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Public health strategies to control a tuberculosis outbreak in a homeless shelter

Jamilah Abdullah Ali

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PUBLIC HEALTH STRATEGIES TO CONTROL A TUBERCULOSIS OUTBREAK IN A HOMELESS SHELTER

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PUBLIC HEALTH STRATEGIES TO CONTROL A TUBERCULOSIS OUTBREAK IN A HOMELESS SHELTER

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2001
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DEDICATION

To the many homeless people who reside at the shelters and in the streets of Hartford, especially at “The Firehouse” and “The Mac”. May God give His Blessings and Mercy.
To them, I dedicate this work.
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INTRODUCTION:

Tuberculosis infection among the homeless is a widely studied public health issue, especially in regards to many urban areas of the US. The Centers for Disease Control and Prevention (CDC) reports that “the overall incidence of active TB and the prevalence of latent tuberculosis infection (LTBI) among the homeless are unknown.” An indication of the extent of the problem, however, is seen in regional studies. Analyses of TB in the homeless in New York City, San Francisco, and Los Angeles document the prevalence of positive TB skin tests ranging from 32% to 79%.²³⁴

In Hartford, Connecticut, the Health Department noted a cluster of shelter-associated cases in early 1998. They invited a coalition of agencies in the city who serviced the homeless to come together to plan for tuberculosis control. A Tuberculosis Control Plan was subsequently implemented. Many of the TB control modalities used in this project were adapted from a TB Control Plan that successfully controlled a TB outbreak in a Seattle homeless shelter in 1988.⁵

One of the major benefits of the TB Control Plan developed by this coalition was a component of improved access to care, by providing direct TB care in the shelter and even on-site phlebotomy services. Only chest radiographs were done off-site. As noted by Rosenbaum and Zuvekas, “… policies that promote healthcare access
among the homeless … will in fact reach a population that values healthcare and uses it appropriately. 6

In 1995, the CDC published specific guidelines and recommendations for addressing the unique concerns of TB control in the homeless population. 7 They advocated that the essential components of TB control should support a preventive focus, which is consistent with public health objectives. These specific strategies include; 1) excluding persons with known infectious TB from the shelters until they are rendered non-infectious through treatment, 2) identification of undiagnosed cases, 3) protecting exposed persons at the shelter through LTBI treatment, and 4) maximizing engineering controls to prevent the spread of TB infection. LTBI treatment is used as an intervention that is hoped to improve patient outcomes, by decreasing the probability of TB infection progressing to disease. 5

Providing LTBI treatment is a medical modality that has a public health function. The treatment is done by giving a course of anti-tuberculin medication that usually interrupts the progression of TB infection into active (infectious) disease. Although isoniazid (INH) has been given extensively as first-line treatment of LTBI, it is not a benign medication. Many health care providers took note when the CDC described patients with severe INH hepatitis in 1993, four of whom died, and four who lived only after receiving liver transplants. 8 INH had been found to be 93% effective for LTBI treatment, and it is generally well tolerated with appropriate patient follow-up. 9,8 But risk versus benefit must always be weighed in its use.
In the homeless, compliance with INH for LTBI treatment has been disappointing.\textsuperscript{10,11} Completion rates with "usual care" have been found to be only 19-26%.\textsuperscript{10,11} Of note, Tulsky found in one study that the only statistically significant predictor of non-compliance in a community-based LTBI treatment program was housing status. Those literally homeless or living in a shelter were more likely to be non-compliant than those marginally housed in hotels, apartments, or "doubled" with friends.\textsuperscript{11}

Rifampin has been shown, since 1996, to be efficacious as LTBI treatment in the homeless. This was shown by a prospective analysis, with data collected during a 1984 epidemic of INH and streptomycin-resistant tuberculosis in Boston Massachusetts, evaluating the efficacy of rifampin as LTBI treatment for homeless persons.\textsuperscript{12} Their results showed that treatment (of LTBI) with any rifampin-containing preventive therapy (rifampin alone or rifampin plus INH) was statistically significantly effective in preventing development of active disease. Subsequently, the ATS/CDC Joint Statement in 2000 found a four-month course of rifampin alone (120 doses within a six month duration), as an acceptable alternative. This regimen is also recommended for the contacts of INH resistant and rifampin-susceptible TB cases.\textsuperscript{13}

The two month regimen of pyrazinamide (PZA) and rifampin to treat LTBI was included in the October 1998 MMWR "Prevention and treatment of tuberculosis among patients infected with Human Immunodeficiency Virus: principles of therapy
and revised recommendations." The data was sufficiently strong to receive the support of the American Thoracic Society (ATS)/CDC 2000 Joint Statement Committee on LTBI treatment, giving it an evidence based “preferred” rating for HIV infected adults, and as an “alternative acceptable to offer” to the HIV-uninfected person. This regimen is not known by this author to have been actually evaluated in the HIV-negative population, but the ATA/CDC state they do not expect its efficacy to be significantly different, other than the possible risk of increased toxicity. (The document doesn’t indicate why this would be a concern.) In fact, the need for more information is formally presented in the Priorities for Future Research section:

“More data are needed regarding the acceptability, tolerability, and effectiveness of the 2-mo regimen of daily rifampin and pyrazinamide in HIV-negative persons.”

OBJECTIVES:

The purpose of this thesis project was to document the implementation of three strategies used to control a TB outbreak in a men’s shelter. The specific interventions used included: 1) the employment of a two-month regimen of PZA and rifampin, 2) onsite collaboration as an alternative to the “usual care” of giving INH therapy provided at the Health Department, as LTBI treatment for those with tuberculosis exposure and infection, and 3) engineering controls which included installation of an additional air treatment unit in the facility, in the shower area.

The two-month course of PZA and rifampin was elected to be used as the preferred medication regimen in this TB Control Plan, which was developed in response to a TB outbreak of 21 active cases in a men’s emergency shelter in
Hartford, Connecticut from 1997 to 2000. The two-month course was prescribed for those for whom it was deemed medically appropriate, on the basis of convenience (as no drug resistance has been identified in this cohort). In the setting of the outbreak, the shelter administration made housing contingent on resident participation in the mandatory TB Control Plan activities.

The key study questions that were investigated included:

1) What were the specifics of this shelter outbreak that differentiated it from the usual presentation of tuberculosis in the United States?

2) What completion rate and percentage of patients remaining in care was achieved in a cluster of homeless men using a shorter course of LTBI therapy?

3) Will the PZA and rifampin be accepted, tolerated and effective in the homeless, which includes both HIV-infected and HIV-uninfected individuals?

4) Was the “mandatory participation” component of the TB Control Plan essential to be effective?

5) Was continuity of care and patient access improved over “usual care” by utilizing a coalition of agencies involved in this TB control program?

6) Should each modality implemented in this TB Control Plan be considered effective, since improvement has been achieved?

7) What policy implications derive from this data in relation to tuberculosis control in other homeless shelters, especially in the setting of an outbreak?
This thesis project will be structured in the following manner. First, a literature review of the issues will be presented. This includes sequential sections on the following topics: 1) an overview of tuberculosis, 2) homelessness, and 3) tuberculosis among the homeless. Then, a description of the shelter outbreak in Hartford will be provided, the different strategies that comprise the TB Control Plan will be discussed, and their implementation will be described. In conclusion, the results of this study will be considered in the context of the study questions and policy recommendations.
OVERVIEW OF TUBERCULOSIS

EPIDEMIOLOGY

This is a pivotal time in the saga of tuberculosis control in the United States. There is an attenuated optimism that TB can again be slated for elimination, but not with the wildly naïve goal of “1 per million by 2010” as proclaimed by the 1989 Healthy People Initiatives. The more modest goal of reducing the incidence to 1 case per 100,000 by 2010 is the revised target goal of the 2000 Initiative. In 1989 they had set an interim goal of 3.5 cases per 100,000 by 2000, but in 1998 there were still 6.8 new cases. The tuberculosis resurgence, represented by a 20 percent increase in cases between 1985 and 1992, is now on the wane. The factors behind the resurgence are thought to include: (1) the unpredicted explosion of highly susceptible HIV infected persons, (2) institutions with poor infection control practices, (3) increased rates of drug-resistant tuberculosis, (4) increased immigration from TB endemic countries and, 5) failure of TB control programs to ensure that active TB cases were cured.

Tuberculosis had been slated for extinction since the advent of effective chemotherapy over 50 years ago. It’s proposed that the two main factors that have set the U.S. off track in its quest for TB elimination include the related issues of HIV infection and the development of multi-drug resistant TB (MDR TB), both of which are prevalent in the homeless. Fortunately, the number of new cases nationally have again been declining since 1993. Therefore, although TB elimination has been set
back by approximately a decade, it is felt that through “significant effort and cooperation between public and private health care providers and agencies at the Federal, State, and local levels” the goals can be realized.\(^{15}\)

The “Joint Statement of the American Thoracic Society (ATS) and the Centers for Disease Control (CDC)”, was released in early 2000\(^{18}\) with revised recommendations (see Recommendations in Appendix A). The newest push for targeted public health interventions are two-pronged. The first thrust is through treatment of latent tuberculosis infection (LTBI) to reduce the number of active cases expected to eventually arise from the estimated TB burden of 15 million persons in the US. Without this approach, approximately 5 to 10% of those would eventually develop active disease.\(^{18}\)

The second tactic is to increase TB awareness and instill a higher index of suspicion for primary disease (active TB that develops within 2 years of an exposure) which has increased from an annual incidence of 15%, to as high as 59% in a recent study of a US urban population.\(^{19}\) The Healthy People Initiative 2010 has set as a target goal to increase to 85% the “proportion of contacts and other high-risk persons with latent tuberculosis infection who complete a course of treatment.” In 1997, 62.2% of TB contacts and other high-risk persons completed treatment for LTBI.\(^{15}\)

It’s an interesting twist that TB, long associated with poverty\(^{20}\) is still far from elimination and control, even in the US, the “land of plenty”. Due to our disparate
wealth, Connecticut is a shining example of this contrasting landscape. It ranks in the top 5 states in per capita income, and 29th in the US in its incidence of tuberculosis in 1999.

As a society we have opted for the public health approach of targeted interventions, instead of pushing for “structural social reform” to insure that there is no need for homeless shelters, jails or urban squalor. As TB cases are once again declining as noted by P Farmer and E Nardell, “as a result of the efficacy of public health interventions—namely, effective therapy and better infection control—bolstered by generous spending…,” and that ultimately, “since poverty and inequality lie at the heart of TB’s persistence and reemergence, we should focus on these root problems as well as on the distal problems of treating the sick.” Even when looking at the risks for TB in the general population; “male gender, ethnicity, incarceration, and a history of serious mental illness or substance abuse or both,” we are describing the demographics of the homeless.

