Self-evidently correlated were the number of visitors & visits ($p < .001$). The number of PPD skin tests and duration of residence were positively correlated as well ($p < .001$). Inmates with longer residences had more annual PPD skin tests. However, the duration of residence & number of PPD skin tests were negatively correlated with the number of institutions lived in ($p < .001$). It appears that inmates who enter the prison system move around multiples times initially before settling down in one location.

Age, county of incarceration, prior incarcerations, AOC housing, education, and drug abuse potential were not tested.

Logistic Regression on the Correlated Groups

The four correlation groups were separately placed into a logistic model. The purpose was to determine the variable with the most statistical significance in each group. The winning variables are seen in Table Nineteen. Wald statistics

TABLE NINETEEN: Most Significant Variables from Correlation Groups

Most Significant Variable	Wald statistic (p-value)
Birthplace (US vs. non-U.S.)	**16.3 ($p < .001$)**
Security (med vs. minimum)	**50.1 ($p < .001$)**
(max vs. minimum)	**30.1 ($p < .001$)**
Visits	**4.69 ($p < .030$)**
Number of PPD skin tests	**10.8 ($p < .001$)**

and deviances are presented in Appendix Eleven. Birthplace (U.S. vs. non-U.S.) was chosen in future models, rather than race, citizenship, and birthplace (Oregon vs. non-Oregon). Similarly, security was chosen over density, visits over visitors, and the number of PPD skin tests over the duration. This is necessary because correlated variables will compete for statistical significance in the multiple regression models.

Logistic Regression Models

Five models were initially chosen for statistical testing. Model one incorporated every variable, while model two tested the significant and borderline significant variables from the univariate analysis. Model three incorporated all the study variables except the redundant correlated variables. Model four tested the significant variables of model three and model five tested the significant variables from model four (Appendix Twelve).

Fifteen additional models were tested by substituting the correlated variables. For example, race or citizenship or birthplace (non-Oregon vs. Oregon) was substituted for birthplace (non-U.S. vs. U.S.), density for security, and the duration for the number of PPD skin tests. All combinations were tested (Appendix Twelve).

Model one incorporated the shotgun approach and was not very helpful. The main purpose was to see if non-significant variables in the univariate analysis became significant. The AOC housing district three ($p < .046$) and the number of institutions ($p < .042$) became statistically significant. The county of incarceration- district five ($p < .057$) was of borderline significance (Appendix Thirteen). Contrary to the univariate analysis, the cases were less likely to be Latino ($p < .065$). Five comparisons were significant at $p < .05$ and ten were borderline at $.05 < p < .10$. Two comparisons had Odds Ratios in the thousands suggesting inadequate sample sizes for

analysis. Too many variables were entered in this model. 78% of the data was utilized (49 of 72 cases and 192 of 234 controls). Twenty-three cases and forty-two controls were excluded due to missing information.

Model two revealed that the cases more likely to be arrested in county district three ($p < .003$). They had fewer PPD skin tests ($p < .087$) and were less likely to live in medium ($p < .001$) and maximum ($p < .001$) security prisons (Appendix Thirteen). Contrary to the univariate analysis, the cases were more likely to live in high density institutions (OR = 38.4, [1.69-872], $p < .022$). Three variables had OR's or 1/OR's between 333 and 1000 suggesting that too many variables were entered into this model. 83% of the data (254 of 306) was used.

Model three revealed that cases were more likely to abuse drugs ($p < .027$), be born in a foreign country ($p < .001$), and be arrested in county district three ($p < .006$) (Appendix Thirteen). They were less likely to be arrested in county district five ($p < .051$) or live in medium ($p < .001$) and maximum ($p < .003$) security prisons. They had fewer PPD skin tests ($p < .024$) and lived in fewer institutions ($p < .025$). It is unclear why the cases were more likely to abuse drugs in this model. This may be due to the interaction of variables and/or the use of 238 of 306 cases and controls (78% of the original sample).

In **Model Four**, the cases were very likely to be born in a foreign country (OR = 14.7, $p < .001$) and not live in a medium (OR = .020, $p < .001$) or maximum (OR = .078, $p < .001$) prison (Appendix Thirteen). They had fewer PPD skin tests (OR = .617, $p < .005$) and lived in fewer institutions (OR = .588, $p < .014$) than the controls. Of borderline significance was the higher

drug abuse potential (OR = 2.42, $p < .095$) and lower arrest rate at county district five (OR = .133, $p < .064$).

In county district five, 8.3% of cases (6 of 72) and 11.1% of controls (26 of 234) were arrested. This small difference may be "statistically significant", but it isn't very impressive. In this study variable, 6 cases and 25 controls had missing data. In the drug abuse potential variable, 10 cases and 7 controls had missing data. It would be more helpful to drop these borderline significant variables and see how the additional data influences the outcome. When drug abuse potential was removed from the model, none of the county of incarceration districts became statistically significant ($p < .138$ - $.878$, $p < .426$ for county district 5), but all the remaining variables continued to be significant ($p < .05$). When the county of incarceration variable was removed, the drug abuse potential remained at borderline statistical significance ($p < .095$) and the others were unchanged ($p < .05$).

Model five was a strong model that utilized 97% (296 out of 306) of the data. The cases were more 10 times more likely to be born in a foreign county (OR = 9.87, [3.06 – 31.8], $p < .001$), 71 times less likely to live in a medium security prison (OR = .014, [.005 – .045], $p < .001$), and 19 times less likely to live in a maximum security prison (OR = .052, [.017 –.158], $p < .001$) (Appendix Thirteen). They had 44% less PPD skin tests (OR = .696, [.529 – .915], $p < .009$) and lived in 56% fewer institutions (OR = .639, [.443 – .922], $p < .017$) compared with the controls.

When double and triple interaction terms (eg. birthplace x security) were added to model five, there was a significant interaction ($p = .021$-$.029$) whenever security (max. vs. min.) and number

of institutions were added together. Cases were 2.5-2.7 times more likely (CI's 1.1-6.2) to live in maximum vs. minimum security prisons and in more institutions than the controls. The models had Odd Ratio's in the hundreds for the variable of security and were not applicable (Appendix Fourteen).

When the logit was graphed vs. the continuous variables, there were no patterns seen to warrant a transformation such as the squaring of data (Appendix Fifteen).

The **fifteen additional models** revealed important information. Birthplace (non-Oregon vs. Oregon), birthplace (non-U.S. vs. U.S.), race (Latino vs. Caucasian), and citizenship (Mexico vs. U.S.) could be used interchangeably except birthplace (non-Oregon vs. Oregon) became non-significant when level of security and number of institutions were in the model (see Appendix Sixteen, Iterations 12 and 14). Security and density could be used interchangeably except density (medium vs. low) became non-significant when birthplace (non-Oregon vs. Oregon) and number of institutions were in the model (see iterations 13 and 15). Duration proved to have an Odds Ratio so close to one (OR = .997-999) that it wasn't practically useful anymore. The number of PPD skin tests was always significant, but the number of institutions became non-significant when density and number of PPD skin tests were in the model (see iterations 1, 5, 9, 13).

Overall, the best models were model five, iteration four, and iteration eight seen in Table 21. They contained the most number of significant variables. Based on these models, the cases were 6 times more likely to be Latino, 10 times more likely to be born outside the U.S., and 13 times more likely to have Mexican citizenship. They were 71-77 times *less* likely to live in medium vs.

minimum security prisons and 19-23 times *less* likely to live in maximum vs. minimum security prisons. The cases had 1.4-1.5 times fewer PPD skin tests and lived in 1.5-1.7 times fewer prisons. On average, the cases lived in more institutions (n = 2.51 vs. 2.43), but a greater proportion of cases (88% vs. 78%) lived in 3 or fewer institutions accounting for the trend.

Based on the other iterations, the cases were 2-3 times more likely to be born outside of Oregon, 5-7 times *less* likely to live in medium vs. low density prisons, and 6-11 times *less* likely to live in high vs. low density prisons.

The final models were good fits according to the R2 adjusted and Hosmer and Lemeshow goodness of fit tests (Appendix Eighteen).

