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FACTORS ASSOCIATED WITH HOUSEHOLD CONTACTS' TUBERCULOSIS
TESTING AND EVALUATION

by

ELVY BARROSO

A dissertation submitted to the Graduate Faculty in Nursing in partial fulfillment of the
requirements for the degree of Doctor of Philosophy, The City University of New York

2018

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Elvy Barroso

This manuscript has been read and accepted for the Graduate Faculty in Nursing in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

Date

Elizabeth Capezuti
Chair of Examining Committee

Date

Donna M. Nickitas
Executive Officer

Supervisory Committee:

William Gallo
David Keepnews
Michelle Macaraig

THE CITY UNIVERSITY OF NEW YORK

Abstract

Factors Associated With Household Contacts' Tuberculosis Testing And Evaluation

by

Elvy Barroso

Advisor: Elizabeth Capezuti

Contact investigation (CI) is one of the core elements of tuberculosis (TB) control. It is intended to achieve early identification of contacts who may have been exposed to a patient with infectious active TB and contacts who may benefit from treatment for latent tuberculosis infection (LTBI). LTBI is an infection in which the *Mycobacterium tuberculosis* organisms cause no signs and symptoms but the infection can be reactivated and develop into full-blown active TB disease. Failure to be identified as a contact is the primary reason for disease development in more than half of TB patients, thus a complete and timely CI is crucial for decreasing the transmission and incidence of TB. However, ensuring that contacts get tested and evaluated is challenging. A retrospective study of deidentified data extracted from the NYC TB registry was conducted to assess the demographic characteristics associated with 3008 household contacts' decision to undergo TB testing (n=2850), evaluation (n=1037), and treatment for LTBI (n=863) from 2010 to 2014. A secondary aim was to examine if there are differences in proportion of contacts tested and evaluated based on type of provider (nurse versus and public health advisors). Multiple logistic regression analysis identified significant household contact characteristics associated with each decision point. The age of the household contacts was associated with acceptance of TB testing, such that the

older the person, the less likely they were to be tested. Household contacts who are older, non-US born, and reside in Brooklyn, Queens, and Staten Island were more likely to have a TB test positive. Among household contacts with a positive TB test, Asians were more likely to undergo full evaluation while older age, males, and non-US born were less likely to be fully evaluated. Household contacts who are older, non-US born, and residing in Brooklyn, Queens, and Staten Island were less likely to accept LTBI treatment, while Asians and Hispanics were more likely to accept LTBI treatment. In terms of provider type, proportion of household contacts tested and evaluated did not differ between nurses and public health advisors.

These study findings identify factors associated with TB testing and evaluation, and LTBI treatment, which will enable public health agencies to streamline the process of contact investigation and plan for effective strategies that will increase the number of household contacts accepting TB testing and evaluation, as well as accepting and completing LTBI treatment.

Keywords: active tuberculosis, contact investigation, contacts of TB case, case management, testing, evaluation, barriers

Dedication

Over the past four years, I have received invaluable help and support from a number of people whom I'd like to acknowledge here. Without their guidance, this dissertation would never have seen the light of day.

First, I express my gratitude to my advisor, Dr. Elizabeth Capezuti, for the unstinting supervision and advice that she so freely gave me from the first day she agreed to help me sharpen my ideas and writing through the completion of this work. I'm also indebted to Dr. Donna Nickitas, our Executive Officer, for all the encouragement and support she provided by giving me the tools I needed to successfully traverse the process that has led to this point. I likewise deeply appreciate the professional guidance that the other members of my dissertation committee, Dr. William Gallo, Dr. David Keepnews, and Dr. Michelle Macaraig, gave me throughout this process. I also extend my heartfelt thanks to Dr. Lorraine Byrne for opening the PhD and academe door to me.

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Chapter 1: Background and Study Purpose

Background

Tuberculosis (TB) is a bacterial disease primarily affecting the lung that remains a global health problem. The incidence of TB is approximately 9.0 million new cases globally each year, and approximately 3.3 million cases are missed by health systems as either undiagnosed or not reported (World Health Organization [WHO], 2014). Of the new cases, an estimated 1.1 million cases occurred among people living with human immunodeficiency virus (HIV) and an estimated 480,000 new cases represented multi-drug-resistant TB (MDR-TB) (WHO, 2014).

Tuberculosis begins when a person is exposed to someone with active pulmonary or laryngeal TB disease and develops latent TB infection (LTBI) or secondary TB (new case of TB) (American Thoracic Society & Centers for Disease Control and Prevention [CDC], 2000; CDC, 2005; CDC, 2011; WHO, 2006). LTBI is an infection in which the *Mycobacterium tuberculosis* (*M. tb*) organisms cause no signs and symptoms or radiographic evidence of TB disease; however, when the immune system breaks down, the infection can be reactivated and develop into full-blown active TB disease (index case) (CDC, 2011). A single infectious index case (infectious active TB disease) can infect up to 10 to 15 individuals, known as contacts, over the course of a year (WHO, 2015). Failure to be identified as a contact is the primary reason for disease development in 54% of TB patients (Chin et al., 2000). For this reason, the Centers for Disease Control and Prevention (CDC) have identified contact investigation (CI) as a fundamental strategy for the prevention and control of TB (CDC, 2005). Prompt identification, testing, and evaluation of contacts through CI is one of the recommended

strategies for achieving the goal of reducing TB disease and related deaths (CDC, 2005; WHO, 2014).

CI is the process of identifying, testing, evaluating, and treating all persons who are at risk for infection with *M. tb* due to recent exposure to an index case (CDC, 2005; CDC, 2011). The primary goals of CI are identification of household and non-household contacts exposed to an index case, prompt testing and evaluation of contacts, and initiation of treatment of eligible contacts with LTBI and secondary TB (Bureau of TB Control [BTBC], 2008; CDC, 2005; CDC, 2011; WHO 2012).

Previous studies have demonstrated that CI is an effective tool to achieve early identification of infectious (active) TB cases, prevent future cases by treatment of contacts, and break the chain of transmission (Anger et al., 2012; Bayona et al., 2003; Becerra et al., 2005; Bur et al., 2003; Cates et al., 2015; Davidow et al., 2003; Driver et al., 2003; Fox et al., 2012; Greenway, et al., 2003; Jereb et al., 2003; Marks et al., 2000; Mohle-Boetani & Flood, 2002; Reichler et al., 2002; Sia et al., 2010; Verver et al., 2004). As such, CI plays an integral role toward TB elimination (Anger et al., 2012; Bur et al., 2003; CDC, 2005).

In New York City (NYC), the TB case manager has an important role in assessing individuals for TB testing and evaluation during CI. According to state and local standards, the TB case manager, either a nurse or non-nurse, uses science-based knowledge to conduct the initial TB interview of the index case. The nurse TB case manager uses nursing processes to determine the history of TB exposure, signs and symptoms, coexisting medical conditions, and risk factors; and to collect information about the patient's contacts in the household and non-household settings. Nurses also

provide education to contacts and facilitate testing and evaluation of all contacts. Their roles as case manager also involve other public health activities to prevent and control the spread of TB disease in the community (Campbell, Galanowsky, & Pirog, 2001).

History of TB Control in New York City

As early as the 1920s, the CDC had begun to use TB skin testing to detect asymptomatic individuals (contacts) exposed to TB disease. The use of chest x-ray (CXR) supplemented the testing in the 1930s. By the mid-1950s, the health department (HD) in NYC was taking more than 500,000 CXRs annually. As more patients received anti-TB medications, the number of sanatoria decreased. A sanatorium is a facility for long-term illness associated with TB. From 20 sanatoria operating in the US, only 17 remained in operation. Although patients formerly required years of hospitalization, average stays in the 1950s dropped to less than 6 months. Despite these developments, there were still significant problems in TB control. The disease continued to affect minority groups, whose death rates averaged three to five times those of whites. Furthermore, the availability of new drugs did not ensure adherence and completion of treatment. Therefore, the declining rate of TB was deceiving (BTBC, 1999).