Because of the association with poverty, there has been stigma with a TB diagnosis. Especially among the foreign-born, who traverse an emotional gauntlet when found to have TB infection or disease. The fact that many have had BCG Vaccine (Bacillus Calmette-Guerin) is of little interest to American trained health providers who have been told that BCG is of variable efficacy, and are instructed to read a positive PPD test (purified protein derivative, the name of the solution used for TB testing) without a different threshold from the unvaccinated. In the United
States, the issue must be taken out of its cultural context, because the basic fact remains that, as noted by Sir Arthur Newsholme in a classic 1926 paper, "Perhaps no single disease has been so fertile as tuberculosis in divergent views as to its causation and means of prevention; and these differences of outlook continue notwithstanding our certain knowledge that in the absence of the tubercle bacillus, there can be no tuberculosis". 20

In any case, our collective public health measures have made measured progress. Nationally, the number of TB cases peaked in 1992. Since that time the nation has seen a progressive decline in cases (26% decrease from 1992 to 1997) At its peak, 22,201 were reported in 1993, and in 1997, 19,855 cases were found. 22 In the state of Connecticut, an 18% decrease in cases was noted from 1994 (147 cases or 4.5 cases per 100,000) to 1999 (121 or 3.7 case rate).21

Directly observed therapy (DOT) has been proposed to be one of the targeted interventions largely responsible for this improvement.20 However, it's unlikely that only one component, (rather the combination of factors that any well-meaning TB control plan must address) has brought about this nationwide improvement.20 These interventions also include; early case identification, targeted PPD testing and post-exposure follow-up, TB education, and environmental controls. All these interventions probably contribute to the improvement in TB incidence. And broad social reform does not fall under the typical definition of the public health domain.
Clearly, the quest for “TB elimination” in the US remains elusive. Yet, it’s the “big picture” that really gives us pause, and paints TB as one of the top ten causes of death in the world. It accounts for more than 3 million deaths worldwide per year (from the World Health Organization (WHO). Eight million new cases develop per year, and 95% of those are in developing countries where resources are scarce, and co-infection with HIV is common.18 Between 19 and 43% of the world’s population is infected with TB (WHO). It is indeed a pathogen to be reckoned with, even today. And eventually, we must expand beyond our borders with our efforts.

PREVENTION AND CONTROL

Consistent implementation of prevention and control measures are key to maintaining the decreasing rate momentum. The CDC recommends collaboration between the public and private sector to achieve the goal of TB control. However, it’s noteworthy that these two sources of care are affected by different issues; the health departments face funding problems and “outsourcing” of programs, and managed care is having a profound effect on physicians.23 In addition, studies indicate that many health care providers are not compliant with the recommendations for providing TB treatment, and this has the potential to sabotage the goal of TB elimination.23

PPD skin testing is a major tool for TB control in the United States. This is a major reason why the BCG vaccine (a live-attenuated strain of *Mycobacterium bovis*)
has been rejected here, as "no method can reliably distinguish tuberculin reactions caused by vaccination with BCG from those caused by natural mycobacterial infections". In addition to its questionable and variable efficacy, is the problem that BCG vaccination renders the PPD skin test unreliable. However, PPD skin testing is approximately 99% specific in populations that have no other mycobacterium exposures.

But in truth, even when PPD screening is implemented on a large scale, as it was in Atlanta (by the Atlanta TB Prevention Coalition), and isoniazide (INH) preventive therapy (now called LTBI treatment) was provided according to the then-current guidelines of the American Thoracic Society and the Centers for Disease Control and Prevention, the outcomes were disappointing. This impressive project administered 7,246 PPD skin tests. Of these, 4,701 (65%) returned to be read, and of these, 809 (17%) had a positive result. 50% (409) met the guidelines to be treated, and of those only 84 (20%) completed the course of treatment. The authors noted that, "for community based programs to be efficacious, preventive therapy regimens that are of shorter duration and safe for older persons will need to be implemented." Now, the revised recommendations have eliminated the age limitation on LTBI treatment, and the alternative course with Rifampin and Pyrazinamide may be more accepted than INH.
TRANSMISSION AND PATHOGENESIS

Tuberculosis is caused by an air-borne bacteria, which is insidious and potentially life threatening, but treatable since the advent of Streptomycin in 1943. Now, approximately seven drugs are in use against TB. The pathogenesis of *Mycobacterium tuberculosis* (*MTB*) is distinctive in its ability to progress into active disease from weeks to many years after infection. Active TB may present in the lungs or in extra-pulmonary sites such as the pleura, lymphatics, bones and/or joints, genitourinary system, disseminated (miliary), meningeal, peritoneal, or other sites. Only active disease in the lungs or larynx are infectious to other people, while extra-pulmonary TB is not contagious.

In the general population of the U.S. as a whole, the there is an estimated TB infection rate of 5 to 10%. However, after close contact with an individual with active pulmonary TB, the risk of becoming infected is 25 to 50%\(^\text{18}\) The risk of developing active TB is 5% during the first two years after infection (defined as primary disease, during which time 50% of cases occur), and carries a 5 to 10% lifetime risk of becoming active without prophylactic treatment.\(^\text{18}\) During this time, the PPD skin test will usually be positive, indicating prior exposure, but the infection is usually latent, and not infectious to others during this stage.

The pathogenesis of *MTB* infection is that aerosolized droplet nuclei (less than 6 um), carrying a single or a few infectious bacilli (1 to 5 um) are aspirated into the
respiratory tract of the recipient. If the bacilli then bypass the upper bronchus to reach and multiply in the terminal air space, infection occurs. Over 3,000 droplet nuclei are produced by a cough or talking for 5 minutes, and over 40,000 are produced by a sneeze. The potential for TB transmission is dependent on four factors: 1) the number of organisms expectorated into the air, 2) the concentration of the organisms expelled, 3) the amount of time exposed, and 4) probably, the immune status of the exposed person.

After inoculation and consumption by macrophages the bacilli continue to multiply and seed regional lymph nodes as well as target organs. At that point, whether the TB infection proceeds to active disease or remains dormant is primarily dependant on host factors. It should be noted, however, that although it is presumed that impaired cell-mediated immunity caused by HIV, or other factors (such as nutritional status, drug abuse or alcoholism) makes one more susceptible to TB infection and disease, those with HIV or AIDS are not more likely to transmit TB.

The length of time the MTB bacilli remain viable and airborne depends upon the relative humidity and temperature of the indoor environment, and the particle’s aerodynamic size. MTB has been called “contagion in slow motion”, as the duration of exposure is usually measured in months (as opposed to a matter of days for measles.) The microorganism must be viable to initiate TB infection. Specific environmental controls shown to reduce TB transmission include dilution with clean air, filtration, and ultra-violet lights.
Co-infection with tuberculosis and HIV has been closely studied. Both are intracellular pathogens that interact at the “population, clinical, and cellular levels.” Immunologic and virologic studies have shown evidence that HIV replication may accelerate in the setting of TB co-infection. The rate of TB disease in HIV infected is approximately 200-800 times higher than the TB rate for the general US population, and the mortality rate is approximately four times that of TB in patients who are HIV negative. If a person with latent TB infection then acquires HIV, the risk of developing active TB is unchanged (5-10%). However, in HIV infected individuals who are secondarily infected with TB, especially those with a low CD4 count, approximately 50% will progress to active TB (if untreated) within 2 years after infection with *MTB*.

Of additional note, when an individual with intact cell-mediated immunity becomes infected with TB, there is a certain amount of protection against reinfection in the setting of a new exposure. However, “exogenous reinfection” has been known to occur in both HIV infected and uninfected, with a predilection for homeless persons.

Anergy testing was performed in the past when PPD testing HIV-positive persons. Anergy testing is known as the application of another skin test of a substance most people have been exposed to in the past (such as candida or mumps), at the time of the PPD skin test. This was thought to be a predictor of the ability to mount a
cutaneous response. If there was the predicted skin reaction to the common antigens, it was presumed the person’s cell-mediated delayed-type hypersensitivity (DTH) was intact, and that a negative PPD response was a true negative. Usually, this was thought to reflect the magnitude of CD4 counts in the HIV infected. However, it has been found that DTH responses to all antigens are too variable, and there is no correlation to PPD response or tuberculosis infection. Therefore, anergy testing is not recommended to be performed to identify TB infection.

CLINICAL MANIFESTATIONS AND TUBERCULOSIS TREATMENT

The four cardinal symptoms of active TB include cough, fever, night sweats and weight loss. Fever is the most easily quantified of the systemic symptoms. Approximately 37 to 80% of patients experience fever with their illness. However, cough is the most common symptom of pulmonary TB. If PPD results are reactive, or symptom screenings warrant, a complete work-up should be done. When in question, sputum for culture of *MTB* and smears for acid-fast bacteria should be collected to rule out active disease, especially in those with HIV infection. A PPD test should be always be given, however, it may be negative in 10 to 25% of patients with active TB.

Interestingly, radiographic features of TB differ in the case of primary versus reactivation of old disease. In primary disease the infiltrate is usually a middle or
lower zone lung infiltrate, but findings may include atelectasis, parenchymal consolidation, lymphadenopathy, pleural effusion, or a military pattern. Usually reactivated disease presents in one or both upper lungs, and cavitations appear in approximately 50% of patients. In old disease, x-rays may show nodules and fibrotic lesions. These findings are at higher risk of developing into active disease. However, old calcified nodules and granulomas are at lower risk of future progression.

Although latent tuberculosis infection (LTBI) treatment is usually given to prevent reactivation, in the setting of recent exposure, the prophylactic treatment of primary TB is the goal. As per the new ATS/CDC recommendations, targeted testing and evaluations should be done in high-risk environments such as homeless shelters and correctional facilities, which are often, in addition, the settings of exposure to known cases of active disease (close contacts).

In the past, six months of isoniazid (INH) medication was recommended for HIV-uninfected patients with a positive PPD, and a negative chest x-ray without symptoms or evidence of active infection, to prevent the development of active TB. Now, the guidelines are to use INH for a nine-month duration for optimal efficacy. Another option is to use a two-month course of Pyrazinamide (PZA) and rifampin. This has been used in HIV infected individuals with latent TB infection, with good results, and is now acceptable to be used in HIV-negative persons with latent TB. In essence, this
may be a more suitable course for homeless persons who have long been identified with poor compliance.

A third alternative is the use of Rifampin alone for four months, for LTBI treatment. And finally, twice weekly dosing may be employed with INH by directly observed therapy (DOT), as used widely in the Connecticut Department of Corrections. It has an “acceptable alternative” rating by the ATS/CDC (2000), for both HIV infected and un-infected patients. Regardless of the medication regimen chosen to treat LTBI, if therapy is interrupted for more than 2 months, a medical re-evaluation should be done to rule out active tuberculosis.

Directly Observed Therapy (DOT) for active disease has been hailed as the “panacea for failed TB programs globally”.\textsuperscript{20} It has been shown that DOT can significantly improve outcomes in environments where therapy completion rate are low. When DOT is employed, treatment completion rates are up to 96%. In the first two years after DOT came into wide use, there was a 21 percent decrease in all TB cases, and a 39% decrease in the rate of multi-drug resistant disease. DOT is actually a “modest and focused public health intervention”,\textsuperscript{20} and is required for all intermittent (twice weekly) LTBI regimens. DOT is not required for regimens with daily dosing, including the two-month course of PZA and rifampin, but it may be a practical consideration.
Among persons co-infected with TB and HIV, roughly 1/3 will have pulmonary, 1/3 will have extra-pulmonary, and 1/3 will have both pulmonary and extra-pulmonary disease. In the setting of co-infection with HIV, the radiographic presentation may be more confusing. Early in the course of HIV infection, the radiographic "cavitations" are common. However, in more advanced HIV x-rays are less reliable, with intrathoracic adenopathy or atypical cavitations present.