TABLE TWENTY: Three Best Logistic Regression Models

Model Five	OR	95% CI	P-value
Birthplace (non-U.S. vs. U.S.)	**9.87**	**3.06 – 31.8**	**.001**
Security (Medium vs. Minimum)	**.014**	**.005 – .045**	**.001**
(Maximum vs. Minimum)	**.052**	**.017 – .158**	**.001**
# PPD skin tests	**.696**	**.529 – .915**	**.009**
Number of institutions	**.639**	**.443 – .922**	**.017**

Iteration Four	OR	95% CI	P-value
Race (Latino vs. Caucasian)	**5.98**	**1.70 – 21.1**	**.005**
(African-American vs. Caucasian)	.748	.157 – 3.56	.716
(Other vs. Caucasian)	1.74	.172 – 17.5	.640
Security (medium vs. minimum)	**.013**	**.004 – .040**	**.001**
(maximum vs. minimum)	**.049**	**.017 – .142**	**.001**
# PPD skin tests	**.649**	**.492 – .856**	**.002**
Number of institutions	**.585**	**.401 – .851**	**.005**

Iteration Eight	OR	95% CI	P-value
Citizenship (Mexican vs. U.S.)	**13.0**	**1.77 – 95.1**	**.012**
(Other vs. U.S.)	7.28	.327 – 162	.210
Security (medium vs. minimum)	**.014**	**.005 – .042**	**.001**
(maximum vs. minimum)	**.043**	**.014 – .127**	**.001**
# PPD skin tests	**.650**	**.490 – .861**	**.003**
Number of institutions	**.587**	**.406 – .850**	**.005**

DISCUSSION

The Oregon Department of Corrections (ODOC) had an estimated prevalence of 3% for PPD positive inmates on medications. The prevalence of PPD positive inmates previously treated was estimated at 5% and extrapolated from the control sample. Five percent of the control sample (18 of 323) were prior positives and could not be used as a control. Therefore, the overall prevalence was approximately 8% for all inmates with latent TB infection. This is still low compared to the 13-30% found in other state prisons. The incidence rate for latent TB infection was estimated at 1.4 per 100 inmate-years. The conversion rate for latent TB infection (LTBI) was estimated at .50 inmates per 100 inmates-years. This is very low compared to the 3.9-6.7 converters per 100 person-years found in the other state prisons.

In the Oregon prisons, the known risk factors for intramural conversion were not seen. The converters lived in prisons with fewer inmates and stayed for shorter durations of time. Their hypothetical exposure to TB was lower compared to the controls in the Oregon prisons. Non-white race was a significant risk factor and paralleled the studies that showed an increased risk for African-Americans. (7-8)

There are only a few possibilities that can explain the initial negative skin test seen in the 49 converters from July 00 – 01: 1) anergy, 2) incubating disease at admission, 3) intramural transmission, and 4) the booster phenemenon. Anergy is a state of depressed immune response to multiple antigens, while the booster phenomenon is a transient decreased immune response to the antigen in the PPD skin test. The anergic individual is immuno-suppressed, but the 'booster' is

often immuno-competent and simply needs the first skin test to 'boost' their immune response to the PPD antigen.

In this study, anergy was not a possible explanation since the converters tested positive on subsequent skin tests. Furthermore, over 60% of the conversions occurred on the second skin test suggesting the boosting phenomenon. Second, incubating disease at admission is possible, but unlikely to differentially affect Latino men. This would affect all inmates equally. Third, there has only been one active case of TB diagnosed in the Oregon prisons from 2000-2001. It is possible, but very unlikely that this single inmate or a few undiagnosed inmates preferentially infected the Latino males who lived in different institutions. Therefore, intramural conversion seems less likely than the last alternative- the booster phenomenon. The high percentage of conversions on the second skin test and lack of another plausible explanation argue in favor of the booster phenomenon.

The risk factors for boosting have not been studied in the prison population according to the author's literature searches. Research on health care workers, school children, and young adults showed older age, previous BCG vaccination, and sensitivity to atypical Mycobacterium to be risk factors. (30-35) Older age decreases the immune response to tuberculin and previous a vaccination or sensitivity to atypical Mycobacterium elicits a weaker response respectively. The converters were young to middle-age and only 11% were fifty or older. Regarding the BCG, Mexico does not give these vaccinations. Previous sensitivity to atypical Mycobacterium is a possible explanation. Early childhood exposure to *Mycobacterium tuberculosis* and a waned response is plausible as well.

In the Maryland prisons, the rate of boosting was 1%. (8) The health officials did not think it was cost-effective to initiate two-step skin testing. When the boosting rate was higher at 5%, a hospital in California initiated two-step skin testing for all employees and patients. (37) The question is whether to implement two-step skin testing in the Oregon Department of Corrections. By testing inmates twice, the booster phenomenon can be evaluated. Two negative tests suggest the absence of infection, while a negative followed by a positive test suggests the booster phenomenon. A boosting study would reveal whether Latino men are specifically at risk for conversion. It would give a definitive answer to true vs. false conversion and elicit information on whether race alone could be a risk factor. In the ODOC, 46 of the 72 converters tested positive on their second skin test. At the maximum, the rate of boosting was .47 per 100 inmates or less than half a percent. It would take 200 extra skin tests to discover one booster in the Oregon prisons. It does not appear cost-effective to test the entire population, but testing a subset of Latino men may be both practical and feasible.

The other screening tool to consider is the Quantiferon TB blood test. It is more specific than the PPD skin test and results in less false positives from BCG vaccination and sensitivity to atypical Mycobacterium. It is recommended by the CDC for high risk populations like inmates. It is marketed to be cost-effective as well ($10 vs. $20 for the PPD skin test). (45) There is no need for nursing follow-up to read the test, but more labor costs in the laboratory.

Regarding the validity of the study, misclassification from the eight potential converters could not change the results. Eight additional 'dummy' inmates were coded in the opposite direction of

the results. The Odd Ratios were reduced but remained significant (Appendix Nineteen). In addition, ten percent of the data set was double checked. If > 5% of the data reviewed was inaccurate, the entire variable was recoded again. In regards to power, a post-hoc analysis showed that the power ranged from 38%-93%, rather than 71%-99% as expected. The estimate is closer to 80-90% because many of the variables studied previously were found to be statistical significant in this one.

Overall, the case-control study was efficient and unique. It used existing data to determine the risk factors for conversion. Only three other prison systems have done this in the U.S.. More importantly, a computerized TB registry and the boosting study aforementioned may soon be implemented. Conversion rates can be followed yearly without the need to perform site visits and a subset of men may be skin tested twice in the future.

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Appendices

Appendix One: Rates of Active TB in Different State Prisons (2002)