By 1960, TB was no longer among the top 10 causes of death in NYC. As a result, health officials grew more interested in preventing other diseases such as heart diseases, cancers, and other lung diseases caused by smoking and pollution. The decline in TB cases led to a decrease in funding for TB control and infrastructure. In 1976, all sanatoria closed, and TB clinic numbers fell from 20 to nine. Some programs run by the HD, such as nurse home visits to follow-up on patients' adherence to treatment (known as medical management), were de-emphasized. This complacency gave rise to the

resurgence of TB. Other factors that contributed to the resurgence were worsening poverty, homelessness, and the influx of immigrants from countries with high prevalence of TB. However, the major factor in the resurgence of TB was the rise of HIV-related disease (BTBC, 1990).

In 1990, there were 3,520 cases (49.8 per 100,000 population) of TB in NYC, which represented a 38% increase (975 cases) since 1989, the highest incidence of TB in 20 years. All cases of TB were assigned to healthcare workers called Public Health Advisors (PHAs) for case management (BTBC, 1990). The NYC HD chest clinics started to carry out a program of HIV counseling and TB testing for all persons who had been exposed to TB disease. The PHAs started home visits to supervise patients on TB treatment in what was called the supervised therapy program (STP). Each PHA had about 10 to 12 patients on STP. The focus had shifted to individuals infected with HIV who were exposed to cases of TB. The PHAs faced tremendous challenges in convincing contacts to undergo TB testing because of the use of needles to test for TB infection and the fear of contracting HIV (BTBC, 1991).

In 1992, once again, hospitals and emergency departments were filled with individuals who were acutely ill with TB. At the peak of this epidemic, there were 3,811 cases (52 per 100,000 population) reported to the HD (BTBC, 1992). NYC accounted for nearly one out of six patients with active TB in the US. The HD budget for TB control was nearly tripled from \$4M (1986) to \$7M (1991) to \$11.2M (1992) (BTBC, 1992). The HD began to rebuild infrastructure to fight TB, such as upgrading laboratory facilities to examine sputum samples of symptomatic patients; funding the provision of directly observed therapy (DOT), formerly known as STP; and educating the public about

the infectious nature of TB (BTBC, 1999). Strict compliance with mandatory reporting of all cases of TB to the HD was enforced. In addition to the municipal funds, the federal government, in the form of CDC cooperative agreement funds, doubled the budget (from \$1.2M to \$3.7M) to support surveillance activities for MDR-TB (BTBC, 1992).

Since 1993, the TB case rate in NYC has consistently decreased every year because of interventions by the HD (BTBC, 2008; CDC, 2005; Dye et al., 2013; Fox et al., 2012; Koh, 2013; Taylor, Nolan, & Blumberg, 2005; Verdier et al., 2011). The CDC estimates that if previous trends had continued, there would have been nearly 52,000 more cases of TB in the US from 1985 to 1992 (BTBC, 1993).

Problem Statement

Testing of contacts of an index case is one of the most productive methods of identifying adults and children with TB; however, convincing asymptomatic contacts to accept TB testing and evaluation is difficult. The national objectives established by the CDC include that contacts should be identified in 100% of infectious TB cases and to increase the proportion of contacts tested and evaluated to 93% by 2020 (CDC, 2015). In 2015, of the 577 index cases reported in NYC, the total number of contacts (household and non-household) identified was 3,920, of which 3,162 (81%) were tested and evaluated. These 3,920 contacts include 1,149 household contacts, and of these only 83 (7%) were tested (Chorba, 2015). In order to improve this rate in NYC and potentially nationally, the primary purpose of this study was to identify factors associated with household contacts' accepting testing and evaluation between 2010 and 2014.

In 2012, a major change in the case management of TB cases was implemented by the NYC Bureau of Tuberculosis Control (BTBC) (Appendix Figure A1). Because of

shortage of TB nurses, the management of TB cases in the DOHMH Chest Clinic was transferred from TB nurse managers to Public Health Advisors (PHAs), which are non-TB nurse managers. A PHA is a public health worker who assists with implementation of the activities of the BTBC. The impact of this personnel change on TB testing has not been evaluated. Thus, as a secondary objective, this dissertation also evaluated the proportion of contacts tested and evaluated by nurse managers versus PHAs by comparing cases prior to (January 2010-June 2012) and following (July 2012-December 2014) this change in BTBC protocol for case management.

Theoretical Framework

Getting household contacts to accept testing and evaluation is challenging in part because household contacts do not manifest symptoms of active TB. They do not feel sick and thus do not see the importance of TB testing and evaluation. In addition, most patients have other confounding issues such as HIV, homelessness, and drug addiction, so that getting tested may not be their priority. Moreover, since educating contacts has not been found effective (Hirsch-Moverman et al., 2010), this study used Pender's (2011) Health Promotion Model (HPM) to guide the examination of factors that influence or prevent contacts from accepting testing and evaluation for TB (Appendix Figure A2).

Acceptance of TB testing requires a behavior based on deliberate action. The HPM implies that an understanding of the major determinants of health behavior informs the counseling of healthy behavior. The philosophical underpinning of HPM is that an individual is partially shaped by the environment. The environment includes the social, cultural, and physical factors that influence behavior. An individual's characteristics that include the prior related behavior and personal factors such as biological, psychological,

socio-cultural as well as life experiences shape his or her behavior. The theoretical roots of HPM derive from social cognitive theory, which stresses the interaction among behaviors, environment, and community. Families, peers, and health care professionals influence participation in health-promoting behaviors. The HPM is based on the following assumptions, which reflect both nursing and behavioral science perspectives (Pender, 2011): (1) individuals seek to actively regulate their own behavior based on their interaction with the environment; and (2) health professionals constitute a part of the interpersonal environment, which exerts influence on a person's behavior. Therefore, the person-environment interaction is essential to behavior change, which in this case is acceptance of TB testing and evaluation. It is expected that uncovering the factors that determine a contact's environment will likely lead to more effective counseling of contacts and healthier behavioral choices for those potentially exposed to TB.

Study Purpose and Research Questions

The primary purpose of this secondary analysis of data extracted from the NYC-TB registry was to identify factors associated with household contacts' testing and evaluation for TB. The secondary purpose was to compare the proportion of household contacts tested and evaluated by a nurse case manager versus a PHA.

This secondary analysis addressed two research questions:

1. What are the household contacts' characteristics associated with TB testing and evaluation?
2. Are there differences in the proportion of household contacts tested and evaluated between index cases with a nurse case manager versus index cases

with a non-nurse case manager, after controlling for potentially confounding factors?

Significance of the Study

A complete and timely CI is crucial for decreasing the transmission and incidence of TB. Therefore, testing and evaluation of household contacts exposed to a patient with active TB disease is of utmost importance (Ailinger and Dear, 1998). The average cost of hospitalization for TB is \$20,100 per case (Holmquist, Russo, & Elixhauser, 2008), and the productivity loss faced by patients undergoing treatment can cost an average of \$260,000 per case (CDC, 2014).

Understanding the factors that influence household contacts' decisions will facilitate development of appropriate strategies that will improve acceptance of TB testing and evaluation among household contacts. Effective CI interventions can also increase initiation of LTBI treatment to prevent the development of active TB disease, reduce the cost of hospitalization due to TB, reduce contacts' productivity loss while undergoing treatment, improve TB care (Fox et al., 2015; Nyirenda et al., 2006; Rutherford et al., 2013; Tornee et al., 2005), and accomplish the national CDC objectives for CI testing and evaluation (CDC, 2015). The long-term goal of this line of research is to improve the timely treatment of LTBI.