Usually, any abnormal chest x-ray findings require collection of three separate sputum samples for evaluation. Acid-fast smears (AFBs) are usually available within 24 hours, and these are about 70% sensitive for active tuberculosis. The specificity ranges from 56% in HIV patients, to 99% in the HIV-uninfected. At least four anti-TB drugs should be started immediately in all patients with positive AFB smears. Delay in the initiation of anti-TB treatment has contributed to community spread of both drug susceptible, as well as drug resistant TB.

Sputum cultures are still the "gold standard" to make a diagnosis of pulmonary TB, and they are 98.5% specific and 81% sensitive for the determination of active disease. Drug resistance testing should be done on all initial isolates from patients with positive cultures. After drug resistance is ruled out, and four drugs have been taken for at least two months and the patient has improved clinically, the medication regimen may be reduced to INH and rifampin alone. This dual therapy may be discontinued after four more months if the sputum cultures remain negative.
Hospitalization and directly observed therapy should be considered for all patients with active TB.²³

Clinical monitoring of patients on tuberculosis treatment (both active disease and LTBI) should be performed to assess for adverse reactions and toxicities. Each visit for monitoring is also an opportunity for the medical provider to reinforce the patient’s understanding of TB disease or LTBI, and its treatment.

In the follow-up of LTBI treatment, baseline laboratory studies are no longer required for those over 35 years of age. However, it is recommended to monitor liver function tests if the patient is at risk of a liver disorder, is HIV infected, or is pregnant or post-partum. Active hepatitis, or end-stage liver disease are relative contraindications to using INH or PZA for LTBI treatment.

INFECTION CONTROL AND COMMUNITY MEDICINE ISSUES

Usually an individual with active TB is considered non-infectious after they have received adequate anti-tuberculin therapy for two to three weeks, have had a favorable clinical response to treatment, and have had three consecutive AFB-negative sputum results collected on different days.³⁰ Meanwhile, infection control measures should be implemented. These include administrative controls (policies and
procedures), engineering controls, and the use of personal respiratory protective equipment in selected areas such as in TB isolation rooms.

All health care facilities, and other settings where the risk of TB infections and transmission may occur, should have a tuberculosis control plan in operation. Should an individual be suspected of having active TB, respiratory isolation should be advised. Consistent clinical guidelines are designed to ensure that a thorough and timely evaluation is performed, and appropriate precautions are taken to prevent tuberculosis transmission. The index of suspicion should be appropriate for the setting, and protocols developed to assist clinicians in their response to the clinical picture, taking reasonable precautions to prevent transmission to self and others. Unfortunately, "studies indicate that many physicians demonstrate poor compliance with recommended tuberculosis treatment and guidelines." 

Screening programs for health care workers should be designed and implemented. Presentations regarding tuberculosis risk including the basic concepts, infection control practices and the importance of participation in surveillance programs should be conducted.

Engineering controls are usually focused on the ventilation systems in areas where prevention of tuberculosis transmission is needed. The employment of air treatment systems may incorporate high-efficiency particulate air (HEPA) filters, and ultraviolet germicidal irradiation. Isolation rooms should provide negative pressure with outside
exhaust, to prevent the dissemination of droplet nuclei to other areas of the facility. The function of HEPA filters is to remove droplet nuclei from the air, and ultraviolet lights are employed to kill *M. tuberculosis* bacteria in the droplet nuclei. However, ultraviolet lights do not have proven efficacy against TB outside the research setting.

Respiratory infection control, a rather difficult and elusive public health activity, is primarily designed with TB prevention as the goal. Certainly colds, flues, measles and a host of other viral infections spread by the respiratory route, are reduced by improved ventilation, and other interventions related to TB control. However, most of these viral infections are mild and self-limited, unlike the pervasiveness and degree of potential morbidity and mortality at risk by TB.

Tuberculosis control efforts benefit from the combined efforts of; (1 ) pulmonologists, (2) infectious disease specialists, (3) public health advocates (such as the local health departments), (4) private, non-profit community health providers, and (5) academicians and researchers. Such collaboration could be considered a core function of the community medicine concept. Clearly, public health policy and government funding should address this ongoing need. We must continue to expand and enhance the coalition of tuberculosis care.
HOMELESSNESS

“Homelessness and hunger exist in the face of abundance. Therein lies the outrage.” Graffit on the sidewalk of East 10th Street, New York city, October 1990 (Jahiel RI, 1992). 34

Creating a universally accepted definition of who is “homeless” in the United States has been an elusive and uncertain undertaking. The Centers for Disease Control and Prevention (CDC) uses this description; “a person who does not have a customary and regular access to a conventional dwelling or residence” 31. Karen Brudney, researcher, says being homeless means to “have a lack of permanent housing.” 32 According to Link, et al...in 1994, the term “literal homelessness” was defined as “sleeping in shelters, abandoned buildings, bus and train stations, etc.”. They found the prevalence of lifetime literal homelessness to be 7.4%. And the lifetime prevalence of all types of homelessness combined was estimated at 14% 33 (Link, et al, Lifetime...1994). But, perhaps we are complicating what is essentially a simple matter. As succinctly under-stated by Rene Jahiel, editor of Homelessness: A Prevention-oriented Approach, “Homeless people are people who have no home.” 34

In truth, many persons drift in and out of homelessness, with an estimated point prevalence of 600,000, (0.26% of the U.S. population). 35 At least 2.3 million adult and children, or nearly 1 percent of the U.S. population, experience a period of homelessness, during a year. This risk of homelessness increases to 6.3% for low income people, based on figures from surveys conducted by the US Census Bureau. However, actual counts of homeless people often produce smaller numbers than
agency estimates. In fact the Census of the Homeless in Hartford, Connecticut, conducted on December 13th, 1999, counted 1,365 persons. Based on this point prevalence, approximately one percent of Hartford residents are homeless at any one time. This figure sounds low, as Hartford has the dubious distinction of being in the top ten poorest cities in the U.S., which implies a large number of low-income residents, who are marginally housed.

The Institute of Medicine has identified three categories of homelessness—temporary, episodic, and chronic. Temporary homelessness is usually the result of a situational event, such as a fire. Recurrent homelessness based on disability, or other sources of income interruptions, may have an episodic nature. The chronically homeless are more likely to suffer from one or more diagnosis of mental illness or substance abuse. Chronic homelessness is defined as one without housing for one year or more. Approximately 30% of homeless populations are estimated to be chronic.

From a historical perspective, it has been proposed that there are notable differences between the “old homeless”, and “new homeless”. Although the homeless have always existed in the United States, their numbers reflecting the ebb and flow of economic prosperity, now the problem has become multi-dimensional. Since the 1980’s we’ve experienced a surge of homelessness that is more pervasive than counts of the homeless even during the worst years of the Great Depression, when top estimates of the homeless was 1.5 million. Studies of the post World War II
era describe skid row locations (apart from the general community) with predominately older, alcoholic, white men. At that time, the definition of homelessness primarily indicated one who was living outside of family units, as opposed to an absolute lack of housing. A study was done of the homeless living in single room occupancy (SRO) hotels in Chicago in the 1950's. They found the median age to be about 50, and more than 90% were white.\textsuperscript{37}

Another historical factor, which has changed the housing options for the homeless, was gentrification resulting in the demolition of the old SRO hotels. For example, from 1970 to 1982, New York City lost 87% of its SRO accommodations, as did most other cities in the U.S.\textsuperscript{38} This component of urban renewal efforts had a profound impact on the urban landscape. The SROs were located in what was called “skid row” sections of cities, which were usually near railroad freight yards and trucking terminals, that provided casual labor opportunities, and money for rents for the inhabitants. This arrangement served to insulate the rest of the community from the affront of poverty.

Now, those facilities have been replaced by homeless shelters, who discharge their clients/residents early every morning into the surrounding neighborhood. Hundreds of individuals must find somewhere to stay the day, if they are unemployed. They become both visible and invisible, integral within our communities, yet a sub-culture. There is an industry of shelters and soup kitchens, which are both public and privately
funded, that strive to serve this network of persons. Community health center practitioners, who practice “poverty medicine” for low-income people, are also vital.

But, the oft quoted and reverberating historical process that had greatly escalated the numbers of homeless and inappropriate incarcerations, has been what’s become known as the deinstitutionalization of the mentally ill. From 1959 to 1988, the number of mentally ill persons in state hospitals decreased from 559,000 nationwide, to approximately 130,000. This happened in large part as a result of federal government policy to exclude funding for “institutions for mental diseases (IMDs)”. This is referred to as the IMD exclusion. It rewards state governments with incentives to move patients out of state hospitals.

Today, there has been a shift in the demographics of homeless people, especially in the areas of gender, race, and age. The percentage of women has increased from 3% in the 1950’s to approximately 25% in the 1980’s. At least forty percent of the homeless now are in families, usually comprised of single women with children. And the percentage of homeless who are white has decreased by 60%, with non-whites comprising the majority (68%) of the homeless population in the U.S. (U.S. Conference of Mayors, 1998). These numbers, however, are consistent with the overrepresentation of African Americans among the poor (the poverty rate for Blacks was 23.6% in 1999, and for non-Hispanic Whites only 7.7%) (U.S. Census Bureau, 2000).
The causes of increased homelessness can only be partially attributed to structural causes, such as a lack of affordable housing. There are social justice issues, such as the rampant discrimination against persons seeking employment with a history of incarceration. And there are many personal causes including; substance abuse, physical or mental disability, domestic violence and social disaffiliation. It is the composite of these that put individuals at risk. Frequently, it is an interaction of personal and structural causes that result in homeless status. 

RESEARCH EFFORTS

Research has been done to try to evaluate the homeless population. As cryptically noted by James Wright in the book *Under the Safety Net*, “Studies of derelicts have produced many a Ph.D. thesis”. So it is probably safe to infer that homeless people have been widely studied, yet remain complex and mysterious. One problem is ethnocentricity, perceiving the group from an outsider point of view, at risk of prejudice. For example, according to Lovell, et al,

"theories of homelessness… have shifted in focus since at least the sixteenth century, sometimes emphasizing personal and moral characteristics and sometimes giving way to social and economic explanations. Psychological and psychiatric theories have abounded since the beginnings of psychological medicine. (Lovell, in: Jahiel Ed. Homelessness-a Prevention Oriented Approach, 1992) "

This brings into question the reliability of measures used to evaluate the homeless from all fields of science, as the basic definitions are usually culture-bound. Prejudice and ethnocentricity adversely affect both research questions and outcome measurements.
There are many other complexities that impact research protocols, such as the known difficulty of tracking homeless people.\textsuperscript{42} This is why a predominance of cross-sectional single structured interviews have predominated the design of studies of the homeless. One research method, the large-scale survey, has been shown to have little value when conducted in the homeless. This is because it is apparent that results are highly associated with interviewer rapport to render consistent results.\textsuperscript{43} Other research tools are equally fraught with difficulty. For example, as a group the homeless are already an amorphous lot. So how to conduct a random sample, without a sampling frame?