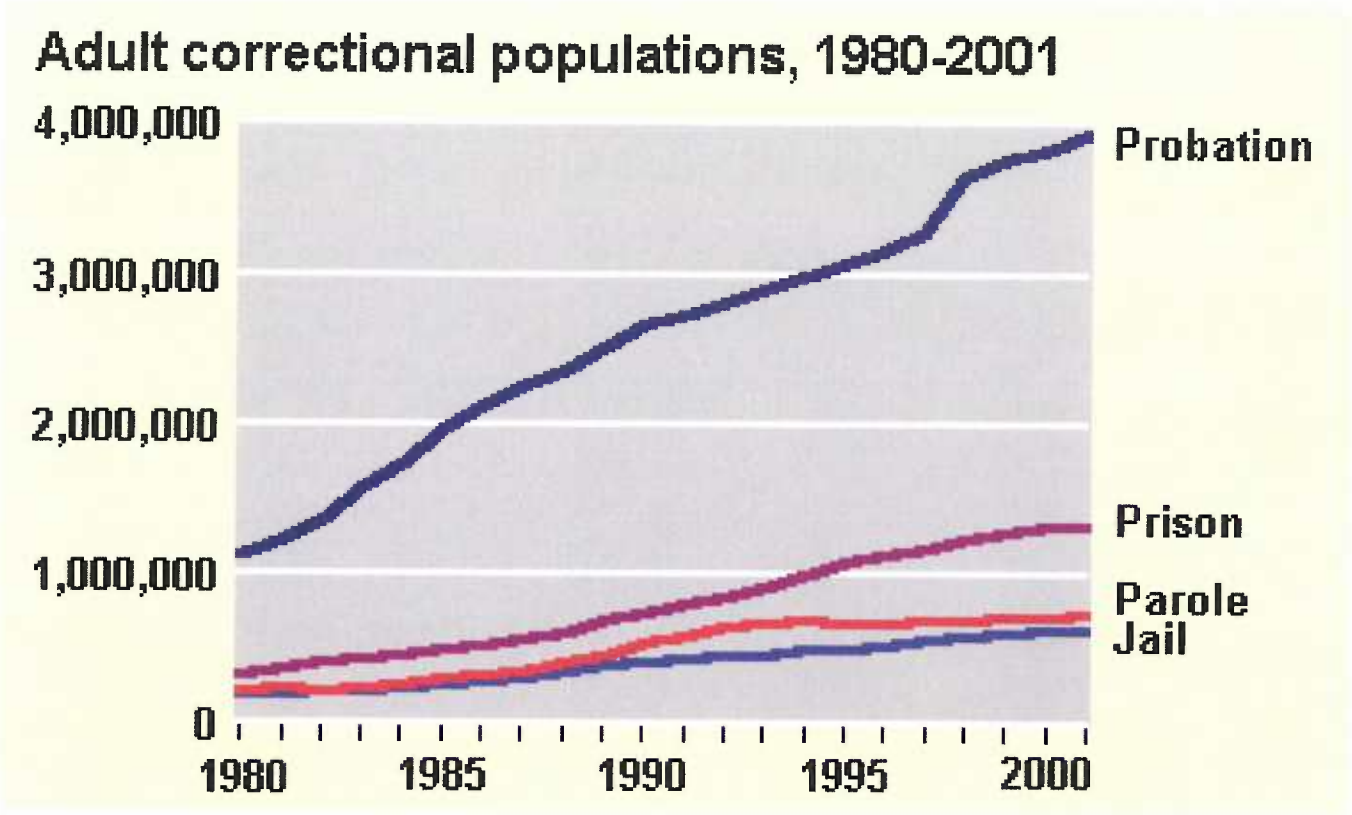
TABLE 1. Number and rate* of reported tuberculosis cases, percentage change in number of cases and rate, and rank according to percentage change in rate, by state and year — United States, 1992 and 2002†

State	1992		2002		% change 1992–2002		Overall rank by % change in rate
	No.	Rate	No.	Rate	No.	Rate	
≥500 cases in 2002							
New York	4,574	(25.2)	1,435	(7.5)	-68.6	(-70.2)	1
Georgia	893	(13.2)	524	(6.1)	-41.3	(-53.8)	11
New Jersey	984	(12.6)	530	(6.2)	-46.1	(-50.8)	14
Illinois	1,270	(10.9)	680	(5.4)	-46.5	(-50.5)	15
Texas	2,510	(14.2)	1,550	(7.1)	-38.2	(-50.0)	16
Florida	1,707	(12.7)	1,086	(6.5)	-36.4	(-48.8)	20
California	5,382	(17.4)	3,169	(9.0)	-41.1	(-48.3)	22
100–499 cases in 2002							
Kentucky	402	(10.7)	146	(3.6)	-63.7	(-66.4)	4
Mississippi	281	(10.7)	135	(4.7)	-52.0	(-56.1)	9
Pennsylvania	758	(6.3)	353	(2.9)	-53.4	(-54.0)	10
Arkansas	257	(10.7)	136	(5.0)	-47.1	(-53.3)	12
Indiana	247	(4.4)	128	(2.1)	-48.2	(-52.3)	13
Tennessee	527	(10.5)	308	(5.3)	-41.6	(-49.5)	17
Hawaii	273	(23.5)	148	(11.9)	-45.8	(-49.4)	18
Missouri	245	(4.7)	136	(2.4)	-44.5	(-48.9)	19
Alabama	418	(10.1)	233	(5.2)	-44.3	(-48.5)	21
South Carolina	387	(10.7)	256	(6.2)	-33.9	(-42.1)	26
North Carolina	604	(8.8)	434	(5.2)	-28.1	(-40.9)	28
Massachusetts	428	(7.1)	271	(4.2)	-36.7	(-40.8)	29
Michigan	495	(5.2)	315	(3.1)	-36.4	(-40.4)	30
Virginia	457	(7.2)	315	(4.3)	-31.1	(-40.3)	31
Louisiana	373	(8.7)	231	(5.2)	-38.1	(-40.2)	32
Maryland	442	(9.0)	306	(5.6)	-30.8	(-37.8)	33
Connecticut	156	(4.8)	104	(3.0)	-33.3	(-37.5)	34
Oregon	145	(4.9)	111	(3.2)	-23.4	(-34.7)	35
Washington	306	(6.0)	252	(4.2)	-17.6	(-30.0)	38
Arizona	259	(6.8)	263	(4.8)	1.5	(-29.4)	39
Ohio	358	(3.2)	257	(2.3)	-28.2	(-28.1)	41
Colorado	104	(3.0)	104	(2.3)	0.0	(-23.3)	42
Oklahoma	216	(6.7)	190	(5.4)	-12.0	(-19.4)	44
Minnesota	165	(3.7)	237	(4.7)	43.6	(27.0)	50
<100 cases in 2002							
Utah	78	(4.3)	31	(1.3)	-60.3	(-69.8)	2
West Virginia	92	(5.1)	30	(1.7)	-67.4	(-66.7)	3
Wyoming	8	(1.7)	3	(0.6)	-62.5	(-64.7)	5
South Dakota	32	(4.5)	13	(1.7)	-59.4	(-62.2)	6
Delaware	55	(8.0)	25	(3.1)	-54.5	(-61.3)	7
Idaho	26	(2.4)	14	(1.0)	-46.2	(-58.3)	8
Nevada	99	(7.5)	85	(3.9)	-14.1	(-48.0)	23
North Dakota	11	(1.7)	6	(0.9)	-45.5	(-47.1)	24
New Mexico	88	(5.6)	57	(3.1)	-35.2	(-44.6)	25
District of Columbia	146	(24.8)	82	(14.4)	-43.8	(-41.9)	27
Wisconsin	106	(2.1)	78	(1.4)	-26.4	(-33.3)	36
Montana	16	(1.9)	12	(1.3)	-25.0	(-31.6)	37
Iowa	49	(1.7)	34	(1.2)	-30.6	(-29.4)	39
Alaska	57	(9.7)	49	(7.6)	-14.0	(-21.6)	43
Rhode Island	54	(5.4)	49	(4.6)	-9.3	(-14.8)	45
New Hampshire	18	(1.6)	19	(1.5)	5.6	(-6.3)	46
Nebraska	28	(1.7)	28	(1.6)	0.0	(-5.9)	47
Maine	24	(1.9)	23	(1.8)	-4.2	(-5.3)	48
Vermont	7	(1.2)	8	(1.3)	14.3	(8.3)	49
Kansas	56	(2.2)	89	(3.3)	58.9	(50.0)	51
Total	**26,673**	**(10.5)**	**15,078**	**(5.2)**	**-43.5**	**(-50.5)**	

* Per 100,000 population.
† Data for 1992 are final; data for 2002 are provisional.

Source: MMWR March 21, 2003. 52(11):217-22.

Appendix Two: Adult Correctional Population from 1980-2001



Source: Bureau of Justice Statistics Correctional Surveys

Probation - court ordered community supervision of convicted offenders by a probation agency. In many instances, the supervision requires adherence to specific rules of conduct while in the community.

Prison - confinement in a State or Federal correctional facility to serve a sentence of more than 1 year, although in some jurisdictions the length of sentence which results in prison confinement is longer.

Jail - confinement in a local jail while pending trial, awaiting sentencing, serving a sentence that is usually less than 1 year, or awaiting transfer to other facilities after conviction.

Parole - community supervision after a period of incarceration. These data include only adults who are on active or inactive parole supervision or some other form of conditional release, including mandatory release, following a term of incarceration.