Chapter 2: Literature Review

Major challenges to the successful control of TB include timely diagnosis and adequate treatment of infectious active TB (the index case), CI or screening of persons in close contact with the index case, and treatment of LTBI to prevent its progression to active TB disease (BTBC, 2008; CDC, 2011; Faccini et al., 2015; Fox et al., 2015; Kwon et al., 2014). These three core elements are the basis of TB control (BTBC, 2008; CDC, 2005; CDC, 2011). CI, as one of the core elements, is an important policy in TB control (BTBC, 2008; CDC, 2005; CDC, 2011; Fox, Dobler, & Marks, 2011) and plays an important role in decreasing the incidence of TB in the US (Taylor, Nolan, & Blumberg, 2005).

The guidelines on CI were first formulated by the American Thoracic Society in 1976. It stated that as soon as an active TB case is diagnosed based on laboratory and/or clinical findings, investigation of contacts should begin without waiting for positive cultures if history, sputum smears, and CXR are suggestive of TB (ATS, 1976). CI is the recommended screening for high-risk groups such as close contacts of a smear-positive index case, including child contacts younger than 5 years old and contacts who are HIV infected (Atif et al., 2012; Australasian Society for HIV Medicine, 2010; Fair et al. 2015; CDC, 2005; CDC, 2011; Hopewell, 2014; Morano-Mendoza, 2010; WHO, 2008; WHO, 2012). The CDC recommends screening of persons who have been in contact with the index case from 3 months prior to the onset of symptoms in the index case (BTBC, 2008; CDC, 2011; Davidow et al., 2009; Fenton & Castro, 2005). Current WHO recommendations suggest that all close contacts of pulmonary TB cases should be investigated without consideration of age (WHO, 2015).

In NYC, TB screening includes the use of Tuberculin Skin Test or the blood-based QuantiFERON test (QFT). The BTBC aims to evaluate at least five contacts per active TB case. TB testing is initially done before 8 weeks and a repeat testing is done at 8 weeks after exposure to a case of TB. Evaluations of contacts with positive TB test results include chest-x-ray and medical evaluation made by a health care provider for possible treatment of LTBI (BTBC, 2008). Besides ensuring that pulmonary smear positive contacts are routinely evaluated, the BTBC expanded its efforts to evaluate all contacts to patients aged 15 years and older with culture-confirmed pulmonary or laryngeal disease. In 1995, an Expanded Contact Investigation Unit was created in the BTBC to allow rapid evaluation of possible transmission of TB in congregate settings (e.g., schools, work sites, or other institutions). When indicated, mass tuberculin skin testing (TST) and education about TB were provided (BTBC, 1995).

Literature Search Method

A literature review was performed to identify trends and barriers to CI worldwide to inform the retrospective study. This integrative review followed the methods described in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement guidelines (Moher et al., 2009). Initially, a scoping review was conducted of literature addressing barriers to TB testing and evaluation. Then a search was conducted of peer-reviewed journals published from 2000 to 2016 using CINAHL, MEDLINE, PubMed, PLOS ONE, and ProQuest nursing databases. Studies relevant to the review that were more than 10 years old were also considered. CINAHL and MEDLINE were searched with the Boolean operators ‘AND’ and ‘OR’ applied to search for keywords. The search term started with the main keywords “active tuberculosis” and

the yield was more than 5,000 articles. Six other keywords were added in all applicable combinations: “contact investigation,” “contacts of TB case,” “case management,” “TB testing,” “TB evaluation,” and “barriers to TB testing and evaluation.” More specific search terms were also applied, as listed in Appendix Table A1a.

In addition to the database search, a hand search was performed of relevant articles from the reference lists of selected citations, including policies and protocols concerning CI. Moreover, a search for grey literature was performed on Google Scholar using the seven keywords.

All titles and abstracts were initially assessed. Full-text articles relevant to the topic were then further assessed. Only full-text articles with complete data on at least one of the seven keywords were reviewed. Inclusion criteria were the following: English language; study design including prospective, case-control, cross-sectional, and case report; data provided on CI of human subjects with active TB or LTBI; testing of household contacts and non-household contacts including congregate settings; and outcomes with the number of contacts tested, number of index cases identified before testing of contacts, number of contacts positive on the skin test, the TST or the blood-test, the interferon-gamma release assay (IGRA) test during screening (or other diagnostic tests), and the number of contacts identified with LTBI and secondary active TB. Evidence from systematic reviews and meta-analyses was included to gain further understanding of the topic.

Exclusion criteria included studies in which CI was based on theoretical models or diagnosis of TB was not made according to clinical, radiologic, or microbiologic criteria. Editorials and conference abstracts were also excluded from the search.

Search Outcome

Appendix Figure A3 diagrams the search results using the PRISMA guidelines, and Appendix Table A1b summarizes the included and excluded studies by database. A total of 91 articles were identified through the CINAHL, MEDLINE, PubMed, PLOS One, and ProQuest nursing databases. Twenty additional articles relevant to the topic were identified through the hand search; these 20 articles were not included in the quantitative analysis. All 91 abstracts were screened and 15 duplicate articles were removed; only 76 relevant articles meeting the inclusion criteria were assessed for eligibility. Thirty-six articles not relevant to the topic were eliminated based on the exclusion criteria. A total of 40 articles were included in the synthesis: five qualitative and 35 quantitative studies (including one dissertation).

Critical Appraisal

Critical appraisal checklists were applied using Pearson's (2004) recommendations for the five qualitative studies (Appendix Table A2a) and Bowling's (2009) recommendations for the 35 quantitative studies (Appendix Table A2b).

Data Extraction

Studies with the most complete data were included. Data extracted from the studies included the following criteria: study design, sample size, state or country, location of exposure, selection criteria for index case, selection criteria for contacts, and screening method employed (Appendix Table A3a); number of index cases, number of contacts tested or screened, number of contacts not tested or screened, number of contacts with LTBI, number of contacts with active TB (secondary case), number of contacts

placed on LTBI treatment, barriers to testing or screening, and key findings (Appendix Table A3b).

Definitions Used

Definitions used in this integrative review to describe contacts, CI processes, and aspects of TB are explained in Appendix Table A4.

Data Abstraction and Synthesis

The guidelines for conducting CI differ worldwide. Some countries have developed their own guidelines for conducting CI. Most have followed the WHO recommendation for testing children younger than 5 years of age and persons with HIV exposed to an index case (WHO, 2008; WHO, 2012). Guidelines should be standardized with regard to definition of contacts, inclusion and exclusion criteria, time of testing, method of recruiting, diagnostic tests used, and the data-collection process for monitoring and evaluation (Fair et al., 2015; WHO 2013). Lack of standardization limits the ability to analyze data on CI and to generalize the results.

Inconsistencies exist in the literature regarding the use of terminology and methodology in CI. The majority of studies did not have standard definitions for contacts, types of contacts identified, or indicators used in CI. Some studies defined a household contact based on location; that is, a person who lived in the same household as the index case (Kwon et al., 2014), while other studies defined contacts (non-household) based on temporal exposure or degree of proximity (Bayona et al., 2003, Marienau et al., 2010). For example, airline passengers seated for greater than 8 hours within two rows of an index case are considered close contacts because they are in close proximity and more likely to be exposed than other passengers (Marienau et al., 2010).