It has been proposed that point-prevalence studies result in bias, when compared to studies of formerly homeless persons. In short, there are many methodological issues to consider when studying the homeless. Unfortunately, they often lead to a choice between relevance and rigor in research design.\textsuperscript{34}

HOUSING STATUS AND MENTAL HEALTH, SUBSTANCE ABUSE, AND INFECTIOUS DISEASE

The state of being un-housed has many far-reaching effects on health. It is well known that the problems of substance abuse and psychiatric illness are frequently present in homeless persons, either alone or in co-morbidity (also known as “dual diagnosis”). Whether these issues are causal, or the result of homelessness is a subject
of considerable debate. In a study conducted in 1989 it was found that the prevalence of substance abuse and psychiatric hospitalization in 1437 homeless adults in Northern California, increased 15% to 33% after they lost housing. The same study also noted that the prevalence of psychotic disorders was lowest among the newly homeless, and increased with the length of time spent homeless.

Without exception, studies show the rates of substance abuse, mental illness and dual diagnosis to be extremely high in the homeless and near-homeless. In addition, all these problems are associated with high risk behaviors for HIV infection. As noted in a paper by Stephen Goldfinger, et al., “Many homeless persons with serious mental illnesses belong simultaneously to other subcultures that have been disproportionately affected by the AIDS epidemic, including intravenous drug users, prison inmates, crack cocaine users, commercial sex traders, and minority ethnic groups.”

The need for mental health services for the homeless is substantial. However, there are many homeless people who are not mentally ill, and only a minority of mentally ill people becomes homeless. Never the less, the estimated prevalence of mental illness in homeless people ranges from 28 to 90%, and qualifies it as a major issue. Whatever organic problems underlie the foundation of mental illness in homeless people, there are multiple situational/environmental enhancers. Personal histories of dysfunctional families, with childhood physical, emotional and sexual abuse, are common. They are at risk of crime and victimization, and fear rape, assault,
robery. They are often overwhelmed by the social service system, and have trouble accessing its services. Their illness often prevents the development of meaningful relationships, and renders them socially isolated. 48

Usually, the homeless with mental illness are considered blameless, and elicit societal pity. This is not the case with substance abusers. Author Michael Katz noted that the public sub-conscious creates a distinction between the “deserving poor”, and the “undeserving poor”. 32 This perception promotes the concept that the homeless have brought their problems upon them selves, through drug abuse and behaviors that increase the risk of HIV infection. This form of victim blaming contributes to the “sympathy fatigue” that also plague homeless program funding efforts. Of course, there is an incredibly high rate of substance abuse; including alcohol, drug use, or poly-addiction. But, if the medical model of addiction used which proclaims that substance dependence is an illness, then substance use could be considered blameless, as well.

It is still unclear as to what degree drug use contributes to homelessness. 49 However, the prevalence of drug use has been documented to be lowest among people who have been homeless less than 6 months. Drug and alcohol treatment issues require special consideration in the homeless. Outpatient programs are unfeasible, and many inpatient programs are too short. One version of substance abuse treatment used in homeless programs is the “harm reduction” model.
Proponents of this approach accept reduced drug and alcohol use among participants, instead of complete abstinence.

Intravenous drug use (IVDU) is a well-known major risk factor for HIV infection, especially in the homeless. But HIV is less studied in the mentally ill homeless. However, what data does exist indicates the population is at high risk for both transmitting and contracting this infection. Their threshold for risk behaviors is often lower due to; cognitive deficits, “vulnerability to coercion”, and a tremendous need for money. Their particular risk factors include various sexual behaviors, social circumstances which do not allow funds for condom purchase, and the use of psychotropic medications, which effectively decreases psychotic symptoms, and thus contributes to more sexual activity.

The conditions of homelessness, and the co-morbidity of substance abuse and mental illness, increase the risk of infectious diseases, especially HIV, TB, and Hepatitis C. The incidence of HIV in the homeless is estimated in some studies to be as high as 62%, but the numbers vary by location.

OTHER PHYSICAL HEALTH PROBLEMS

Due to the harsh environment and living conditions of homeless persons, a strong argument can be made that mental illness, substance abuse and physical health
problems are interrelated and share etiologies. But, overall, the physical problems have received less attention than the psychological problems.

What are some of the environmental and situational effects of being homeless that impact health? Limited ability to maintain a healthy diet, inadequate sleep, limited access to facilities for hygiene upkeep, communal bathing, eating and sleeping, exposure to the elements, constant exposure to potential violence, dysfunctional and absent family support, and the lack, for many, of adequate health insurance. In terms of health care access, it could be considered that passage of universal health care reforms would eliminate this last issue for the homeless.

In fact, it is interesting to note that homelessness does persist in countries with 'nationalized healthcare”, as evidenced by the volume of research data available on the homeless residing in both Canada and the United Kingdom. But, when an analysis of the mortality rate of the homeless in Toronto was compared to mortality rates in the US, the findings were striking. Although the Canadian homeless were found to have a higher mortality rate than the general population of Canadian residents, still the rate was significantly lower than the mortality rates of homeless persons in 3 major cities in the U.S. Could this be an indicator of a positive result of a universal health care single payer system, in terms of the health status of homeless people?

As stated, homelessness in the U.S. has been implicated as an independent risk factor in mortality studies, to be associated with a high death rate. In fact, cohort
studies of the age-adjusted mortality of the homeless have demonstrated a rate 3.5 to 4 times that of the general US population. Furthermore, the causes of death were studied in the homeless in Boston. Of note, it was found that homicide was the leading cause of death in men 18 to 24 years of age. Acquired Immunodeficiency Syndrome was the major cause of death in those 25 to 44 years of age. Heart disease and cancer were the major causes of death in those 45 to 65 years of age. Based on this data, it could be considered that a universal healthcare system could help the high mortality rates for homeless people over the age of 24 who are dying of medical causes, if access to healthcare is a factor.

Health care access has many barriers for the homeless. In a needs assessment based on a probability sample of homeless people, many expressed dissatisfaction with their care. However, most groups of people would also complain when faced with long clinic waits, and frequent changes in health providers, which are problems often experienced by homeless people. Homeless people have been described as experiencing alienation, fearing authority, and having low self-esteem, characteristics which may also have a negative impact on accessing health care. They may seek health care too late, or not at all, increasing the chances of presenting with an advanced stage of disease, with fewer available treatments. Other findings have shown the homeless to express an interest in improving their health, but also to be realistic about their options for getting care.
When considering preventive health care for the homeless, interventions on the primary and secondary level are hard to implement. As noted by author Linda Weinreb, MD, "Disease prevention services may seem almost ludicrous in the acute or chronic crisis of homelessness." For instance, tobacco use may be one of the most under-stated health issues in the homeless. Studies have shown the prevalence of tobacco use to be greater than 70% This is more than twice the prevalence of tobacco use in the general population. Tobacco use is often linked to other common problems in the homeless, such as other addictive behavior (alcohol and substance abuse) and mental disorders. It is generally felt that promoting smoking cessation in the homeless is an "elusive goal".

The cost of health care for the homeless is very high on the tertiary end of the health care continuum. A large-scale retrospective study was done comparing homeless persons to other low-income persons with regards to hospital stays and costs of admissions, in New York City during 1992 and 1993 This study found that 51.5% of admissions among the homeless were for substance abuse or psychiatric illness, compared to 22.8% of low income patients who were not homeless. The homeless stayed an average of 4.1 days longer, resulting in much higher costs.

NEEDS OF HOMELESS PEOPLE

Outreach to homeless individuals and families, takes place in many settings. Persons who are literally homeless require street outreach, developing rapport to encourage use of shelters or soup kitchens, to accept clothing or health care. On-site
health services are provided by Health Care for the Homeless (HCH) Programs, which were federally funded by the Stewart B. McKinney Homeless Assistance Act in 1987. The HCH programs receive support from the Bureau of Primary Health Care. As of 1997, there were 123 of these programs nationwide. The mission of these projects is to provide sensitive and culturally competent primary care, mental health services, dental care, and substance abuse services for homeless people. Often these services are provided right in the shelter setting, which has a profound effect on access.

The needs of homeless people are as varied as the diversity of individuals that compose the population. However, recurring themes highlight some aspects of care to consider. One such need is the treatment and prevention of domestic violence. According to therapists who treat the perpetrators of abuse, most frequently men, specialized therapy not simply anger management or couples counseling is required. The victims of domestic violence, and their children, may suffer from the effects of Post Traumatic Stress (PTS) Syndrome, and need special care. Single parents with children may also need help with parenting skills, especially in the unstable environment of shelter living.

Culturally diverse bi-lingual therapists should be available. Cognitive Therapy approaches to coping with the micro-aggression brought about by racism, sexism, and prejudice against the homeless may be effective. In the setting of a psychiatric de-compensation, one can be held involuntarily if they express suicidal or homicidal
ideation. Workers and case managers with skills to defuse such situations are at a high premium in the shelters.

Vocational training is a big need for homeless persons, and computer skills are being taught in many shelters. Housing programs need a large component of case management and relapse prevention to be successful. Long-time shelter residents often are prone to becoming "institutionalized", with many having left conjugal housing in jails, for the same type of life in the shelters. Life skills for independent living need to be taught and reinforced. Some persons with long-standing substance abuse, may need an equally long-term residential treatment program. Work opportunities should also be developed for those with a history of incarceration.

Housing for people with AIDS is often too strict for those with active substance abuse problems. Some modified housing could be helpful. Stay-in programs at the shelters for the HIV infected are provided through Ryan-White funding. HIV risk prevention and testing programs, such as needle-exchange programs, can save lives among the homeless. It is particularly important to reach the young people in the homeless population, who are at the very high end of the risk continuum.

Eliminating homelessness, and the conditions that foster it, should become a proactive mission for our society. Resources exist, and we must work through the barriers to create options for those who are caught up in chronic homelessness. Sometimes radical ideas work, and there is plenty of room for improvement in this
environment. Ways to prevent homelessness need to be explored. As an old saying wisely asserts, “If you give a man a fish, he’ll eat for a day. If you teach him how to fish, he’ll eat forever.”
INTRODUCTION

The study of tuberculosis as a major infectious disease in homeless people highlights many sadly interesting issues and nuances. First, the history of TB in the US, and it’s treatment by public health officials, is akin to the chronicle of the deinstitutionalization of the mentally ill from the 1960’s to the 1980’s. Inpatient care in asylums was supposed to be replaced by outpatient, more humane, community mental health services. These outpatient services were, unfortunately, often not created or funded. Many of these mentally ill persons, once deinstitutionalized, ended up homeless, and now constitute a sub-population of long–term residents of virtually every homeless shelter. 32

Likewise, by the late 1960’s, most TB sanitarium beds had been closed. “In the heyday of the war on poverty, at a time when worship of modern medicine was at it’s height, lengthy hospitalization appeared unnecessary and pills could and would be available to all in the community,” as noted by TB researcher, Karen Brudney. 32 Unfortunately, these services have followed a tertiary, rather than a primary course of intervention, resulting in numerous outbreaks of active tuberculosis in homeless shelters across the country. Now TB, like the saga of mental illness, is found in homeless shelters.
Studies show the prevalence of TB infection in the homeless to be as high as 50%, and that the risk of active TB was 150 to 300 times higher in the homeless than in the housed in the early 1990's. It's estimated that 20 to 30% of all TB patients are homeless, and why not? Their environment has all the risk factors that foster TB disease and transmission; severe crowding of persons with ill health and poor nutritional status, put together into poorly ventilated buildings.