Appendix Three: Map and Statistics of Oregon Prisons (2000-01)

Legend

Initials	Prison	City	Inmate Population*	Level of Security
PRCF	Powder River Correctional Institution	Baker City	171	MIN
SCCI	Shutter Creek Correctional Institution	North Bend	267	MIN
SRCI	Snake River Correctional Institution	Ontario	2794	MED
OCIC	Oregon Corrections Intake Center	Oregon City	(intake)	(intake)
EOCI	Eastern Oregon Correctional Institution	Pendleton	1528	MED
CRCI	Columbia River Correctional Institution	Portland	492	MIN
SCI	Santiam Correctional Institution	Salem	488	MIN
OSP	Oregon State Penitentiary	Salem	1919	**MAX**
OSCI	Oregon State Correctional Institution	Salem	879	MED
MCCF	Mill Creek Correctional Facility	Salem	311	MIN
SFFC	South Fork Forest Camp	Tillamook	154	MIN
TRCI	Two Rivers Correctional Institution	Umatilla	1007	MED

- * = Average of July 2000 and July 2001 population census
- Map was taken from http://www.doc.state.or.us/institutions/inst.shtml?all_prisons
- Coffee Creek Correctional Facility (CCCF) wasn't open during the start of the project

Appendix Four: Monthly TB Statistics in the Oregon Department of Corrections

July 2000	TRCI	SRCI	SCI	PRCF	OSP	OSCI	MCCF	EOCI	CRCI/ SFFC	SCCI
# On treatment caseload	24	28	5	0	13	18	2	13	4	5
% non-compliant with prophylaxis	0	0	0	0	0	0	0	0	25 (n = 1)	0

August 2000	TRCI	SRCI	SCI	PRCF	OSP	OSCI	MCCF	EOCI	CRCI/ SFFC	SCCI
# On treatment caseload	21	0	6	1	*	9	3	7	4	5
% non-compliant with prophylaxis	0	0	0	0	*	0	0	0	25 (n = 1)	0

* Missing

September 2000	TRCI	SRCI	SCI	PRCF	OSP	OSCI	MCCF	EOCI	CRCI/ SFFC	SCCI
# On treatment caseload	25	*	4	1	16	11	3	6	5	4
% non-compliant with prophylaxis	0	0	0	0	0	0	0	0	0	0

* = Missing

October 2000	TRCI	SRCI	SCI	PRCF	OSP	OSCI	MCCF	EOCI	CRCI/ SFFC	SCCI
# On treatment caseload	26	*	*	1	11	5	1	6	5	2
% non-compliant with prophylaxis	0	0	*	0	0	0	0	0	0	0

* = Missing

November 2000	TRCI	SRCI	SCI	PRCF	OSP	OSCI	MCCF	EOCI	CRCI/ SFFC	SCCI
# On treatment caseload	23	*	4	2	4	14	5	5	10	4
% non-compliant with prophylaxis	0	*	0	0	0	0	0	0	0	0

* = Missing

December 2000	TRCI	SRCI	SCI	PRCF	OSP	OSCI	MCCF	EOCI	CRCI/ SFFC	SCCI
# On treatment caseload	24	22	8	3	4	13	5	5	8	4
% non-compliant with prophylaxis	0	0	0	0	0	0	0	0	0	0

January 2001	TRCI	SRCI	SCI	PRCF	OSP	OSCI	MCCF	EOCI	CRCI/ SFFC	SCCI
# On treatment caseload	39	22	6	4	10	15	6	6	8	4
% non-compliant with prophylaxis	0	0	0	0	0	0	0	0	0	0

February 2001	TRCI	SRCI	SCI	PRCF	OSP	OSCI	MCCF	EOCI	CRCI/ SFFC	SCCI
# On treatment caseload	40	28	5	3	8	16	6	9	13	1
% non-compliant with prophylaxis	0	0	0	0	0	0	14% (n=1)	10% (n=1)	0	0

March 2001	TRCI	SRCI	SCI	PRCF	OSP	OSCI	MCCF	EOCI	CRCI/ SFFC	SCCI
# On	37	28	9	1	18	20	7	9	10	4

treatment caseload										
% non-compliant with prophylaxis	3% (n=1)	0	0	0	0	5% (n=1)	13% (n=1)	10% (n=1)	0	0

April 2001	TRCI	SRCI	SCI	PRCF	OSP	OSCI	MCCF	EOCI	CRCI/ SFFC	SCCI
# On treatment caseload	40	26	5	1	11	26	6	10	8	4
% non-compliant with prophylaxis	0	0	0	0	8% (n=1)	4% (n=1)	14% (n=1)	9% (n=1)	0	0

May 2001	TRCI	SRCI	SCI	PRCF	OSP	OSCI	MCCF	EOCI	CRCI/ SFFC	SCCI
# On treatment caseload	45	25	6	1	7	23	5	12	8	3
% non-compliant with prophylaxis	8% (n = 4)	0	0	0	0	8% (n=2)	0	*	0	0

* = Missing

June 2001	TRCI	SRCI	SCI	PRCF	OSP	OSCI	MCCF	EOCI	CRCI/ SFFC	SCCI
# On treatment caseload	54	27	6	1	13	27	5	13	8	4
% non-compliant with prophylaxis	0	0	0	0	0	7% (n=2)	0	*	11% (n=1)	0

* = Missing

July 2001	TRCI	SRCI	SCI	PRCF	OSP	OSCI	MCCF	EOCI	CRCI/ SFFC	SCCI
# On treatment caseload	39	28	6	3	9	21	4	13	10	4
% non-compliant with prophylaxis	0	0	0	0	0	5% (n=1)	0	7% (n=1)	0	0

Appendix Five: List of Study Variables

1) Age
2) Race
3) Citizenship
4) Birthplace #1 (Oregon vs. non-Oregon)
5) Birthplace #2 (U.S. vs. foreign)
6) County of Incarceration (by District)
7) Prior Incarcerations
8) # Visitors in 1 year
9) # Visits in 1 year
10) Final Educational Assessment (GED)
11) Number of PPD skin tests
12) Duration (days prior to conversion or censorship)
13) Housing (coded by AOC district)
14) Housing (by level of security)
15) Housing (by inmate density)
16) Number of Institutions Inhabited (up to time of conversion or censorship)
17) Potential for substance abuse (from initial psychiatric assessment)

Appendix Six: Code Sheet for all the Variables

Age	Race	Citizenship	Birthplace #1	Birthplace #2
2 = 20-29	0 = Caucasian	0 = USA	0 = Oregon	0 = US
3 = 30-39	1 = Latino	1 = Mexico	1 = Other	1 = Non-US
4 = 40-49	2 = African-American	2 = Other		
5 = 50-59	3 = Other Groups			
6 = 60-69				
7 = 70-79				

Final Educational Assessment #2
1 = GED
2 = No GED
99 = Non-testable

County of Arrest according to:

Association of Oregon Counties (AOC Districts)

DISTRICT 1	DISTRICT 2	DISTRICT 3	DISTRICT 4
1 = Baker, Grant, Malheur, Umatilla, Union, Wallowa	2 = Crook, Deschutes, Harney, Jefferson, Klamath, Lake	3 = Gilliam, Hood River, Morrow, Sherman, Wasco, Wheeler	4 = Coos, Curry, Douglas, Jackson, Josephine
DISTRICT 5	DISTRICT 6	DISTRICT 7	DISTRICT 8
5 = Benton, Lane, Linn	6 = Marion, Polk, Yamhill	7 = Clatsop, Columbia, Lincoln, Tillamook	8 = Clackamus, Multnomah, Washington