The process and methods used for CI differ based on epidemiologic circumstances and availability of resources (WHO, 2012). However, lack of guidance in methodology can lead to inconsistencies in CI, and this can affect the process of conducting CI in terms of identifying and prioritizing contacts, as revealed in most studies in this review. Studies in this synthesis used the standard clinical, radiologic, and bacteriologic criteria for the diagnosis of active TB disease; however, many showed no standard method for testing contacts. Globally, the TST and CXR are the most commonly used tests (Australasian Society for HIV Medicine 2010; CDC, 2011; Joint Tuberculosis Committee of the British Thoracic Society, 2000; National Institute of Health and Clinical Excellence, 2006; Richard & Kerri, 2010; WHO, 2012). In the US, the standard test is the TST (CDC, 2011, Menzies, 2000). Since most candidates for TB testing are born outside the US, with a history of Bacille Calmette-Guerin (BCG) vaccination, the US has adopted the use of IGRA for testing contacts (BTBC, 2008; CDC, 2011, Mazurek et al., 2005). IGRA eliminates the boosting effect and the false-positive results caused by BCG vaccine and non-tuberculosis mycobacteria (NTM). CI performed in developing countries with high coverage of BCG vaccination, as shown by studies in this review, has used only the sputum smear in finding contacts. Furthermore, some countries have used sputum smear when TST for testing contacts and sputum culture as part of the bacteriologic criteria were not available (Bayona et al., 2003; Fox et al., 2015; Ratovoson et al., 2014; Singh et al., 2005). Other countries have used more sophisticated tests for the diagnosis of TB, especially in the case of an outbreak. Examples are the use of DNA fingerprinting, polymerase chain reaction (PCR), and genotyping analysis such as the mycobacterial interspersed repetitive unit-variable

number tandem repeat (MIRU-VNTR) assay (Anderson et al., 2014; Bur et al., 2003; Faccini et al., 2015; Fox et al., 2015; Gounder et al., 2014; Ruddy et al., 2004; Yoshiyama et al., 2010). However, the costs of these tests have hindered their use by TB programs that have inadequate funding.

The international, national, and local guidelines in the selection criteria for conducting CI recommend the concentric-circle approach for identifying contacts of an index case (BTBC, 2008; CDC, 2005; CDC, 2011; Erkens et al., 2010; European CDC, 2013). A concentric-circle approach is a method of testing contacts in order of their intensity and time of exposure and risk of being infected (BTBC, 2008; CDC, 2005).

Some studies have followed the concentric-circle approach (Bur et al., 2003; Collins et al., 2003; Faccini et al., 2015; Kettunen et al., 2007; Yun et al., 2003); however, this review found various other methods as well (Appendix Table A3a). Most contacts were identified by the index case (Chee et al., 2005; Davidow et al., 2003; Driver et al., 2003; Fox et al., 2012; Singh et al., 2005; Suggaravetsiri et al., 2003; Wares et al., 2000), and investigators in retrospective studies used the TB registry for finding contacts. One study used the “invitation model” as an effective method of identifying contacts. This is a method in which an index case is asked to invite his or her contacts to be examined at a health care facility (Chakhaia et al., 2014).

CI is crucial in preventing the development of active TB disease; however, CI is not considered successful without treatment of LTBI (BTBC, 2008; Bur et al., 2003; CDC, 2005; CDC, 2011; Chakhaia et al., 2014; Fair et al., 2015). In the US, approximately 20% to 30% of all contacts have LTBI (CDC, 2005). In NYC in 2015, 267 contacts were eligible for LTBI treatment and 217 (81%) initiated treatment (Chorda,

2014). The results of studies included in this review showed that the percentage of contacts not tested ranged from about 0% to 52%, and the percentage of contacts who initiated LTBI treatment ranged from 7% to 100% (Appendix Table A5). Some studies did not include any data on the number of contacts who were not tested or the number who initiated LTBI treatment. The wide range in the percentage of contacts not tested can be due to the lack of standard criteria for expanding investigations to include those with less frequent exposure, and the lack of standard procedures for identifying, screening, and tracking of contacts (Atif et al., 2012; Bur et al., 2003; Chakhaia et al., 2014; Marienau et al., 2010; Seddon et al., 2013; Shapiro, 2013; Wares et al., 2000; Yoshiyama et al., 2010; Zellweger et al., 2015). Furthermore, the wide range can be due to barriers that prevent contacts from adhering to TB testing (Fox et al., 2015). The wide range in the percentage of contacts who initiated LTBI treatment can be due to the provider's lack of knowledge about LTBI treatment or lack of sufficient funding for treatment (Atif et al., 2007; Chakhaia et al., 2014; Kettunen et al., 2007). It is crucial that health care providers are educated not only about the disease process but also about the necessity for LTBI treatment to prevent the development of active TB disease.

This review revealed that the majority of studies conducted on CI were quantitative with an observational and retrospective design. Biases were reported in outcomes, owing to the retrospective design of most studies and the lack of suitable matched controls (Fox et al., 2013). Of the 35 quantitative articles in this review, only two studies had a design with a matched control group. Only one study was a randomized controlled trial (RCT) (Fox et al., 2015). The impact of TB testing on transmission can be established through an RCT, and it is only through an RCT that

findings can be generalized. In the absence of an RCT, it is not possible to make strong recommendations for the implementation of specific interventions in CI (Fox et al., 2013).

Perceived Barriers in Testing of Contacts

This review identified several barriers to testing of contacts. These barriers can be categorized into four groups, including patient factors, provider factors, medical/technical factors, and health system factors (Appendix Table A6).

These four barriers must be addressed because a single contact that has been exposed and infected, yet not tested and evaluated, can develop active TB disease at some point in his or her life. A single index case can infect up to 10 to 15 contacts over the course of a year (WHO, 2012) and can give rise to TB outbreaks.

The patient-related barriers have several explanations. Gaps in knowledge about how TB is transmitted and why testing is important can lead to contacts not showing up for testing. Misconceptions about transmission, such as the belief that TB occurs because of sharing food and utensils, can give rise to stigma (Collins et al., 2003; Faccini et al., 2015; Fox et al., 2014; Kiter et al., 2003; Kwon et al., 2014). Lack of knowledge about the development of TB disease in the body (pathogenesis) can lead to the belief that smoking tobacco increases the risk of developing TB (Chakhaia et al., 2014; Fox et al., 2015). Moreover, poor communication between the patient and provider because of language barriers among non-US-born populations creates difficulty in conveying correct information. Ethical concerns regarding the harms of getting tested, confidentiality of information, and/or a fear of getting deported play a role in testing of contacts (Dewan et al., 2006; Fox et al., 2012; Kambali et al., 2015). Practical issues such as long distances

between the home and clinic, difficulties in taking time off from work and school, forgetting to attend scheduled appointments, and changing residences can influence contacts' adherence to testing (Anger et al., 2012; Fox, et al., 2015; Gounder et al., 2014).

Evidence has shown that gaps in providers' knowledge about TB contribute to suboptimal care (Dresser et al., 2012). If providers do not consider TB as a possible diagnosis, there will be a prolonged delay until a patient with TB is diagnosed and failure to identify contacts until beyond 3 months after exposure. In addition, inappropriate identification and selection of contacts can lead to an incomplete CI (Cates et al., 2015; Chee et al., 2005; Davidow et al., 2003; Kambali et al., 2015; Marks et al., 2000; Ratovoson et al., 2014; Wares et al., 2000; Yoshiyama et al., 2010). To acquire full information from the index case during CI, it is critical for providers to establish trust and rapport (Driver et al., 2003; Faccini et al., 2015; Marks et al., 2000). However, current national and international guidelines lack guidance for staff involved in TB control on how to establish rapport with cases during interviews. Nothing was found in the literature about interviewing techniques or training interventions that can be used to decrease feelings of stigma among cases and contacts (Anderson et al., 2014; Faccini et al., 2015; Marks et al., 2000). In addition, providers with incomplete knowledge about LTBI will not consider treatment for LTBI and therefore will not prevent TB from becoming active (Chakhaia et al., 2014; Kettunen et al., 2007; Yun et al., 2003). Furthermore, no studies were found that assessed the rates of TB testing based on the type of provider. Most of the providers involved in CI are physicians, nurses, and epidemiologists. However, after receiving basic training, lay workers also conduct TB screening (Shah et al, 2013).