In addition, multiple studies have documented the same characteristics that are associated with an increased risk of TB infection and disease, are identical to risk factors of homelessness including; male gender, ethnicity, incarceration, mental illness, and/or substance abuse. Karen Brudney notes, "If you wanted to design a laboratory setting to insure tuberculosis infection, you would be hard pressed to do better than the shelters...We have recreated the conditions in which TB was spread in the 19th century."

In 1997 the CDC reported 1242 cases of active TB in homeless persons. This represented an increase from 5.7% of TB cases, nationally in 1994, to 6.5% in 1997, indicating that TB remains a problem in the homeless, even though TB case numbers in the US have been declining since 1992. In Connecticut, TB cases in the homeless represented 12% of the total TB cases in 1993, with a declining case rate of 84% until the 1998 outbreak, but still representing 9.4% of cases in the state.
In 1992 the CDC published prioritized recommendations specific for tuberculosis prevention and control for homeless persons. They are as follows:

1. Detection, evaluation, reporting, and treatment of homeless persons with active TB.

2. Screening and preventive therapy for homeless persons with HIV.

3. Examination and appropriate treatment of persons with recent, inadequately treated TB.

4. Screening and appropriate treatment of persons exposed to an infectious case of TB.

5. Screening and preventive therapy for homeless persons with known medical conditions that increase the risk of TB.

Urban areas generally have a high incidence and prevalence of three factors; TB infection, homelessness, and HIV. Many local public health departments have found these recommendations were neither practical nor feasible. For instance, in New York City over 3,600 new cases of active TB were found in 1991 alone, and with only 400 public health field workers, full implementation of the recommendations was not feasible.
In 1995 the CDC recommendations focused the efforts on “screening to find cases of active TB among the homeless” with “a chest radiograph (and possibly a sputum smear and culture) to determine current disease.” TB skin testing programs to determine LTBI were discouraged unless the resources were available to complete evaluation and adequate treatment. However, a successful effort has been documented in a homeless shelter using mass screenings and DOT in Seattle. It has been proposed that similar shelters with a stable client pool would benefit from similar on-going interventions.  

But, the magnitude of the problem of tuberculosis in the homeless can vary widely. In Chicago, for instance, a two-year screening from 1986 to 1988 found only one case of active TB. Therefore, interventions and policy planning must be appropriate for the regional need.

CHARACTERISTICS OF TB SPECIFIC TO THE HOMELESS

It’s interesting that until recently, most (85%) cases of active TB in the US have been the result of reactivation of latent TB, often in the foreign-born who were infected as children in an endemic country, and never received treatment of their LTBI. Now, the incidence of primary TB is increasing, and studies of active cases in the homeless persons show a high rate of primary disease. The use of DNA restriction fragment analysis to determine relatedness of infecting TB strains, has
been used by the public health community to distinguish primary from reactivated disease in this population.\textsuperscript{59,60}

A large prospective study of TB in the homeless in San Francisco found 25 incident cases of active disease in 2,774 homeless first seen between 1990 and 1994. DNA restriction fragment analysis identified 60\% of the cases to have clustered patterns, indicating recent transmission, with rapid progression to disease. They found independent risk factors for TB to include HIV infection, non-white ethnicity, positive PPD skin test results, age, and less education.\textsuperscript{62}

Hospitalization of TB patients is the biggest cost. Data on US cases in 1997 showed that 70\% of homeless patients with active TB were hospitalized, versus 50\% of other patients. Furthermore, 18\% of homeless patients were hospitalized more than once, versus 8\% of other patients. These homeless patients were also more likely to have a diagnosis of HIV or drug/alcohol dependence, and to have no or unknown insurance status.\textsuperscript{58} This co-morbidity and the associated costs to the public are immense. But, long-term hospitalization is often more effective for the homeless TB patient, as it allows interruption of transmission in the shelters, and permits other problems such as psychiatric and substance abuse to receive intensive treatment.\textsuperscript{32}

A study of multi-drug resistant tuberculosis (MDR TB) in homeless men in NYC identified a five-fold increased rate of MDR TB if the history showed prior treatment of TB. However, even of those who denied a history of previous treatment (2/31)
were found to have MDR TB. The homeless are at high risk of non-compliance, and “noncompliant patients are ten times more likely than compliant patients to transmit MDR TB, to require prolonged treatment and to experience disease progression or relapse; they are also more likely to die as a result of their infection.”

It is well known that MDR TB is more likely to present in patients co-infected with HIV and TB. Although the prevalence of HIV infection in the homeless is difficult to quantify, some studies indicate it is as high as 60%. Since there is a 10% lifetime risk of untreated co-infected persons developing active TB, it’s likely for those entering the shelter system to develop active disease unnoticed, unless proper screening is provided.

Exogenous reinfection with tuberculosis is thought to be common in developing countries where TB is endemic. In these environments, the population is affected by the effects of stress, malnutrition, and other co-morbidity, which contribute to incomplete immunity after a previous TB infection. In the US and other Westernized countries, exogenous reinfection has been considered “relatively unimportant”, except in cases involving high exposure.

However, when a large outbreak of TB in the homeless was investigated in Boston in 1986, 7 of 22 cases of shelter-related TB were shown to be exogenous reinfection. Another outbreak in Seattle, in 1991 resulted in 36% (10 of 28) of cases to be reinfections, and at least 3 of those were likely from an exogenous source. In
this comparison, the conditions of the homeless that put them at risk of re-contagion may be similar to those in a third world country. Furthermore, it’s unlikely that exogenous reinfection (as opposed to endogenous reactivation) can be prevented by LTBI treatment, one of the major strategies used for TB control.

Finally, it has been noted in another study from L.A., that homeless patients with active TB are more likely than housed TB patients to receive their diagnosis in public hospital emergency rooms (54% versus 23%, \(P<.001\)). The homeless patients also were not found to be living in shelters at the time of their diagnosis.\(^6\) Therefore, the potential for a ripple effect of contagion into the community is quite likely.

**TREATMENT ISSUES**

The issues of TB treatment of homeless persons, which includes treatment of active cases as well as latent TB infection (LTBI), needs careful consideration. Treatment non-compliance is the most glaring problem, as homeless persons are often persistently non-adherent. Therefore, implementation of directly observed therapy (DOT), providing incentives for compliance, and even involuntary confinement for treatment are some of the interventions which have been studied. This last may seem reminiscent of pre-1950’s TB sanitariums, but to protect the public safety and well being in some circumstances it is a necessity.
Successful treatment of TB in the homeless, even with DOT, has only a 50% successful completion rate in several studies, compared to greater than 90% completion rate in non-homeless populations.62 An intermittent DOT program conducted in Spain from 1990 to 1994 included 71 homeless of 102 patients with active TB. At the end of 6 months, 87 had completed treatment (85%). It’s not known if the homeless patients, specifically, were less compliant, as more than one risk factor for non-compliance was included in the study.63

DOT has been advocated by some for all patients with TB, so as not to discriminate with the “associated intrusion on personal privacy and liberty.” However, in practice, DOT is usually reserved for the non-compliant, of whom the homeless are clearly at increased risk.62 On the flip side of the coin, however, the homeless are at increased risk of tuberculosis exposure, and may need and deserve increased protection. A perception of this resulted in a class action suit filed by homeless advocates against city, state and county health officials in Chicago in 1993, accusing them of inadequate efforts to control TB.63

The risk versus the benefit of treatment of TB in the homeless is not a relevant question. It must be treated. Brewer, et al. note that, “although untreated TB has a higher mortality than treated TB, drug toxicity increases a healthy patient’s baseline mortality. Therefore treatment strategies that reduce the time to treatment while avoiding treating patients unnecessarily are associated with lower average mortalities.”29
In this regard, prompt screenings for active disease with earlier care has merit when treating homeless individuals, who are often costly inpatients while completing the components of the initial TB work-up. Because they are staying in conjugate housing, they must be cleared of active TB before being allowed to return to the shelter from an infection control perspective.

PREVENTION AND CONTROL MEASURES

The most important cornerstone of TB prevention and control in the homeless population is early case finding and treatment. This may be done with TB skin test screening and directly observed therapy for those found to have active disease. The CDC recommends screening with chest x-rays during an outbreak investigation, due to lack of compliance with patients returning for TB skin test reading. 31

Studies of the outcomes of PPD skin testing in the homeless have generally been disappointing. A study of voluntary TB skin testing in Kansas City homeless shelters was performed. Of 856 skin tests given, 654 were read, and 89 (13.6%) were positive. Of these, only 8 persons (of 42) who were started on preventive therapy (LTBI treatment) completed the course. 64 Another study looking at the prevalence of PPD skin test positivity in homeless persons in Los Angeles found a rate of 32%. They identified an association of a positive PPD with long-term homelessness, geographic area, history of a psychiatric hospitalization, and age. 2 Encouragingly, a prospective study in which the shelter facilities agreed to make housing contingent on
participation in a mandated TB screening program of homeless people in Portland, did show over ten years to have an 89% decrease of active disease. Was it the mandated component of this program that gave it its good results?

As noted previously, Boston experienced an epidemic of INH and streptomycin resistant TB in the homeless population, which responded well to rifampin preventive therapy (LTBI treatment), from 1984 to 1992. A cash incentive did improve completion of DOT with INH for LTBI treatment in San Francisco (odds ratio, 2.57; 95% CI, 1.11 – 5.94). A monetary incentive improved adherence to referral for TB evaluation, as well. Those using IV drugs, and younger individuals were found to be at higher risk of non-compliance.

After the notable increase in active TB cases in homeless shelters in the 1980’s, environmental controls began to be explored and implemented. The homeless shelter facilities generally consist of conjugate sleeping quarters, often with only one to two feet between beds. The high population density in the dormitory-style accommodations used by most shelter facilities may greatly contribute to the high transmission rates of TB.

Adequate ventilation in a shelter should provide at least 25 cubic feet of outside air per minute per person. Most shelters recirculate air, due to heating costs and economic restraints. So air treatment units have been installed in many shelters to provide engineering controls, including the use of ultraviolet light air disinfection
combined with HEPA (high efficiency particulate air) filtration. The installation of these units were found to decrease the number of skin test conversions among homeless shelter staff in a large facility in Boston, as a marker of efficacy. However, cases of active TB continued to occur at the shelter, although it’s impossible to know if they were infected before or after the air treatment units were installed. 67

Due to the high rate of clustered cases found in the San Francisco study, especially in the HIV and African American homeless, they agreed with TB control measures that included DOT and incentive approaches, LTBI treatment of HIV infected, and screening in hotels and shelters. 61 This is why, in conjugate housing situations such as shelters, a symptom screening interview, and a nightly “cough log” can be helpful to identify for evaluation those who are potentially at risk of active disease.