Housing, Security, and Density

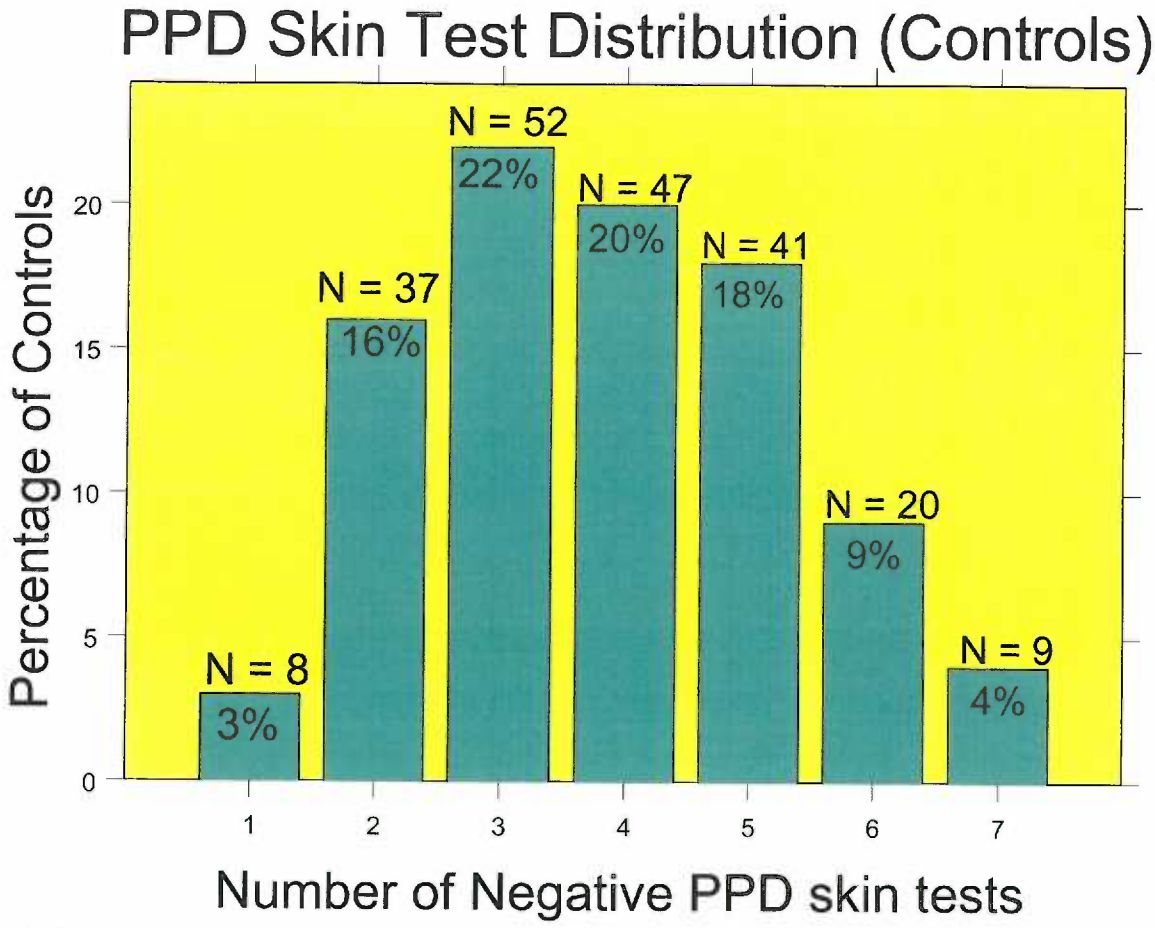
Institution Most Inhabited by Inmate	Institution by AOC District	Level of Security	Inmate Density
1 = OCIC (intake center)	1 = EOCI	1 = Minimum	1 = Low
2 = EOCI	1 = SRCI	2 = Medium	2 = Medium
3 = SRCI	1 = PRCF	3 = Maximum	3 = High
4 = PRCF	1 = TRCI		
5 = OSCI	4 = SCCI	1 = CRCI, SFFC,	1 = PRCF, SCCI
6 = SCI	6 = OSCI	MCCF, SCCI,	SFFC
7 = OSP	6 = SCI	PRCF, SCI	
8 = SCCI	6 = OSP		
9 = TRCI	6 = MCCF	2 = TRCI, EOCI,	2 = CRCI, MCCF,
10 = SFFC	7 = SFFC	SRCI, OSCI	OSCI, SCI, TRCI
11 = MCCF	8 = OCIC		
12 = CRCI	8 = CRCI	3 = OSP	3 = EOCI, OSP
99 = Unknown	99 = Unknown		SRCI
		99 = Missing	99 = Missing

Note: See Appendix Three for the Legend

THE CONTINUOUS VARIABLES
Prior number of incarcerations
Number of visitors in 1 year
Number of visits in 1 year
Number of PPD skin tests
Duration in days prior to conversion or censorship
Number of Institutions Inhabited

Potential for Substance Abuse
1 = Low
2 = High
99 = Missing

Appendix Seven: Bar Graph of Skin Test Distribution by Sequence in the Control Sample



NOTE: Eight percent of the controls with greater than 7 tests are not shown

Appendix Eight: Statistical Comparison of Verified Controls vs. Entire Control Sample

Continuous Variables	T-test (p-values)	Confidence Intervals
Prior number of incarcerations	P < .734 (equal variances) P < .734 (equal not assumed)	(-.45, .32) (-.45, .32)
Number of visitors	P < .720 P < .721	(-12.1, 8.4) (-12.1, 8.4)
Number of visits	P < .636 P < .639	(-7.6, 4.7) (-7.7, 4.7)
Number of PPD skin tests	P < .354 P < .357	(-.56, .20) (-.56, .20)
Duration of residence	P < .983 P < .983	(-179, 183) (-180, 184)
Number of institutions	P < .554 P < .557	(-.326, .175) (-.328, .177)

Categorical Variables	Chi-Square (p-value)
Age	P < .98
Race	P < .74
Citizenship	P < .74
Birthplace (Oregon)	P < .42
Birthplace (US)	P < .36
County of incarceration by AOC District	P < .99
Final Educational Assessment (GED)	P < .98
Institution by AOC district	P < .99
Level of Security	P < .98
Density of Institution	P < .97
Drug Abuse Potential	P < .87

Appendix Nine: Univariate Analysis by Chi-square and T-test

Categorical Variables	Chi-Square (p-value)	Meaning
Age	P < .326	No difference
Race	**P < .001**	Cases tended to be non-white
Citizenship	**P < .001**	Cases had more foreign citizenship
Birthplace (Oregon)	**P < .004**	Cases were more likely to be born outside of Oregon
Birthplace (US)	**P < .001**	Cases were more likely to be born in a foreign country
County of incarceration	P < .427	No difference
Final Educational Assessment (GED)	P < .069	Cases were less likely to have a GED
Institution by AOC district	**P < .048**	Cases tended to live in other districts from the controls
Level of Security	**P < .001**	Cases tended to live in different security prisons than the controls
Density of Institution	**P < .003**	Cases tended to live in different density prisons than the controls
Drug Abuse Potential	P < .207	No difference

Continuous Covariates	T-test (p-value)	Meaning
Prior incarcerations	P < .353 (equal variance) P < .351 (unequal variance)	No difference
Number of visitors in one year	**P < .067** (equal variance) **P < .017** (unequal variance)	Cases had FEWER visitors
Number of visits in one year	**P < .021** (equal variance) **P < .001** (unequal variance)	Cases had FEWER visits
Number of PPD skin tests	**P < .001** (equal variance) **P < .001** (unequal variance)	Cases had FEWER skin tests
Duration before censorship or a positive skin test	**P < .001** (equal variance) **P < .001** (unequal variance)	Cases had SHORTER stays in prison
Number of Institutions for the duration of stay	P < .634 (equal variance) P < .566 (unequal variance)	No difference

Appendix Ten: Correlation Groups

	Race	Citizenship	Birthplace (Oregon)	Birthplace (U.S.)
Race	1	**.151 (p < .008)**	**.154 (p < .007)**	**.241 (p < .001)**
Citizenship		1	**.159 (p < .005)**	**.594 (p < .001)**
Birthplace (Oregon)		.	1	**.267 (p < .001)**
Birthplace (U.S.)				1

	Level of Security	Density
Level of Security	1	**.352 (p < .001)**
Density		1

	Visitors	Visits
Visitors	1	**.938 (p < .001)**
Visits		1

	Duration	Number of PPD skin tests
Duration	1	**.459 (p < .001)**
Number of PPD skin tests		1

	Duration	Number of PPD skin Tests	Number of Institutions
Duration	1	**.459 (p < .001)**	**-.294 (p < .001)**
Number of PPD skin tests		1	**- .218 (p < .001)**
Number of Institutions			1

Appendix Eleven: Logistic Regression on the Correlation Groups

Correlated variables	Wald statistics (p-value)
Race (Latino vs. Caucasian)	.061 (p < .805)
(Black vs. Caucasian)	.006 (p < .937)
(Other vs. Caucasian)	.122 (p < .727)
Citizenship (Mexican vs. U.S.)	.434 (p < .510)
(Other vs.U.S.)	.138 (p < .710)
Birthplace (Oregon vs. non-Oregon)	.835 (p < .361)
Birthplace (U.S. vs. non-U.S.)	**16.3 (p < .001)**

* Likelihood Ratio Test, G = D0 – D1. (G = 55.7, D0 = 333.9, D1 = -278.2) (p < .001)

Birthplace (U.S. vs. non-U.S.) had the most significance in this correlation group.