Medical and technical factors are also potential barriers in CI. Contacts who are immunocompromised because of HIV infection, malnutrition, or alcohol dependence, which are considered co-morbidities of TB, have a much higher risk of developing TB disease than contacts with normal immune systems. Their weakened immune system may not respond to TB tests such as TST or IGRA (Bayona et al., 2003; Seddon et al., 2013; Shapiro, 2013; Singh et al., 2005; Suggaravetsiri et al., 2003). The timing and duration of exposure to MDR-TB are critical factors that require prompt results of drug susceptibility tests of the index case; delays in obtaining results can result in ineffective treatment and transmission of MDR-TB to contacts (Bayona et al., 2003; Seddon et al., 2013). Technical factors such as the boosting effect of BCG vaccine and infection with NTM can give rise to false-positive results on TST and cause misclassification of criteria for transmission (Cates et al., 2015; Seddon et al., 2013). Thus, IGRA should be used when testing contacts with a history of BCG vaccination (Diel et al., 2006; Zellweger et al., 2015). In addition, IGRA is associated with better compliance because it does not require a patient to come back for the test results, unlike TST. However, technical procedures pertaining to IGRA can result in false-negative findings (Diel et al., 2006; Zellweger et al., 2015). QuantiFERON-TB (QFT) is not sensitive enough to confirm true LTBI (Diel et al., 2006), and neither is TST (Seddon et al., 2013). Therefore, to increase the reliability and validity of TST, two-step testing should be applied, meaning that a baseline TST is followed by another TST in 7 to 10 days (Chee et al., 2005; Collins et al., 2003; Seddon et al., 2013).

Health systems from different countries employ various guidelines for CI procedures depending upon the population and availability of resources. Most studies

have restricted testing to contacts exposed to an index case with positive sputum smear and culture. However, one study in this review concluded that transmission can still occur among contacts who are exposed to an index case with negative sputum smear and culture results. Therefore, contacts exposed to an index case with negative sputum smear and culture but with TB symptoms should still be tested (Cates et al., 2015). Moreover, there are no standard guidelines on CI regarding the number of persons exposed who warrant CI. For example, contacts of index cases in correctional facilities who are to be released within 6 months are not getting tested (Bur et al., 2003). In addition, workplaces with fewer than 15 persons were not included in CI (Driver et al., 2003).

Finally, CI is labor-intensive and requires manpower. CI diverts staff members from performing other TB activities such as managing cases of TB disease, which could be more cost effective (Cates et al., 2015; Wares, et al., 2000). Because of limited resources, CI is not always feasible. As mentioned before, TST and CXR are the most commonly used tests in CI. However, guidelines on CI from Pacific Island countries suggest not administering TST to contacts unless the National TB Program can offer 6 months of isoniazid therapy to TST-positive contacts and monitor them until completion of treatment (Richard & Kerri, 2010). In the US, the guidelines on CI suggest employing CXR only when the result of the TST is positive. Taking this US recommendation into account could save resources in low-income countries (Atif et al., 2012). Guidelines from the United Kingdom recommend the use of IGRA if the TST is positive (National Institute of Health and Clinical Excellence, 2006). Recent US guidelines by the CDC state that IGRA (QFT) can be used in all circumstances in which the TST is currently used (BTBC, 2008; CDC, 2011; Mazurek et al., 2005).

Evolving Role of Nurses Versus Public Health Advisors in NYC

In the literature search described, five qualitative studies were identified (Appendix Table A7a) that support the role of nurses as case managers in TB control. The primary role of nurses in TB control was to provide support for adherence to treatment (medical management). In the mid-1990s, the nurses of the BTBC at DOHMH Chest Clinics started case management of TB patients and became the primary clinician responsible for index cases at the Chest Clinics, including contacts of index cases. The nurses became involved in the risk assessment of contacts for testing and evaluation.

In 2012, a major change in the case management of TB cases was implemented by the BTBC (Appendix Figure A1). The management of TB cases, including contacts of the index cases at the Chest Clinics, was transferred back from TB nurse managers to non-TB nurse managers, the Public Health Advisors (PHAs). A PHA is a public health worker who assists with activities of the BTBC. The title was adopted by the BTBC from the CDC workforce. The requirements to be appointed as a PHA include a baccalaureate degree or a four-year high school diploma or its educational equivalent approved by a State's Department of Education, or experience on the basis of 30 semester credits from an accredited college for one year of full-time experience. The PHA works under the supervision of a higher-level PHA position.

PHA responsibilities have evolved over the years. In the early 1940, the initial role of the PHA in the BTBC was mainly to assist in TB screening. In 1970s, the role of the PHA in the BTBC was to locate contacts that had been exposed to a case of active TB disease (index case). In the 1980s, the role of the PHA expanded to interviewing and investigating contacts of an index case, including testing; returning the patient to medical

care and follow-up; and performing chart review. In the early 1990s, after extensive training to support their role, the PHAs started to review epidemiological data and conduct health risk assessments of varying degrees of difficulty ranging from TB case management to assisting supervisory personnel in the planning, organizing, and conducting of disease control efforts in the BTBC. The PHA became the primary case managers in the DOHMH Chest Clinics. However, in the mid-1990s, the PHA role was changed to assisting nurses in the management of cases and focused more on finding patients lost to follow-up and returning those patients back to medical care (BTBC, 1990). In 2012, because of the shortage of nurses, the PHA became the primary case managers in the DOHMH Clinics (Appendix Table A7b).

Summary

To ensure the success of CI, TB control programs must identify barriers to testing contacts and routinely evaluate the outcomes of CI (Fair et al., 2015). The literature review described above identified wide variations in CI practices and several barriers to effective CI due to knowledge gaps and other issues in countries worldwide. It is therefore of interest to determine the impact of expanding PHA roles on TB case management in the BTBC. Of the 35 quantitative studies included in the literature review, only one study supported the role of lay workers (non-nurses) in CI who were provided basic training (Shah, 2013). However, no studies were found that evaluated the effectiveness of non-nurse TB case managers. This study is the first to examine the proportion of contacts tested and evaluated based on type of provider.

Chapter 3: Methods

Research Design

A retrospective case-control study design was conducted to explore the factors associated with TB testing, evaluation, and treatment. This was an analysis of secondary data from the NYC TB registry. The data is collected through routine case management activities, and is entered in the TB registry by the case managers and other Bureau staff. Contacts of active TB cases from 2010 to 2014 were identified and variables associated with testing of contacts and evaluation was examined. Variables extracted from the TB registry included demographics, contact information, reporting and assignment, clinical disposition, and case management.

Study Site

The TB registry includes demographic, social, and clinical information on individuals with confirmed active TB and with suspicion of disease, and their contacts. The electronic registry allows the BTBC to generate statistics about the incidence and prevalence of TB in NYC, report data to the CDC through the computerized system, respond to clinicians' questions about specific TB cases, and share epidemiologic information with researchers both inside and outside the NYC Department of Health and Mental Hygiene. Numerous quality assurance measures are put in place to ensure the quality and integrity of data in the TB registry (BTBC, 1995).

In 2003, a computerized patient registration system was implemented in all Chest Clinics; this system became an electronic medical record that allows more efficient patient management and billing (BTBC, 2003).

Sample

The study sample included all household contacts of New York confirmed cases of active TB identified from 2010 to 2014; this included all household contacts who were tested and those who were not tested and evaluated for TB ($n=3,008$). Non-household contacts were excluded. A complete case analysis or listwise deletion was used to address missing data. Thus, contacts that had missing information were removed from the data analysis. The study sample includes demographic information and testing, evaluation, and treatment information at three time points. For all household contacts, gender, age, country of birth, race/ethnicity, and borough of residence are recorded. The study sample also includes information about whether a household contact was tested for TB, their TB test results, whether they were fully evaluated, and if they accepted or refused LTBI treatment.

Measures

The outcomes that were measured are testing, evaluation, and treatment. The first dependent variable is testing. Testing is the act of accepting the TB test, therefore, it measures a person tested for TB. This is a binary (0/1) variable, 1= Tested (post window); 0=Not tested. The second dependent variable is the result of the test for TB. The results of the TB test are whether a person tests positive or negative for TB. This is a binary (0/1) variable, 1 = positive TB test result (post-window); 0 = negative TB test result (post-window). The third dependent variable is evaluation. Evaluation is when a person with a positive result on TB testing accepts evaluation that include a chest x-ray and assessment TB signs and symptoms, therefore, it measures a person who was evaluated among those tested with a positive result. This is a binary (0/1) variable, 1=Evaluated; 0= Not evaluated. The fourth dependent variable is whether a contact

accepted/completed LTBI treatment. This is a binary (0/1) variable, 1 = did not accept LTBI treatment; 0 = accepted/completed LTBI treatment. The fifth dependent variable is whether a contact refused LTBI treatment. This is a binary (0/1) variable, 1 = Did not refuse LTBI treatment; 0 = Refused LTBI treatment.