The consideration of offering the BCG vaccine as primary prevention of TB in the homeless was analyzed on a theoretical basis. The homeless met CDC criteria for BCG vaccine established in 1988, as a group with a rate of new infections in excess of 1% per year, and who live in an area where adequate surveillance is not “feasible”. Use of the BCG vaccine did demonstrate cost effectiveness, but the assumptions used in the study were based on efficacy rates of 8%, 50% and 100%. 24 The effect of the uncertainty of the vaccine efficacy was not addressed in the study, and because the BCG renders PPD skin testing to be unreliable, that marker in the homeless would no longer be useful. At any vaccine efficacy less than 100%, TB case finding would then be limited to symptom review and a work-up using chest x-rays to evaluate for active
pulmonary TB. This may prove to be less effective than looking for PPD conversions in the homeless population.

Providing more homeless shelters to decrease the density of persons using the facilities is a costly, but effective, way to reduce the risk of TB infection among the homeless.\textsuperscript{31} Another more easily implemented, and cost effective modality is simply to provide tissues to persons who are coughing.\textsuperscript{30} This provides filtration at the source, preventing droplet nuclei from entering the environment, if the individual is willing to use them. Source management in the shelters that includes providing an isolation area with negative-pressure rooms is not feasible in the homeless shelter setting. This is why transfer to an appropriate emergency department is the best direct response in the case of a client who is coughing, with night sweats, fever, and weight loss.

CONCLUSION

Uncertainty characterizes shelter living, and colors the real-life impact of an outbreak of tuberculosis in the homeless. Shelters don’t begin to resemble well-controlled research settings, where different modalities can be isolated and tested for their individual impact on TB transmission.

Also, the chaotic background of subtle changes that happens to others in the low-income population may have an effect on TB transmission in the shelters. This includes factors like the number of shelter occupants and changing demographics.
which vary by season and by days of the month, related to the economics of income cycles, labor pool jobs and multiple other local unpredictable factors.
DESCRIPTION OF THE OUTBREAK

The recent wave of TB cases in the shelters in Hartford has been identified by the city and state health departments since 1997. At the time of this writing, 21 cases of active TB disease were identified in individuals who have stayed at McKinney Shelter and Immaculate Conception Shelter during the past three years. Both of these facilities are relatively large emergency shelters for men, and both are classified as "wet shelters"; meaning that although drugs and alcohol are not supposed to be used on the premises, it is permissible to enter the facility under their influence. Each shelter houses approximately 90 men on any given night, in close quarters as described below.

The demographics of both shelters mirror the risk factors identified by the CDC for TB infection and disease. These two shelters have a high prevalence of persons with HIV infection and other chronic conditions that affect immune function such as diabetes, substance abuse, and poor nutritional status. Many of the residents have been incarcerated, most are non-white or of Hispanic/Latino ethnicity, and all are at the lowest end of the economic strata. While the Department of Public Health dropped its guard surrounding TB surveillance i.e. the homeless shelters, because active cases of TB in the homeless had declined by 84% through 1997, active tuberculosis disease, like the sleeping giant it often proves to be, again increased in incidence.
Table 1. The Epidemic Curve

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</tbody>
</table>

Cases of tuberculosis are shown by month of diagnosis in clients in a homeless shelter. One box equals one case. The years are divided into 2-month segments. Numbers within boxes represent the phage type of the *M. tuberculosis* isolate associated with those cases.
### TABLE 2
**Active TB Cases**

<table>
<thead>
<tr>
<th>#</th>
<th>Date of Diagnosis</th>
<th>Age at Diagnosis</th>
<th>Race/Eth*</th>
<th>Genotype**</th>
<th>TB/HIV</th>
<th>P/EP***</th>
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<td>P</td>
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<tr>
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<td>12/97</td>
<td>51</td>
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<td>Yes</td>
<td>P</td>
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<td>3</td>
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<td>P</td>
</tr>
<tr>
<td>4</td>
<td>2/98</td>
<td>36</td>
<td>H</td>
<td>2</td>
<td>UK</td>
<td>P</td>
</tr>
<tr>
<td>5</td>
<td>3/98</td>
<td>39</td>
<td>B</td>
<td>1</td>
<td>UK</td>
<td>EP</td>
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<td>6</td>
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<td>7</td>
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<td>P</td>
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<tr>
<td>8</td>
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<td>46</td>
<td>W</td>
<td>1</td>
<td>No</td>
<td>P</td>
</tr>
<tr>
<td>9</td>
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* Race/Ethnicity: B- black, H- Hispanic, W- white
** Matching DNA genotype strains
*** Pulmonary/Extra-Pulmonary

Two cases were probably examples of exogenous re-infection. #12 had been previously treated for active TB in 1994 per HHD records. #13 noted that his brother had active TB as a child, and the whole family received treatment at that time, including this patient. Both match the genotype 1 strain that predominates the shelter outbreak.

#14 is the only case known who reports housing only at Immaculate Shelter. #15 is the only case infected with genotype 2 who reports he never stayed at Immaculate.
DNA “fingerprinting” (restriction fragment-length polymorphism, or RFLP) is a laboratory technique that has proved to be an accurate method of identifying the relatedness of *Mycobacterium tuberculosis* strains, to help determine the pattern of transmission in an outbreak. RFLP was employed in this outbreak, by the health department, and two genotypes were found in 20 of the 21 cases. (see Table 1: The Epidemiic Curve, and Table 2: Active TB Cases) The majority (95%) of these active TB cases have been found in men who have stayed primarily at McKinney Shelter. However, many of the men with the second tuberculosis genotype identified stayed also at the Immaculate Conception shelter. At first glance, the differences in the two shelters would implicate the Immaculate Shelter as more prone to transmission of active TB. The facility at McKinney is located in an old firehouse, with it’s 90 residents sleeping in bunk beds, split between two floors, while the Immaculate Shelter uses the basement of a church, with all 90 occupants sleeping on mattresses placed on the floor, literally head to head.

Both shelters employ HEPA Filtered/UV air treatment units. The Immaculate has two units in one large room, and McKinney has three slightly smaller units between two floors (two were downstairs, and one upstairs). The specifications of the units at the two shelters also differed. Immaculate had a total of sixteen 4-foot UV lamps, while Mckinney had only twelve 4-foot lamps. The Immaculate had four HEPA filters, while Mckinney had three.
Additionally, the philosophies of the two shelters differ, with the McKinney shelter being known to enforce rules regarding TB testing, and makes housing contingent upon residents obtaining the recommended follow-up such as chest radiographs, laboratory studies, and LTBI treatment. Although the administration at Immaculate does allow the TB Control Plan to be implemented, it does not require residents to participate.

On further evaluation, scrutiny of other differences in the two shelters may be related to the higher incidence of TB cases at McKinney. First, the residents at McKinney have a longer length-of-stay. A study of a similar outbreak noted that the affected shelter had a stable client pool (as does McKinney) and that the persons with active tuberculosis were more likely to have used the shelter more frequently than the controls. The Immaculate is a “seasonal” shelter, open during the colder months from October through early May. Even during this time frame, there is generally more turnover of clients than at the McKinney Shelter.

This factor was highlighted during shelter targeted testing efforts, when the percentage of TB tests “not read” was consistently higher in the Immaculate group, than at McKinney (23% versus 11% in November 1999, and 26% versus 16% in March 2000). The compliance rate for follow-up achieved at Immaculate was negligible, as well. Therefore, the lower rate of PPD conversions noted at Immaculate, could relate to a lower incidence of active disease, or it could be related to poor follow-up, more transience, better engineering controls, refusal of many to be
tested or evaluated, or some unknown factor. This analysis, therefore, is generally based on data collected at McKinney.

Another caveat to note regarding TB, is that prior infection with tuberculosis should afford an individual a degree of protection against infection upon exposure to another case of active pulmonary disease.\textsuperscript{13} Unfortunately, this has not been shown to hold true in TB outbreaks in homeless shelters. In Boston, Massachusetts at least four of 22 cases of active TB cases were found to be exogenous reinfection.\textsuperscript{28} In this current outbreak in Hartford, Connecticut there is a history of previous TB disease or infection in two of the 21 cases. The fact that their TB strains match the other cases, by RFLP, is reliable evidence that both cases are likely a result of exogenous reinfection, as well.

TB CONTROL PLAN:

As part of their mission to achieve control of active tuberculosis, the Hartford Health Department (HHD) has facilitated development of the Homeless Shelter Health Coalition. The collaborating agencies include the Health Care for the Homeless Program (a federally funded program sponsored by a local community health center), and the shelter staff (the McKinney shelter is run by the Community Renewal Team). The group has been advised by officials from the State of Connecticut Tuberculosis Control Program, which also funded radiographic chest exams for uninsured patients, laboratory studies and medication therapy, as indicated.
The TB Control Plan (TBCP) (see Appendix A), was developed as a program to control TB as an ongoing activity, during and after this current outbreak. Its two main objectives are: 1) to achieve rapid identification of active TB cases, and 2) to prevent new TB infections. These objectives have been realized through implementation of the TB Control Program strategies, active participation of the infected homeless men, and the assistance of the shelter staff. Funding efforts through the shelter administration may be needed. Evidence of the TB Control Plan effectiveness, will be ascertained by a reduction in the frequency of new tuberculosis skin test (TST) conversions during the targeted testing, and an absence of new cases of active TB disease in the McKinney shelter.

The TBCP was first developed during the fall of 1999, and was revised several times. It incorporates the following goals, which are consistent with CDC recommendations:

- **Identifying TB infection** promptly (both active and latent cases) in homeless persons (and staff) in the shelters, implementing appropriate therapy, and monitoring its successful completion

- **Improving health care access** for the homeless by providing direct health care services in the shelters. This will include TST “targeted testing”, on site phlebotomy services, and twice per week medical services. The shelter
administration has elected to make housing at their facility, contingent upon completing the medical evaluation.

- **Conducting on-going Targeted Testing** and symptom assessment screening of shelter clients and shelter staff, using a master computer database to facilitate case tracking. In addition, a “cough log” will be maintained by the night staff at the shelter, and those on the list will be evaluated by Health Care for the Homeless medical providers. All new clients will be screened with a symptom assessment.

- **Fostering linkages** with local hospitals and specialists to expedite care for homeless persons requiring hospitalization.

- **Implementing Directly Observed Therapy (DOT)** for TB infected shelter residents with active TB, those co-infected with TB/HIV, and those with LTBI. The two-month course of PZA and rifampin will be provided, if not otherwise contra-indicated, for LTBI. Again, compliance with the recommended treatment is mandatory for clients, especially in this setting of an outbreak.

- **Providing education** to shelter staff and homeless clients regarding tuberculosis information, and infection control guidelines.
• **Optimizing environmental controls** to reduce risk of TB exposure associated with poor ventilation. One modality in use is the HEPA filtered air treatment units with germicidal UV lamps, to reduce the potential for infectious disease transmission in the shelter.

PROGRAM IMPLEMENTATION:

Most of the individuals with active TB have been treated with DOT conducted by the State of Connecticut Health Department. Three of these (3/21 - 14%) have been detained for long-term hospitalization for the duration of therapy, due to non-compliance. This is a much higher percentage than shown in a study of 8000 TB patients in New York City, for whom mandated orders were issued for less than 4 percent of patients. However, it is important to note that the New York study included non-homeless as well as homeless TB infected persons.