Correlated variables	Wald statistics (p-value)
Security (Medium vs. Minimum)	**50.1 (p < .001)**
(Maximum vs. Minimum)	**30.1 (p < .001)**
Density (Medium vs. Low)	1.33 (p < .249)
(High vs. Low)	**8.20 (p < .004)**

* Likelihood Ratio Test, G = D0 – D1. (G = 166.4, D0 = 289.8, D1 = -123.4) (p < .001)

The institutional density had the more significance than the level of security. However, the high vs. low density comparison was highly significant.

Correlated variables	Wald statistics (p-value)
Visitors	2.83 (p < .093)
Visits	**4.69 (p < .030)**

* Likelihood Ratio Test, G = D0 – D1. (G = 10.0, D0 = 333.9, D1 = -323.9) (p < .007)

The number of visits had more significance than the number of visitors.

Correlated variables	Wald statistics (p-value)
Number of PPD skin tests	**10.8 (p < .001)**
Duration	7.62 (p < .006)

* Likelihood Ratio Test, G = D0 – D1. (G = 63.8, D0 = 333.9, D1 = -270.1) (p < .001)

The number of PPD skin tests had more significance than the duration of residence.

Appendix Twelve: Multiple Regression Models

Model One*	Model Two**	Model Three***
Race	Race	
Citizenship	Citizenship	
Birthplace (non Oregon vs. Oregon)	Birthplace (non Oregon vs. Oregon)	
Birthplace (non-U.S. vs. U.S.)	Birthplace (non-U.S. vs. U.S.)	Birthplace (non-U.S. vs. U.S.)
Final Educational Assessment (no GED vs. GED)	Final Educational Assessment (no GED vs. GED)	Final Educational Assessment (no GED vs. GED)
Housing by AOC district		Housing by AOC district
Level of Security	Level of Security	Level of Security
Density of Institution	Density of Institution	
Drug abuse potential		Drug abuse potential
Number of visitors in one year	Number of visitors in one year	
Number of visits in one year	Number of visits in one year	Number of visits in one year
Number of PPD skin tests	Number of PPD skin tests	Number of PPD skin tests
Duration before conversion or censorship	Duration before conversion or censorship	
Age		Age
County of Incarceration	County of Incarceration	County of Incarceration
Prior incarcerations		Prior incarcerations
Number of institutions		Number of institutions

* All study variables
** All significant variables from the univariate logistic regression
*** All variables were tested except the redundant variables in the correlation groups

Model Four	Model Five
Birthplace (non-U.S. vs. U.S.)	Birthplace (non-U.S. vs. U.S.)
County of incarceration	
Level of Security	Level of Security
Drug abuse potential	
Number of PPD skin tests	Number of PPD skin tests
Number of institutions	Number of institutions

Models Based on the Correlated Variables

Model Five	Iteration 1	Iteration 2	Iteration 3
Birthplace (non-U.S. vs. U.S.)	Birthplace (non-U.S. vs. U.S.)	Birthplace (non-U.S. vs. U.S.)	Birthplace (non-U.S. vs. U.S.)
Security	Density	Security	Density
# PPD skin tests	# PPD skin tests	Duration	Duration
Number of institutions	Number of institutions	Number of institutions	Number of institutions

Iteration 4	Iteration 5	Iteration 6	Iteration 7
Race	Race	Race	Race
Security	Density	Security	Density
# PPD skin tests	# PPD skin tests	Duration	Duration
Number of institutions	Number of institutions	Number of institutions	Number of institutions

Iteration 8	Iteration 9	Iteration 10	Iteration 11
Citizenship	Citizenship	Citizenship	Citizenship
Security	Density	Security	Density
# PPD skin tests	# PPD skin tests	Duration	Duration
Number of institutions	Number of institutions	Number of institutions	Number of institutions

Iteration 12	Iteration 13	Iteration 14	Iteration 15
Birthplace (non Oregon vs. Oregon)	Birthplace (non Oregon vs. Oregon)	Birthplace (non Oregon vs. Oregon)	Birthplace (non Oregon vs. Oregon)
Security	Density	Security	Density
# PPD skin tests	# PPD skin tests	Duration	Duration
Number of institutions	Number of institutions	Number of institutions	Number of institutions

Appendix Thirteen: Results of the Regression Models

Multivariate Model	Odds Ratio	95% CI	p-values (all < .10)
Model One			
Race (Latino vs. Caucasian)	.001	.001 – 2.051	.065
Citizenship (Mexican vs. U.S.)	3.86 x e^5	.305 – 4.9 x e^11	.073
(Other vs. U.S.)	.001	.001 – 1.192	.052
Birthplace (non-U.S. vs. U.S.)	3.68 x e^8	.305 – 4.8 x e^11	.048
County of Incarceration (District 5 vs. Tri-county)	.001	.001 – 1.412	.057
Prior number of incarcerations	.141	.015 – 1.29	.082
Visitors in one year	1.19	.975 – 1.46	.087
Number of PPD skin tests	.017	.001 – 1.36	.068
Housing by AOC District (District 1 vs. Tri-county)	.001	.001 – 4.48	.063
Housing by AOC District (District 6 vs. Tri-county)	.001	.001 – .721	.046
Security (Medium vs. Minimum)	.001	.001 – .149	.031
Security (Maximum vs. Minimum)	.001	.001 – .267	.038
Density (Medium vs. Low)	.001	.001 – 6.76	.084
Duration of residence	.996	.991 – 1.0	.064
Number of institutions	.098	.010 – .922	.042
Model Two			
County of Incarceration (District 3 vs. Tri-county)	862	9.4 – 7.9 x e^4	.003
# PPD skin tests	.630	.371 – 1.07	.087
Security (Medium vs. Minimum)	.003	.001 – .020	.001
Security (Maximum vs. Minimum)	.001	.001 – .022	.001
Density (High vs. Low)	38.4	1.69 – 872	.022
Model Three			
Birthplace (non-U.S. vs. U.S.)	33.5	4.25 – 265	.001
County of Incarceration (District 3 vs. Tri-county)	611	6.36 – 5.8 x e^4	.006
County of Incarceration (District 5 vs. Tri-county)	.038	.001– 1.02	.051
Security (Medium vs. Minimum)	.007	.001 – .050	.001
Security (Maximum vs. Minimum)	.010	.001 – .211	.003
Drug abuse potential	7.28	1.26 – 42.1	.027
# PPD skin tests	.468	.243 – .903	.024
Number of institutions	.489	.261 – .914	.025
Model Four			
Birthplace (non-U.S. vs. U.S.)	14.7	4.05 – 53.7	.001
County of Incarceration (District 5 vs. Tri-county)	.133	.016 – 1.12	.064
Security (Medium vs. Minimum)	.020	.006 – .073	.001
Security (Maximum vs. Minimum)	.078	.021 – .290	.001
Drug abuse potential	2.42	.857 – 6.81	.095
# PPD skin tests	.617	.440 – .865	.005
Number of institutions	.588	.385 – .897	.014

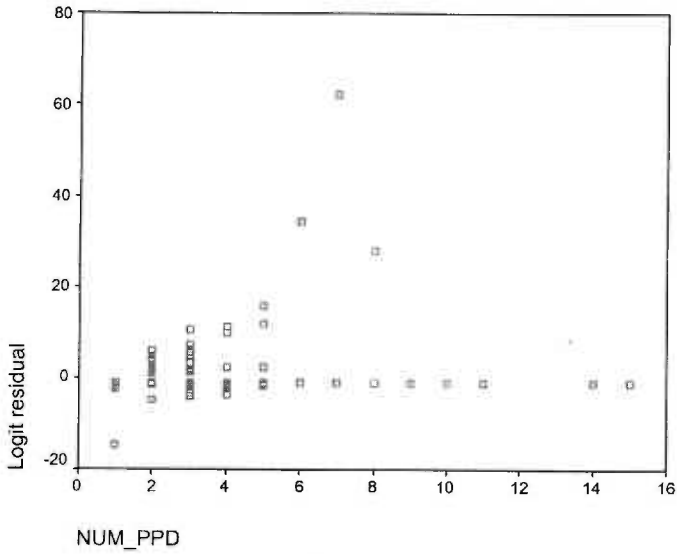
Model Five			
Birthplace (non-U.S. vs. U.S.)	9.87	3.06 – 31.8	.001
Security (Medium vs. Minimum)	.014	.005 – .045	.001
Security (Maximum vs. Minimum)	.052	.017 – .158	.001
# PPD skin tests	.696	.529 – .915	.009
Number of institutions	.639	.443 – .922	.017