Data Collection Plan

A research scientist staff member from the Surveillance and Epidemiology Unit abstracted data from the TB registry and provided the de-identified data to the doctoral student. This de-identified data was saved as the newly developed data set for analysis. No separate tool was needed to reorganize the existing data from the TB registry.

Data Analysis

In order to explore the factors that are associated with TB testing, evaluation, and treatment among household contacts, data were tested by estimating a logistic multi-level model for each of the five dependent variables on TB testing, evaluation, and treatment. The logistic multi-level models and bivariate statistics were run in R. The logistic multi-level models allowed the researcher to assess the impact of the independent variables on the outcome, the relative impact of each independent variable by refitting the model adding each independent variable incrementally, the potential collinearity among these variables by exploring for effect of the independent variables controlling for potential confounding between the independent variables, and any changes in testing and evaluation effects. The variation inflation factor (VIF) was used to check for collinearity. The VIF number indicates how much larger the error for the unique effect of a predictor. Ideally scores should be below 2. The odds ratio, which is derived from the log odds estimate of the multi-level model, is reported and interpreted. 95% confidence intervals

are computed for the odds ratio and interpreted to compare the significance of the effect between the predictor variables, and to compare the impact of incrementally adding demographic variables to determine if the independent variables are confounds of each other. At each time point, the full model, with all independent variables (both significant and non-significant predictors) is interpreted and discussed. This tells the researcher about the relative effect of each independent variable in predicting the outcome at each time point.

The independent variables that was derived from the TB registry and included in the analysis are: gender, age, country of birth, race/ethnicity, and borough of residence. Age group was binned into minors, adults aged 18-44, middle-aged adults aged 45-64, and senior adults aged 65 and older. Country of birth is grouped into two categories: those born in the US and those born outside of the US. Race/Ethnicity was grouped into the categories: non-Hispanic Black, Hispanic of any race, Asian, non-Hispanic White, and Other including those identified with 2 or more racial or ethnic groups. Borough of residence is one of the 5 boroughs in the City of New York: the Bronx, Brooklyn, Manhattan, Queens, and Staten Island.

Descriptive analysis was used to identify factors associated with testing and evaluation. The independent variables included in the analysis are categorical, so proportions and frequency counts were calculated and presented. Prior to multivariate analyses, bivariate analyses are presented separately in order to explore the effect of the demographic variables on the outcome without controlling for the other independent variables. Group comparisons of categorical variables were made using Pearson's chi-square (χ^2) tests at each time point. The Pearson's chi-square test tells the researcher if

there is a significant relationship between the group level variable and the outcome variable. A significant relationship means that the outcomes at the different time points were significantly different between the different levels of the group; the groups were behaving differently from each other in terms of the outcome variable. The row percentages reflect relative odds of each group level within an independent variable, which controls for different number of household contacts in each group, and were interpreted in line with the results of the logistic multi-level models.

Lastly, the results of the bivariate and multivariate statistics were compared to show the changes in importance of each independent variable as a predictor of the dependent variable when controlling for the other variables. Analysis of this secondary data was not predefined and not part of primary research, therefore, there was no need to adjust for multiplicity of comparison (Guowei et al., 2016).

Note that to explore the effect of type of provider (nurse vs. PHA) on whether household contacts were tested and evaluated, Pearson's chi-square tests with Yates' continuity correction were run and interpreted. This analysis examined the effect of a nurse vs. PHA on the outcomes of TB testing and evaluation by comparing data from September 2010 through July 2012 when nurses were the primary case managers to data from July 2012 through December 2014 when PHAs were the primary case managers.

Protection of Human Subjects

All analyses for this study consisted of de-identified data that were reported only in aggregate form. Study procedures were evaluated by the Institutional Review Board of the NYC DOHMH. Then following approval, the City University of New York Human Research Protection Program reviewed the proposed study procedures.

Limitation of Analysis of Secondary Data

The TB registry consists of data collected for program evaluation and is not intended for research purposes; therefore, it does not capture all information necessary to conduct a comprehensive analysis about CI.

Chapter 4: Results

The primary purpose of the proposed study was to identify factors associated with household contacts' TB testing and evaluation between 2010 and 2014. Getting household contacts to accept testing and evaluation is challenging because household contacts do not manifest symptoms of active TB disease. In 2016, of the 565 index (those with confirmed active TB) cases reported to the NYC Department of Health, the total number of contacts (household and non-household) identified was 3,595, of which 2,716 (76%) were tested and evaluated (Chorba, 2016). In order to improve this rate in NYC and potentially nationally, data from the NYC Bureau of Tuberculosis Control TB registry between 2010 and 2014 was examined on potential demographic factors influencing testing and evaluation rates.

The secondary purpose was to evaluate the proportion of contacts tested and evaluated by nurse managers versus Public Health Advisors (PHAs) by comparing household contacts tested and evaluated from January 2010 through - June 2012, when nurses were the primary case managers and from July 2012 through - December 2014 when the primary case managers were PHAs. To determine the impact of expanding PHA roles to TB case management in the BTBC, the proposed study examined the proportion of contacts tested and evaluated based on type of provider.

Sample Size

Following identification of contacts there are three points in which household contacts may not comply with the established protocol for testing and evaluation:

1. Tested or Not Tested for TB
2. Fully Evaluated and Not Fully Evaluated (among those who test positive for TB)

3. Acceptance/Completed or Refused LTBI Treatment

Figure 1 presents the flow of the 3,008 household contacts through these three points. First, among the 3,008, 2,850 (94.75%) household contacts were tested and of these 2,850, 38.25% (1,090) of contacts tested positive for TB. Second, of the 1,090 contacts with positive TB tests 95.14% (1,037) were fully evaluated. Of the 53 not fully evaluated, 33 refused to be fully evaluated, 20 others died, moved, or were lost prior to evaluation. Of the 1,037 that were fully evaluated, 174 (16.8%) were deemed by the physician as not infected, had a prior positive on TB test, not in need of treatment or were administratively closed since they were unable to be found or moved out of the NYC area. Third, the remaining 863 were offered treatment for latent TB infection, and 76.13% (657) accepted and completed treatment, while 28.87% (206) refused treatment. Thus, of the 3,008, we are not certain of the TB status of 158 cases, and among the 1,090 contacts with a positive TB test, 206 refused LTBI treatment after a full evaluation and an additional 53 refused or were lost to follow-up, moved or died without receiving a full evaluation. Since cases are lost at each time point, the characteristics of testing, evaluation, and treatment are presented separately.

Figure 1. Household contacts' testing & evaluation flow chart.

Overall Sample Characteristics

Table 1 provides the overall characteristics of household contacts from 2010 through 2014. The data was examined for the following demographics: gender, age group, country of birth, race/ethnicity and borough residence of contacts. Among the household contacts, the proportion of male (49.63%, $n=1493$) and female (50.37%, $n=1515$) were almost equal. The plurality of household contacts by age group were adults 18-44 (43.95%, $n=1322$). Over a quarter of household contacts were younger than 18 years old (28.76%, $n=865$). A little more than one-in-five household contacts were middle-aged adults 45-64 (21.28%, $n=640$) and the smaller age group was seniors 65

years old and older (6.02%, $n=181$). The majority, approximately two-thirds, of household contacts were born outside of the USA (66.56%, $n=2002$). The largest proportion of household contacts reported Asian race/ethnicity (39.06%, $n=1175$), followed by Hispanic household contacts (32.21%, $n=969$). Nearly one-in-five household contacts self-reported their ethnicity/race as non-Hispanic Black (19.38%, $n=583$). The smallest proportions of ethnicity/racial categories self-reported non-Hispanic White (5.85%, $n=176$) and Other (3.49%, $n=105$). The plurality of household contacts lived in the borough of Queens (43.58%, $n=1311$). Nearly one-third of household contacts lived in Brooklyn (31.05%, $n=934$). The remaining quarter of household contacts lived in the Bronx (16.02%, $n=482$), Manhattan (7.18%, $n=216$), and Staten Island (2.16%, $n=65$). Overall, most household contacts were adults 18-44 years of age, non-US born, Asian or Hispanic, and residing in Queens or Brooklyn.