In February of 1998, a cluster of active TB cases was identified at the McKinney Shelter. These cases spurred the first post-exposure targeted screening that identified 22 individuals with positive TST results (39% of those tested). (Table 3) Several subsequent rounds of post-exposure targeted testing conducted by the health department and the Health Care for the Homeless (HCH) Program were able to identify individuals with LTBI, as well as additional active cases, which totaled 21 by April 2000.
TABLE 3: SUMMARY OF POST-EXPOSURE TARGETED TESTING RESULTS*

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<td>57</td>
<td>74</td>
<td>59</td>
<td>61</td>
<td>36</td>
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<tr>
<td>TSTs Placed (%)</td>
<td>57 (100)</td>
<td>74 (100)</td>
<td>59 (100)</td>
<td>61 (100)</td>
<td>36 (100)</td>
</tr>
<tr>
<td>TSTs Not Read (%)</td>
<td>8/17(14)</td>
<td>13/74(18)</td>
<td>7/59(12)</td>
<td>10/61(16)</td>
<td>12/36 (33)</td>
</tr>
<tr>
<td>TSTs Read (%)</td>
<td>49/57(86)</td>
<td>61/74(82)</td>
<td>52/59(88)</td>
<td>51/61(84)</td>
<td>24/36 (66)</td>
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<tr>
<td>Non-Reactive TSTs</td>
<td>27/49(55)</td>
<td>41/61(67)</td>
<td>47/52(90)</td>
<td>34/51(66)</td>
<td>15/24 (62)</td>
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<tr>
<td>Reactive TSTs ***</td>
<td>22/49(45)</td>
<td>20/61(33)</td>
<td>5/52 (10)</td>
<td>17/51(33)</td>
<td>9/24 (37)</td>
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<tr>
<td>Conversions*</td>
<td>5/22(23)</td>
<td>3/20(15)</td>
<td>UK</td>
<td>UK</td>
<td>2/9 (22%)</td>
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<tr>
<td>Staff Reactors (not included in N)</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>2</td>
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</table>

* Combined data from the Health Care for the Homeless Program, and the Hartford Health Department (HHD). Conversions were based on this combined database.

** N= the number of clients tested from a total of 90 clients at the shelter on any given night. The TB Skin Test (TST) is not provided for clients who provide a history of a past positive TST.

*** Any degree of induration in this setting deserves further evaluation, although 5 millimeters is the threshold for a positive test.

One deficiency in the strategy, that seemed to prevent efficacious TB control, was the fragmentation of care provided by different agencies providing LTBI treatment to the men at the shelter. A few individuals did complete the six-month course of INH (the standard of care at the time), but adherence was poor. It was determined that by reducing the length of the course of treatment, and providing additional “on site” care at the shelter including phlebotomy services in the evenings, the homeless community would be better served, and compliance with the full treatment prescribed would be improved.
Most of the LTBI treatment was conducted with DOT by the shelter staff. Each week the health care providers filled the medication boxes. Doses were counted, and the requirement of 60 doses within 90 days was easily ascertained. Of note, a number of the residents who needed LTBI treatment had severe mental health problems. They often had to be cajoled by the staff to take their medications, and the logic of the treatment had to be reiterated many times. However, some of the men with mental health issues became the most adherent, with support and encouragement by the shelter case managers.

In addition to the implementation of LTBI treatment, environmental control issues were addressed. A site inspection was done in December 1998, by engineers from Travelers Property Casualty, to review the facility and its ventilation maintenance program. At that time, the HEPA filter systems with germicidal UV lamps were evaluated. It was recommended that an additional unit be installed in the “gang” showers off the upstairs bunk area to reduce the potential for disease transmission. The “gang” showers were used by all the residents, and so had the potential to be a common transmission point.

A measurement of dilution ventilation was done in March 2000, by evaluating carbon dioxide (CO2) levels with a “Draeger Colorimetric Indication Tube” instrument, in the upstairs and downstairs at different times of day with different numbers of occupants and activities (see Table 4).
At McKinney, two of the air treatment units were downstairs in the large room, and one was located in the second floor bunk area. Both floors sleep roughly the same number of occupants (40 to 45). It has been observed, however, that the units are not always turned on.

RESULTS (Numbers are keyed to the research questions)

1) Case Characteristics

An analysis of the 21 cases of active TB (see Table 5), showed an equal number of cases in African-American and Latino men (43% each), and 3 cases (14%) in Caucasian men. These numbers reflect the general racial demographics of the shelter. In both minority groups, TB cases were balanced between older and younger men.

### TABLE 4

**MCKINNEY SHELTER Carbon Dioxide (CO2) MEASUREMENTS**


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<th>Time</th>
<th>Location</th>
<th>CO2 ppm*</th>
<th># Occupants</th>
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</thead>
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<td>Early AM (5 AM)</td>
<td>upstairs</td>
<td>700 ppm</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>downstairs</td>
<td>800 ppm</td>
<td>44</td>
</tr>
<tr>
<td>Afternoon (3 PM)</td>
<td>upstairs</td>
<td>500 ppm</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>downstairs</td>
<td>700 ppm</td>
<td>30</td>
</tr>
<tr>
<td>Evening (10 PM)</td>
<td>upstairs</td>
<td>1500 ppm</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>downstairs</td>
<td>1000 ppm</td>
<td>42</td>
</tr>
</tbody>
</table>

* Parts Per Million
The white men with active TB were all over age 45. Fortunately, none of these cases were found to be drug-resistant. Eight (38%) of the men with active TB were known to be co-infected with HIV, whereas only 11% of the TB cases in the State of Connecticut in 1998 had co-infection. The co-infected patients were somewhat more likely to be Hispanic (5 cases), than Black (3 cases). None of the white men with active TB were co-infected with HIV.

Table 5

Demographics and Case Comparison of Hartford Shelter TB Cases: 11/97 – 4/00

<table>
<thead>
<tr>
<th></th>
<th>Total N</th>
<th>(%)</th>
<th>CT TB Cases 1998 (%)</th>
<th>HIV/TB (%)</th>
<th>Age 30-45 (%)</th>
<th>Age 46-64 (%)</th>
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<tr>
<td>Black</td>
<td>9/21</td>
<td>(43)</td>
<td>43/110 (39)</td>
<td>3/21 (14)</td>
<td>4/21 (19)</td>
<td>5/21 (24)</td>
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<tr>
<td>Hispanic</td>
<td>9/21</td>
<td>(43)</td>
<td>20/110 (18)</td>
<td>5/21 (24)</td>
<td>6/21 (29)</td>
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</tr>
<tr>
<td>White</td>
<td>3/21</td>
<td>(14)</td>
<td>30/110 (27)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
<td>(100)</td>
<td>110 (100)</td>
<td>8/21 (38)</td>
<td>10/21 (47)</td>
<td>11/21 (52)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Genotype 1 (%)</th>
<th>Genotype 2 (%)</th>
<th>Pulmonary (%)</th>
<th>Extra-Pulmonary (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>7/21 (33)</td>
<td>1/21 (5)</td>
<td>7/21 (33)</td>
<td>2/21 (9)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>4/21 (19)</td>
<td>4/21 (19)</td>
<td>7/21 (33)</td>
<td>3/21 (14)</td>
</tr>
<tr>
<td>White</td>
<td>2/21 (9)</td>
<td>1/21 (5)</td>
<td>3/21 (14)</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>13/21 (62)</td>
<td>6/21 (28)</td>
<td>17/21 (81)*</td>
<td>5/21 (24)*</td>
</tr>
</tbody>
</table>

* Combined percentages are higher than 100, as one client had both pulmonary and extra-pulmonary TB.

Seventeen of the cases (17/21 - 81%) were pulmonary, and five were extra-pulmonary, including one case who was co-infected with HIV/TB, who had both pulmonary and extra-pulmonary TB (see Table 5). This is to be expected, because as
many as 1/3 of persons co-infected with HIV have multi-site disease. Of note, the incidence of pulmonary tuberculosis in the State of Connecticut TB cases in 1998 was 68%. Because only pulmonary TB is infectious to others, and clients of this shelter have a 13% higher incidence of pulmonary TB, this outbreak had the potential to become self-perpetuating.

A total of three DNA fingerprints were found. However, two genotypes predominated in the outbreak, with 13 (62%) of the cases matching the initial cases, and 6 (29%) of the cases matching the other strain. Both genotypes were found in every racial group. Therefore, assuming the first case of each genotype (the index cases) was a reactivation of LTBI, it’s reasonable to assign primary (recently acquired) TB status to the other cases in the outbreak, except the lone case of a third genotype which we also presume was LTBI reactivation. This means the incidence of primary TB was 85.7%, which is approximately 70% higher than in the population as a whole.

2) Completion rate and percentage of patients remaining in care while using a shorter course of LTBI therapy.

Of the 35 men found to have untreated, or inadequately treated LTBI, 25 (71%) started the 2-month course of PZA and rifampin. Of these, 11 (31%) have completed the course at the time of this writing, and 4 (11%) have their treatment in progress. Fourteen (31%) have left the shelter and are lost to follow-up (see Table 6). However,
they are on a “tickle list” of potentially barred residents, and should they try to reenter
the shelter they will be required to be evaluated by the medical personnel.

### TABLE 6

**McKINNEY SHELTER GUESTS**
**WITH UNTREATED LTBI**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TOTAL (%)</td>
<td>Treatment Completed (%)</td>
</tr>
<tr>
<td>HIV +</td>
<td>1/35 (3)</td>
<td>2/35 (6)</td>
</tr>
<tr>
<td>HIV- /UK</td>
<td>31/35 (89)</td>
<td>10/35 (29)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>35/35 (100)</td>
<td>11/35 (31)</td>
</tr>
</tbody>
</table>

Percentages may not add to 100, due to rounding.

* 3 persons had baseline Liver Function Studies (LFTs) too high to start LTBI treatment. One developed markedly increased LFTs (although he was asymptomatic), but no baseline was done. His medications were stopped, but it’s unknown if the toxicity was caused by the medications. He left, and a recheck of his LFTs off medications could not be done.

**Discussion**

3) Acceptance and toleration of PZA and rifampin.

This thesis project could be considered as a small feasibility study for tolerability of the two month LTBI treatment course of PZA and rifampin, in a cohort of homeless men who are HIV uninfected as well as HIV co-infected. They did well,
especially when one considers the extent of baseline liver damage/trauma in this group. The prevalence of Hepatitis C infection is estimated from 40 to 90% in similar populations. In addition, most of the shelter guests are active drinkers and/or drug users. It was not required (although it was recommended) that they alter their substance use while on therapy. Therefore, the potential risk of liver injury and hepatotoxicity is substantial. Our results indicate the short course of PZA and rifampin was well tolerated based on laboratory values, as well as by clinical monitoring, in 15 of 16 persons.

Eight of the 11 clients who completed treatment had laboratory studies done at baseline and seven weeks later. Only one client (13%) developed increased hepatic enzymes (2.3 times the upper limit of normal (ULN)), which normalized after he completed the therapy. The ATS/CDC suggests it’s acceptable to allow liver enzyme increases up to 5 times the ULN, if the patient is asymptomatic, and three times the ULN if symptomatic. Another patient’s treatment was deferred when his liver enzymes were found to be elevated 3.6 times the ULN, even though he was asymptomatic. His baseline and post-medication laboratory levels are unknown. Also unknown is his HIV status, and he is thus far lost to follow-up.