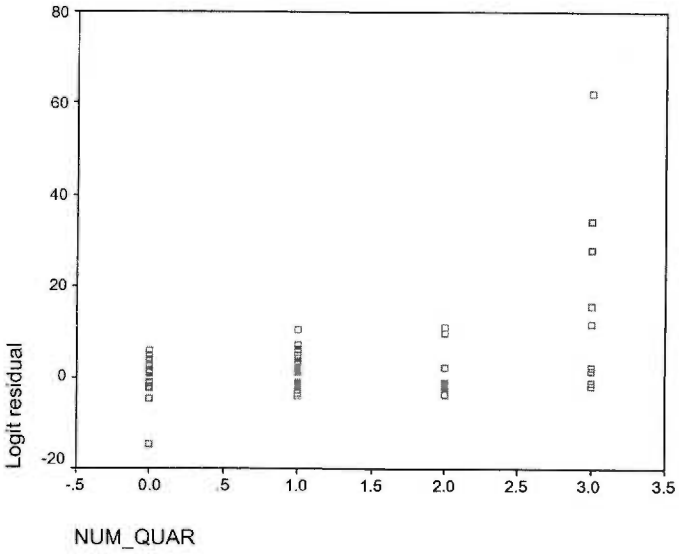
Appendix Fourteen: Models with Significant Double Interactions

Multivariate Model	Odds Ratio	95% CI	p-values (all < .10)
One			
Birthplace (non-Oregon vs. Oregon)	1.57	.57 – 4.4	.386
Security (med vs. min)	.002	.001 – .024	.001
(max vs. min)	.004	.001 – .044	.001
# PPD skin tests	.627	.46 – .85	.003
Number of institutions	.403	.23 – 7.1	.001
Number of institutions x Security (med vs. min)	2.08	.92 – 4.7	.080
Number of institutions x Security (max vs. min)	**2.56**	**1.1 – 5.8**	**.025**
Two			
Race	1.26	.76 – 2.1	.377
Security (med vs. min)	.002	.001 – .023	.001
(max vs. min)	.004	.001 – .043	.001
# PPD skin tests	.622	.46 – .84	.002
Number of institutions	.388	.22 – .68	.001
Number of institutions x Security (med vs. min)	2.11	.92 – 4.9	.079
Number of institutions x Security (max vs. min)	**2.65**	**1.2 – 6.1**	**.022**
Three			
Citizenship	5.21	1.53 – 17.7	.008
Security (med vs. min)	.002	.001 – .022	.001
(max vs. min)	.004	.001 – .041	.001
# PPD skin tests	.644	.48 – .87	.005
Number of institutions	.393	.22 – .69	.001
Number of institutions x Security (med vs. min)	2.17	.94 – 5.0	.068
Number of institutions x Security (max vs. min)	**2.76**	**1.2 – 6.3**	**.017**
Four			
Birthplace (non-U.S. vs. U.S.)	9.58	2.95 – 31.1	.001
Security (med vs. min)	.003	.001 – .037	.001
(max vs. min)	.005	.001 – .058	.001
# PPD skin tests	.689	.51 – .93	.013
Number of institutions	.435	.25 – .76	.004
Number of institutions x Security (med vs. min)	1.85	1.1 – 6.1	.187
Number of institutions x Security (max vs. min)	**2.63**	**1.1 – 6.1**	**.024**

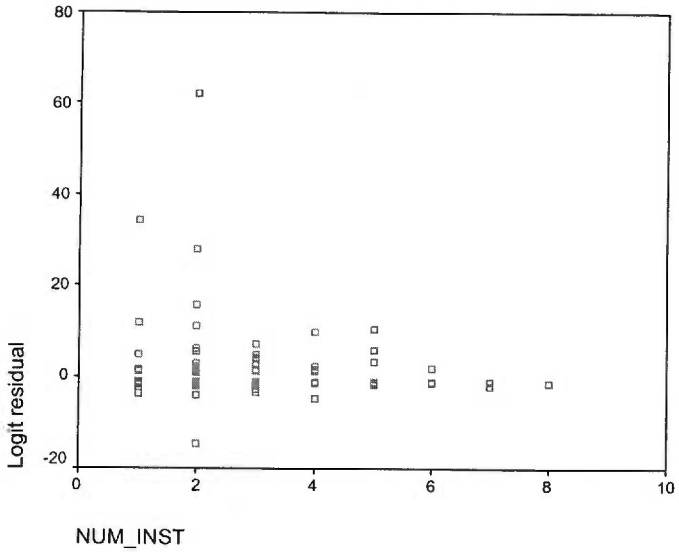
Appendix Fifteen: Graph of Logit vs. Continuous Variables (Number of PPD skin tests and Number of Institutions)

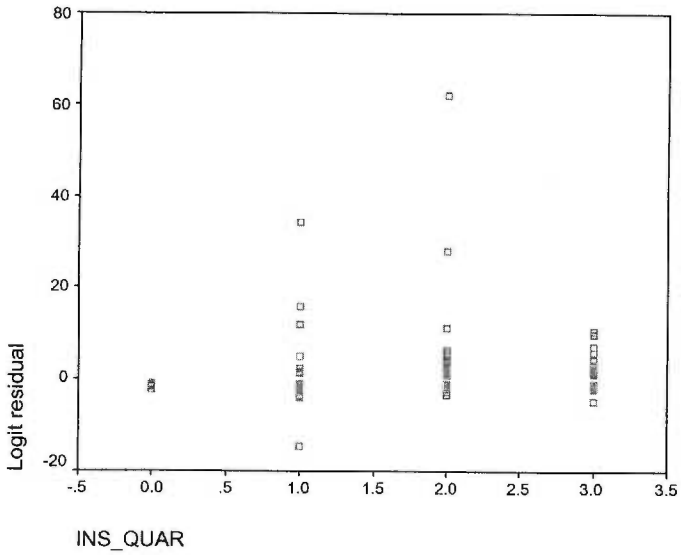
Number of PPD tests





Number of Institutions





Appendix Sixteen: Regression Models on the Correlated Variables

Multivariate Model	Odds Ratio	95% CI	p-values (all < .10)
Iteration One			
Birthplace (non-U.S. vs. U.S.)	**11.3**	**5.06 – 25.0**	**.001**
Density (medium vs. low)	**.140**	**.030 – .651**	**.012**
(high vs. low)	**.107**	**.024 – .469**	**.003**
# PPD skin tests	**.570**	**.428 – .757**	**.001**
Number of institutions	.831	.629 – 1.10	.191
Iteration Two			
Birthplace (non-U.S. vs. U.S.)	**12.4**	**3.54 – 43.7**	**.001**
Security (medium vs. minimum)	**.011**	**.003 – .038**	**.001**
(maximum vs. minimum)	**.061**	**.020 – .189**	**.001**
Duration	.999	.998 – 1.00	.005
Number of institutions	**.534**	**.354 – .806**	**.003**
Iteration Three			
Birthplace (non-U.S. vs. U.S.)	**9.94**	**4.32 – 22.9**	**.001**
Density (medium vs. low)	**.139**	**.029 – .678**	**.015**
(high vs. low)	**.092**	**.020 – .428**	**.002**
Duration	.998	.997 – .999	.001
Number of institutions	**.691**	**.504 – .948**	**.022**
Iteration Four			
Race (Latino vs. Caucasian)	**5.98**	**1.70 – 21.1**	**.005**
(African-American vs. Caucasian)	.748	.157 – 3.56	.716
(Other vs. Caucasian)	1.74	.172 – 17.5	.640
Security (medium vs. minimum)	**.013**	**.004 – .040**	**.001**
(maximum vs. minimum)	**.049**	**.017 – .142**	**.001**
# PPD skin tests	**.649**	**.492 – .856**	**.002**
Number of institutions	**.585**	**.401 – .851**	**.005**
Iteration Five			
Race (Latino vs. Caucasian)	**6.56**	**2.87 – 15.0**	**.001**
(African-American vs. Caucasian)	.948	.287 – 3.14	.930
(Other vs. Caucasian)	2.35	.506 – 10.9	.275
Density (medium vs. low)	**.143**	**.030 – .680**	**.014**
(high vs. low)	**.111**	**.025 – .499**	**.004**
# PPD skin tests	**.523**	**.397 – .689**	**.001**
Number of institutions	.775	.591 – 1.02	.065
Iteration Six			
Race (Latino vs. Caucasian)	**6.23**	**1.74 – 22.4**	**.005**
(African-American vs. Caucasian)	1.21	.239 – 6.13	.817
(Other vs. Caucasian)	2.10	.208 – 21.1	.530
Security (medium vs. minimum)	**.011**	**.004 – .036**	**.001**