Table 1. Demographic Characteristics of All Household Contacts of Active TB Cases (n=3,008)

Demographics	Frequency	Percentage
<i>N=3,008</i>		
Gender		
<i>Male</i>	1,493	49.63
<i>Female</i>	1,515	50.37
Age-Group		
<i>0-17</i>	865	28.76
<i>18-44</i>	1,322	43.95
<i>45-64</i>	640	21.28
<i>65+</i>	181	6.02
Country of Birth		
<i>US-Born</i>	1,006	33.44
<i>Non-US Born</i>	2,002	66.56
Race/Ethnicity		
<i>Non-Hispanic Black</i>	583	19.38
<i>Hispanic</i>	969	32.21
<i>Asian</i>	1,175	39.06
<i>Non-Hispanic White</i>	176	5.85
<i>Other</i>	105	3.49
Borough		
<i>Bronx</i>	482	16.02
<i>Brooklyn</i>	934	31.05
<i>Manhattan</i>	216	7.18
<i>Queens</i>	1,311	43.58
<i>Staten Island</i>	65	2.16

Sample Characteristics at Three Time Points

Chi-squared tests of independence were calculated comparing the frequencies of behaviors of household contacts at different time points. This was done to determine whether behaviors of household contacts at different time points were related to demographic variables of age, gender, country of origin, race/ethnicity, and borough of residence. Responses for different time points were analyzed separately.

Behaviors of household contacts at different time points are presented first regardless of demographic variables. Probability (p) values less than 0.05 ($p < .05$) are considered to be significant. If a significant relation exists between a demographic variable and behaviors of household contacts at different time points, behaviors of household contacts at different time points are further reported by demographic variables. Only contingency tables are showed for variables that approached significance ($p < .10$) result and interpreted.

Tested and Not Tested

Among the $N=3,008$ household contacts, the vast majority (94.75%, $n=2850$) of household contacts were tested for TB and only about one-in-twenty (5.25%, $n=158$) were not tested for TB.

The proportion of household contacts being tested did not significantly differ by gender group, in Table 2. A chi-squared test of independence looking at the relationship between testing by gender ($\chi^2(1)=0.44$, $p=0.51$) was not significant.

Table 2. Demographic Characteristics of Household Contacts Tested/Not Tested for by Gender

	Tested	Not Tested	Total
<i>Male</i>	1,410	83	1,493
	94.44%	5.56%	
<i>Female</i>	1,440	75	1515
	95.05%	4.95%	
<i>Total</i>	2,850	158	3,008
	94.75%	5.25%	

The proportion of household contacts being tested significantly differed by age group, in Table 3. A chi-squared test of independence looking at the relationship between testing by age group ($\chi^2(3)=39.09$, $p<.001$) was significant. A much higher proportion of household contacts that were 0-17 years old (98.73%, $n=854$) were tested for TB compared to the other age groups. Household contacts 45 years old older were less likely to be tested (45-64 years old: 92.97%, $n=595$, 65 years and older: 92.27%, $n=167$).

Table 3. Demographic Characteristics of Household Contacts Tested/Not Tested for by Age Group

	Tested	Not Tested	Total
<i>0-17</i>	854	11	865
	98.73%	1.27%	
<i>18-44</i>	1,234	88	1,322
	93.34%	6.66%	
<i>45-64</i>	595	45	640
	92.97%	7.03%	
<i>65+</i>	167	14	181
	92.27%	7.73%	
<i>Total</i>	2,850	158	3,008
	94.75%	5.25%	

The proportion of household contacts being tested significantly differed by country of birth, in Table 4. A chi-squared test of independence looking at the relationship between testing by country of birth ($\chi^2(1)=11.23$, $p<.001$) was significant. A lower proportion of household contacts that were not born in the US (93.76%, $n=1877$) were tested for TB than the proportion of household contacts that were born in the US (96.72%, $n=973$) that were tested for TB.

Table 4. Demographic Characteristics of Household Contacts Tested/Not Tested for by Country of Birth

	Tested	Not Tested	Total
<i>US-Born</i>	973	33	1,006
	96.72%	3.28%	
<i>Non-US-Born</i>	1,877	125	2,002
	93.76%	6.24%	
<i>Total</i>	2,850	158	3,008
	94.75%	5.25%	

The proportion of household contacts being tested significantly differed by race/ethnicity, in Table 5. A chi-squared test of independence looking at the relationship between testing by race/ethnicity ($\chi^2(4)=11.47, p<.05$) was significant. A lower proportion of household contacts identified as Other (91.43%, $n=96$), Non-Hispanic Black (93.14%, $n=543$), and Non-Hispanic White (92.05%, $n=162$) were tested for TB than household contacts identified as Hispanic (95.15%, $n=922$) and Asian (95.91%, $n=1127$).

Table 5. Demographic Characteristics of Household Contacts Tested/Not Tested for by Race/Ethnicity

	Tested	Not Tested	Total
<i>Non-Hispanic Black</i>	543	40	583
	93.14%	6.86%	
<i>Hispanic</i>	922	47	969
	95.15%	4.85%	
<i>Asian</i>	1,127	48	1,175
	95.91%	4.09%	
<i>Non-Hispanic White</i>	162	14	176
	92.05%	7.95%	
<i>Other</i>	96	9	105
	91.43%	8.57%	
<i>Total</i>	2,850	158	3,008
	94.75%	5.25%	

The proportion of household contacts being tested did not significantly differ by borough, in Table 6. A chi-squared test of independence looking at the relationship between testing by borough ($\chi^2(4)=3.68$, $p=0.45$) was not significant.

Table 6. Demographic Characteristics of Household Contacts Tested/Not Tested for by Borough

	Tested	Not Tested	Total
<i>Bronx</i>	459	23	482
	95.23%	4.77%	
<i>Brooklyn</i>	888	46	934
	95.07%	4.93%	
<i>Manhattan</i>	206	10	216
	95.37%	4.63%	
<i>Queens</i>	1,233	78	1,311
	94.05%	5.95%	
<i>Staten Island</i>	64	1	65
	98.46%	1.54%	
<i>Total</i>	2,850	158	3,008
	94.75%	5.25%	

Testing Positive and Testing Negative

Among the $N=2850$ household contacts tested, over one-third (38.25%, $n=1090$) of household contacts tested positive for TB.

The proportion of household contacts that tested positive significantly differed by gender, in Table 7. A chi-squared test of independence looking at the relationship between testing positive by gender ($\chi^2(1)=4.74$, $p<.05$) was significant. A higher proportion of males (40.28%, $n=568$) tested positive for TB than the proportion of females (35.25%, $n=522$) that tested positive for TB.

Table 7. Demographic Characteristics of Household Contacts Testing Positive Versus Negative by Gender

	Positive	Negative	Total
<i>Male</i>	568	842	1,410
	40.28%	59.72%	
<i>Female</i>	522	918	1,440
	36.25%	63.75%	
<i>Total</i>	1,090	1760	2,850
	38.25%	61.75%	

The proportion of household contacts that tested positive significantly differed by age group, in Table 8. A chi-squared test of independence looking at the relationship between testing positive by age group ($\chi^2(3)=146.56, p<.001$) was significant. The highest proportion of household contacts testing positive for TB was in the 45-64 years old age group where nearly half tested positive for TB (49.75%, $n=296$). The lowest proportion of household contacts testing positive for TB was in the 0-17 years old age group where only one-in-five tested positive for TB (21.90%, $n=187$).