Due to potential drug interactions with rifampin, a careful medication history must be obtained for any patient considering the treatment. Special attention should be given to those on psychiatric medications, anti-convulsants, anti-viral (HIV), and even some diabetic and anti-hypertension medications. In our sample, four (11%)
could not use the rifampin for this reason. One of these four was placed on INH, but the others are watched with symptom reviews and serial chest radiographs, if indicated.

4) Effectiveness of “mandatory participation” component of the TB Control Plan.

As active tuberculosis is a serious public health hazard, the shelter administration took seriously their responsibility to provide a safe environment for the clients and staff at the shelter. They located funding for both the medical and environmental components. They backed up their philosophy of mandatory care, usually with only cajoling by the case managers. Clients suspended for lack of compliance were given alternative housing options.

5) Continuity of care and patient access for coalition of agencies compared to “usual care”.

The course of “usual care” was at work in this outbreak as illustrated in Fig. 1 during the time frame from November 1997 to November 1999. Clearly, a steady stream of active TB, with the same genotypes at play throughout, were not responding to the “usual (and often fragmented) care”.

6) Effectiveness of modalities implemented in this TB Control Plan.

When the TB Control Plan was implemented by the Homeless Shelter Health Coalition, its first effort was to provide collaborative targeted TB skin testing (TST),
and symptom screening in November 1999 (see Table 3). At that time, two additional cases of active tuberculosis were identified. Subsequently, the percentage of reactive TST's increased 23%; from 10% in November 1999, to 33% a few months later in March 2000. The last active TB case (at the time of this writing) came into care in April 2000. Also in April, the shelter-based LTBI treatment intervention was implemented, and at the same time, an engineering modality in the form of a fourth air treatment unit, was added to the shelter. Therefore, it is still possible that further active TB cases will be identified in the future, who were infected in the recent past.

The shelter had been found to need environmental modifications, as was noted in a report to the City Health Director regarding an inspection done by Travelers Property Casualty in December 1998. The report stated that, “general dilution ventilation is provided by natural “ventilation” provided by…opened windows and the large garage doors in the main first floor gathering area”. It may also be worthy to note that smoking is permitted downstairs. This factor is proposed to have the inverse effect of clogging the HEPA filters, thus making them better filters for smaller microbes until they reach capacity (at which point air is not pulled through the filters, which renders them ineffective).

When CO2 measurements were performed in the McKinney Shelter during March 2000, different results were obtained between the two floors (see Table 4). Because CO2 readings of 1000ppm or higher are a marker for poor ventilation, reflecting inadequate dilution with fresh air, the evening measurements did show potential
problem readings of 1500ppm upstairs, and 1000ppm downstairs. It is hoped that the installation of a new HEPA Filtered/UV lamp unit in the upstairs shower area will provide additional air treatment in that region of the facility.

On a purely environmental basis, it may be preferable to increase the quantity of outside air on the second floor, instead of just cleaning recirculated air. However, during the winter months this is an economic issue due to heating fuel costs. Air treatment units then become the next best alternative, by increasing the equivalent of fresh air changes to the area. When the shower renovations were begun in late April 2000, this potential risk factor was temporarily eliminated. This occurred at the same time that the PZA and rifampin LTBI treatment program was implemented. Therefore, any or all aspects of the modalities that were implemented contributed to the improvement in tuberculosis control in the shelter.

7) Policy implications for tuberculosis control in other homeless shelters.

A cooperative model was used to design this Tuberculosis Control Plan (see Appendix A), utilizing the medical expertise of providers in the Health Care for the Homeless Program, the Public Health Department, and intensive case management services by the shelter staff. This worked well. Prior to the collaboration, these services were provided in a fragmented manner.

As always, a major piece of the policy considerations was budgetary. The shelter administration secured funding for increased medical care ($7000/one year), and the environmental modifications ($30,000/one time expense).
Conclusion  In the analysis of this outbreak, it was noted that two major TB
control modalities were implemented at roughly the same time. The environmental
modification took place at approximately the same time that the LTBI short-term
treatment with two drugs was implemented on-site. This understandably confounds
the data in regards to efficacy. But no new cases of shelter-associated active TB have
been diagnosed during a six-month (see Fig. 1) follow-up period. This is the first sign
of improvement since the outbreak began in 1997. The specific aspect(s) of the
intervention responsible for this move towards recovery was not able to be
distinguished, but the issue is less important than that the overall program appeared to
be effective, and that suffering and morbidity in the shelter appeared to be prevented.

As usual, when analyzing an outbreak the exact identification of the index case of
each genotype is problematic. It is possible that either of the TB DNA genotypes
were the results of an exposure to a case of active TB that was shelter-unrelated.

The management of tuberculosis infection in the homeless shelter environment
has been shown to respond to standard TB control modalities in other outbreaks.\(^5\)
The recent ATS/CDC Joint Statement Committee on Latent Tuberculosis Infection
2000 recommends, “comparison of strategies using both shorter and longer treatment
regimens” as a direction for future research.\(^13\) In this relatively small population of
homeless persons, the new guidelines were used to make treatment decisions resulting
in a fairly good compliance rate (43% remained in care). This sample included HIV
infected as well as un-infected persons, a number of persons at risk of liver disease,
and the usual problem in the homeless of persons leaving the shelter, being mentally
ill, and becoming lost to follow-up. The long-term effects of this treatment modality on TB control in shelters is yet to be fully appreciated. However, the outlook is encouraging.
30 CDC. Core curriculum on tuberculosis. What the clinician should know. 1994
37 Rossi PH. The old homeless and the new homelessness in historical perspective. Amer Psychologist 1990; 45(8):954-959.
40 Geller JL. Excluding institutions for mental diseases from federal reimbursement for services: strategy or tragedy? Psychiatr Serv 2000; 51(11):1397-1403.
64 Griffin RG, Hoff GL. Tuberculosis screening in Kansas City homeless shelters. Mo Med 1999;96(10):496-499
Appendix A

Recommendations: ATS/CDC Statement Committee on Latent Tuberculosis 2000
Relevant Changes and Highlights for Clinical Management

- **Nomenclature:** What used to be known as TB infection (not active disease) is now referred to as Latent Tuberculosis Infection (LTBI). No longer will the term prophylaxis be used. Instead we are prescribing treatment of LTBI.

- Routine PPD testing of low-risk individuals is no longer recommended.

- PPD in pregnancy and CXR, even in the first trimester with proper shielding, is fine, as the risk of congenital and/or progressive TB is greater than the risk of the evaluation, if there is a potential TB risk.

- The criteria for a positive PPD is essentially unchanged, with the further designation of a 10 mm threshold for recent immigrants (within the past 5 years) from high prevalence countries. In addition, an underweight person (> 10% of ideal body weight) in an otherwise low risk person constitutes a risk for active TB. However, it is now the presence or absence of risk factors for active TB that guides us in our clinical decision to treat LTBI.

- There is no age limit guiding the clinical decision to treat LTBI. Always recommend treatment if conditions put the patient at risk of developing active TB.

- Active TB must be excluded before starting one or two drug LTBI treatment. A chest xray which shows prior, healed TB still needs sputums for AFB and culture. If a patient stops medication for LTBI for two months or more, re-evaluation for active TB must be completed prior to restarting medications.

- Active hepatitis or end stage liver disease are contraindications for LTBI treatment.

- *Clinical* monitoring of medication side effects is acceptable in most cases of LTBI treatment. Lab monitoring is indicated for persons at risk of hepatotoxicity, HIV infected, pregnant, or with abnormal baseline lab studies. During treatment some experts suggest to hold medication if the liver enzymes increase 5 times the upper limit of normal in an asymptomatic person, and 3 times the upper limit of normal in a symptomatic person.

- New shorter course regimens for LTBI are acceptable; PZA plus Rifampin for 2 months (60 doses within 3 months), or Rifampin alone for 4 months (120 doses within 6 months). The recommended duration of treatment with INH is now 9 months (270 doses within 12 months) for both HIV infected and non-infected.

- When evaluating completion of LTBI treatment, quantify the number of doses in addition to the duration of treatment.
## Appendix B

**TB Control Plan- (McKinney Shelter)**

**HOMELESS HEALTH COALITION**

<table>
<thead>
<tr>
<th>STRATEGY</th>
<th>IMPLEMENTATION</th>
<th>WHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Render known infectious cases non-infectious</td>
<td>A. Infectious cases will be medically cleared as non-infectious before returning to the shelter (per CRT policy)</td>
<td>Attending hospital medical staff</td>
</tr>
<tr>
<td></td>
<td>B. Directly Observed Therapy (DOT)</td>
<td>State of CT Health Department</td>
</tr>
<tr>
<td></td>
<td>C. Involuntary hospitalization of repeatedly noncompliant patients</td>
<td>HHD/State of CT Health Department</td>
</tr>
<tr>
<td>2. Find undiagnosed infectious cases</td>
<td>A. Targeted Testing and symptom assessment of shelter clients and staff, using PPD skin testing and chest x-rays every 4 – 6 months if needed for post exposure. Yearly, if no known exposures.</td>
<td>Homeless Health Coalition</td>
</tr>
<tr>
<td></td>
<td>B. Symptom/PPD status assessment of residents at intake. Refer to medical providers as indicated.</td>
<td>Shelter Staff</td>
</tr>
<tr>
<td></td>
<td>C. Cough Log; Nightly surveillance</td>
<td>Shelter Staff</td>
</tr>
<tr>
<td></td>
<td>D. Medical evaluation weekly of identified coughers.</td>
<td>HCH Program of FHC</td>
</tr>
<tr>
<td>STRATEGY</td>
<td>IMPLEMENTATION</td>
<td>WHO</td>
</tr>
<tr>
<td>----------</td>
<td>----------------</td>
<td>-----</td>
</tr>
<tr>
<td>E. PPD/Chest X-Ray surveillance of new or symptomatic residents. Approx. 5 – 10 PPDs planted each week.</td>
<td>HCH Program of FHC</td>
<td>HCH Program of FHC</td>
</tr>
<tr>
<td><strong>3. Protect exposed shelter residents and staff who are:</strong></td>
<td>Surveillance by repeated PPDs to ascertain conversion.</td>
<td>HCH Program Of FHC</td>
</tr>
<tr>
<td>PPD negative:</td>
<td>Targeted Testing efforts</td>
<td>Homeless Health Coalition</td>
</tr>
<tr>
<td>PPD positive:</td>
<td>Provide appropriate evaluation and prescribe LTBI** treatment as indicated (60 dose PZA/ Rifampin is preferable). Med boxes will be filled weekly.</td>
<td>HCH Program of FHC</td>
</tr>
<tr>
<td></td>
<td>Directly Observed Therapy provided for most LTBI shelter clients.</td>
<td>HCH Program of FHC</td>
</tr>
<tr>
<td><strong>4. Make the shelter environmentally safe.</strong></td>
<td>Exclude known infectious cases, and identified residents who don’t comply with medical requirements</td>
<td>Shelter Staff in consultation with HCH Program of FHC</td>
</tr>
<tr>
<td></td>
<td>Improve and maintain the shelter’s System for air disinfection and exchange</td>
<td>CRT</td>
</tr>
</tbody>
</table>


** Latent Tuberculosis Infection