(maximum vs. minimum)	**.053**	**.017 – .159**	**.001**
Duration	.999	.998 – .999	.001
Number of institutions	**.491**	**.324 – .744**	**.001**
Iteration Seven			
Race (Latino vs. Caucasian)	**6.11**	**2.58 – 14.5**	**.001**
(African-American vs. Caucasian)	1.27	.376 – 4.32	.698
(Other vs. Caucasian)	2.54	.507 – 12.7	.257
Density (medium vs. low)	**.135**	**.027 – .683**	**.016**
(high vs. low)	**.091**	**.019 – .445**	**.003**
Duration	.997	.997 – .998	.001
Number of institutions	**.638**	**.468 – .870**	**.005**
Iteration Eight			
Citizenship (Mexican vs. U.S.)	**13.0**	**1.77 – 95.1**	**.012**
(Other vs. U.S.)	7.28	.327 – 162	.210
Security (medium vs. minimum)	**.014**	**.005 – .042**	**.001**
(maximum vs. minimum)	**.043**	**.014 – .127**	**.001**
# PPD skin tests	**.650**	**.490 – .861**	**.003**
Number of institutions	**.587**	**.406 – .850**	**.005**
Iteration Nine			
Citizenship (Mexican vs. U.S.)	**11.8**	**3.15 – 44.0**	**.001**
(Other vs. U.S.)	4.66	.357 – 60.8	.240
Density (medium vs. low)	**.184**	**.040 – .843**	**.029**
(high vs. low)	**.129**	**.029 – .567**	**.007**
# PPD skin tests	**.530**	**.403 – .696**	**.001**
Number of institutions	.778	.596 – 1.02	.064
Iteration Ten			
Citizenship (Mexican vs. U.S.)	**11.1**	**1.49 – 81.9**	**.019**
(Other vs. U.S.)	4.57	.187 – 111	.352
Security (medium vs. minimum)	**.012**	**.004 – .038**	**.001**
(maximum vs. minimum)	**.050**	**.016 – .149**	**.001**
Duration	.999	.998 – 1.00	.002
Number of institutions	**.501**	**.334 – .751**	**.001**
Iteration Eleven			
Citizenship (Mexican vs. U.S.)	**9.49**	**2.56 – 35.2**	**.001**
(Other vs. U.S.)	2.73	.201 – 37.3	.450
Density (medium vs. low)	**.173**	**.035 – .855**	**.031**
(high vs. low)	**.107**	**.022 – .509**	**.005**
Duration	.998	.997 – .998	.001
Number of institutions	**.636**	**.469 – .864**	**.004**
Iteration Twelve			
Birthplace (non Oregon vs. Oregon)	1.67	.618 – 4.53	.311
Security (medium vs. minimum)	**.014**	**.005 – .042**	**.001**
(maximum vs. minimum)	**.040**	**.014 – .116**	**.001**

# PPD skin tests	**.632**	**.476 – .839**	**.001**
Number of institutions	**.616**	**.431 – .880**	**.008**
Iteration Thirteen			
Birthplace (non Oregon vs. Oregon)	**2.28**	**1.05 – 4.93**	**.037**
Density (medium vs. low)	.251	.055 – 1.15	.075
(high vs. low)	**.165**	**.037 – .731**	**.018**
# PPD skin tests	**.524**	**.401 – .685**	**.001**
Number of institutions	.824	.643 – 1.06	.129
Iteration Fourteen			
Birthplace (non Oregon vs. Oregon)	2.45	.907 – 6.60	.077
Security (medium vs. minimum)	**.013**	**.004 – .039**	**.001**
(maximum vs. minimum)	**.045**	**.015 – .135**	**.001**
Duration	.998	.998 – .999	.001
Number of institutions	**.517**	**.348 – .768**	**.001**
Iteration Fifteen			
Birthplace (non Oregon vs. Oregon)	**3.19**	**1.45 – 7.05**	**.004**
Density (medium vs. low)	.223	.044 – 1.12	.068
(high vs. low)	**.129**	**.026 – .634**	**.012**
Duration	.997	.996 – .998	.001
Number of institutions	**.659**	**.491 – .884**	**.005**

Appendix Seventeen: Number of Institutions Resided by Cases vs. Controls

Number	Cases	Controls
One	10	82
Two	29	62
Three	24	40
Four	5	26
Five	3	12
Six	1	8
Seven	0	3
Eight	0	1

Appendix Eighteen: Goodness of Fit Tests on the Three Best Models

1) Model Five

A)

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	143.609	.433	.665

.665 = .433 / R2 max

R2 max = .651

Interpretation: The model is moderately good at predicting the outcome.

B)

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	6.809	8	.557

The expected number of converters for the deciles weighted according to the predicted probabilities results in a chi-square statistic that is not significant. The model is a good fit.

2) Iteration Four

A)

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	151.203	.418	.643

.643 = .418 / R2 max

R2 = .650

Interpretation: The model is moderately good at predicting the outcome.

B)

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	5.368	8	.718

The expected number of converters for the deciles weighted according to the predicted probabilities results in a chi-square statistic that is significant. The model is a good fit.

3) Iteration Eight

A)

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	151.196	.418	.643

.643 = .418 / R2 max

R2 max = .650

Interpretation: The model is moderately good at predicting the outcome.

B)

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	9.656	8	.290

The expected number of converters for the deciles weighted according to the predicted probabilities results in a chi-square statistic that is significant. The model is a good fit.

Appendix Nineteen: Results of the Three Best Models After Misclassification is Accounted

Model Five	OR	95% CI	P-value
Birthplace (non-U.S. vs. U.S.)	**5.72**	**2.19 – 14.9**	**.001**
Security (Medium vs. Minimum)	**.041**	**.017 – .098**	**.001**
(Maximum vs. Minimum)	**.057**	**.020 – .163**	**.001**
# PPD skin tests	**.766**	**.615 – .954**	**.017**
Number of institutions	**.704**	**.519 – .956**	**.024**

Iteration Four	OR	95% CI	P-value
Race (Latino vs. Caucasian)	**3.24**	**1.14 – 9.24**	**.028**
(African-American vs. Caucasian)	.575	.139 – 2.38	.445
(Other vs. Caucasian)	1.23	.170 – 8.85	.840
Security (medium vs. minimum)	**.036**	**.015 – .085**	**.001**
(maximum vs. minimum)	**.053**	**.019 – .147**	**.001**
# PPD skin tests	**.729**	**.584 – .911**	**.005**
Number of institutions	**.658**	**.482 – .898**	**.008**

Iteration Eight	OR	95% CI	P-value
Citizenship (Mexican vs. U.S.)	**7.31**	**1.36 – 39.4**	**.021**
(Other vs. U.S.)	5.34	.328 – 86.7	.239
Security (medium vs. minimum)	**.037**	**.016 – .088**	**.001**
(maximum vs. minimum)	**.049**	**.018 – .136**	**.001**
# PPD skin tests	**.733**	**.585 – .917**	**.007**
Number of institutions	**.666**	**.490 – .905**	**.009**