Table 8. Demographic Characteristics of Household Contacts Testing Positive Versus Negative by Age Group

	Positive	Negative	Total
<i>0-17</i>	187	667	854
	21.90%	78.10%	
<i>18-44</i>	528	706	1,234
	42.79%	57.21%	
<i>45-64</i>	296	299	595
	49.75%	50.25%	
<i>65+</i>	79	88	167
	47.31%	52.69%	
<i>Total</i>	1,090	1,760	2,850
	38.25%	61.75%	

The proportion of household contacts that tested positive significantly differed by country of birth, in Table 9. A chi-squared test of independence looking at the relationship between testing positive by country of birth group ($\chi^2(1)=247.72, p<.001$) was significant. The highest proportion of household contacts testing positive for TB were not born in the US where nearly half tested positive (48.59%, $n=912$). A much lower proportion of household contacts that were born in the US tested positive for TB where only about one-in-five tested positive for TB (18.29%, $n=178$).

Table 9. Demographic Characteristics of Household Contacts Testing Positive Versus Negative by Country of Birth

	Positive	Negative	Total
<i>US-Born</i>	178	795	973
	18.29%	81.71%	
<i>Non-US-Born</i>	912	965	1,877
	48.59%	51.41%	
<i>Total</i>	1,090	1,760	2,850
	38.25	61.75%	

The proportion of household contacts that tested positive significantly differed by race/ethnicity, in Table 10. A chi-squared test of independence looking at the relationship between testing positive by race/ethnicity ($\chi^2(4)=36.68, p<.001$) was significant. More than half (52.08%, $n=50$) of household contacts that identified as Other tested positive for TB. This was a higher proportion of household contacts testing positive for TB than other racial/ethnic groups. The second highest proportion of household contacts testing positive for TB were those household contacts identified as Asian (42.15%, $n=475$). The lowest proportion of household contacts testing positive for TB were identified as non-Hispanic Black (29.28%, $n=159$) and non-Hispanic White (31.48%, $n=51$).

Table 10. Demographic Characteristics of Household Contacts Testing Positive Versus Negative by Race/Ethnicity

	Positive	Negative	Total
<i>Non-Hispanic Black</i>	159 29.28%	384 70.72%	543
<i>Hispanic</i>	355 38.50%	567 61.50%	922
<i>Asian</i>	475 42.15%	652 57.85%	1,127
<i>Non-Hispanic White</i>	51 31.48%	111 68.52%	162
<i>Other</i>	50 52.08%	46 47.92%	96
<i>Total</i>	1,090 38.25%	1,760 61.75%	2,850

The proportion of household contacts that tested positive significantly differed by borough, in Table 11. A chi-squared test of independence looking at the relationship between testing positive by borough ($\chi^2(4)=44.75, p<.001$) was significant. The highest proportion of household contacts testing positive for TB lived in Queens (43.23%, $n=533$). The lowest proportion of household contacts testing positive for TB lived in the Bronx (25.49%, $n=117$). Residents in Brooklyn (38.29%, $n=340$), Manhattan (36.89%, $n=76$), and Staten Island (37.50%, $n=24$) had a similar proportion of household contacts testing positive for TB.

Table 11. Demographic Characteristics of Household Contacts Testing Positive Versus Negative by Borough

	Positive	Negative	Total
<i>Bronx</i>	117	342	459
	25.49%	74.51%	
<i>Brooklyn</i>	340	548	888
	38.29%	61.71%	
<i>Manhattan</i>	76	130	206
	36.89%	63.11%	
<i>Queens</i>	533	700	1,233
	43.23%	56.77%	
<i>Staten Island</i>	24	40	64
	37.50%	62.50%	
<i>Total</i>	1,090	1,760	2,850
	38.25%	61.75%	

Fully Evaluated vs Not Fully Evaluated

Among the $N=1090$ household contacts that tested positive for TB, the vast majority (95.14%, $n=1037$) of household contacts were fully evaluated. Only one-in-twenty (4.86%, $n=53$) household contacts were not fully evaluated.

The proportion of household contacts that were fully evaluated significantly differed by gender, in Table 12. A chi-squared test of independence looking at the relationship between undergoing evaluation by gender ($\chi^2(1)=9.41$, $p<.01$) was significant. A higher proportion of females (97.32%, $n=508$) were fully evaluated compared to the proportion of males (93.13%, $n=529$) that were fully evaluated.

Table 12. Demographic Characteristics of Household Contacts Fully Evaluated Versus Not Fully Evaluated by Gender

	Fully Evaluated	Not Fully Evaluated	Total
<i>Male</i>	529 93.13%	39 6.87%	568
<i>Female</i>	508 97.32%	14 2.68%	522
<i>Total</i>	1,037 95.14%	53 4.86%	1,090

The proportion of household contacts that were fully evaluated significantly differed by age group, in Table 13. A chi-squared test of independence looking at the relationship between undergoing evaluation by age group ($\chi^2(3)=10.63$, $p<.05$) was significant. Nearly all household contacts 0-17 years old (99.47%, $n=186$) were fully evaluated. The lowest proportion of household contacts that were fully evaluated were adults 18-44 years old (93.56%, $n=494$) followed by adults aged 45-64 (94.93%, $n=281$).

Table 13. Demographic Characteristics of Household Contacts Fully Evaluated Versus Not Fully Evaluated by Age Group

	Fully Evaluated	Not Fully Evaluated	Total
<i>0-17</i>	186	1	187
	99.47%	0.53%	
<i>18-44</i>	494	34	528
	93.56%	6.44%	
<i>45-64</i>	281	15	296
	94.93%	5.07%	
<i>65+</i>	76	3	79
	96.20%	3.80%	
<i>Total</i>	1,037	53	1,090
	95.14%	4.86%	

The proportion of household contacts that were fully evaluated significantly differed by country of birth, in Table 14. A chi-squared test of independence looking at the relationship between undergoing evaluation by country of birth ($\chi^2(1)=9.65, p<.01$) was significant. All individuals born in the US were fully evaluated (100.00%, $n=178$) whereas nearly a majority were fully evaluated (94.19%, $n=859$) that were born outside of the US.

Table 14. Demographic Characteristics of Household Contacts Fully Evaluated Versus Not Fully Evaluated by Country of Birth

	Fully Evaluated	Not Fully Evaluated	Total
<i>US-Born</i>	178	0	178
	100.00%	0.00%	
<i>Non-US-Born</i>	859	53	912
	94.19%	5.81%	
<i>Total</i>	1,037	53	1,090
	95.14%	4.86%	

The proportion of household contacts that were fully evaluated did not significantly differ by race/ethnicity, in Table 15. A chi-squared test of independence looking at the relationship between undergoing evaluation by gender ($\chi^2(4)=2.42$, $p=0.66$) was not significant.

Table 15. Demographic Characteristics of Household Contacts Fully Evaluated Versus Not Fully Evaluated by Race/Ethnicity

	Fully Evaluated	Not Fully Evaluated	Total
<i>Non-Hispanic Black</i>	153 96.23%	6 3.77%	159
<i>Hispanic</i>	335 94.37%	20 5.63%	355
<i>Asian</i>	455 95.79%	20 4.21%	475
<i>Non-Hispanic White</i>	47 92.16%	4 7.84%	51
<i>Other</i>	47 94.00%	3 6.00%	50
<i>Total</i>	1,037 95.14%	53 4.86%	1,090

The proportion of household contacts that were fully evaluated significantly differed by borough, in Table 16. A chi-squared test of independence looking at the relationship between undergoing evaluation by borough ($\chi^2(4)=10.10$, $p<.05$) was significant. All household contacts were fully evaluated that lived in Staten Island (100.00%, $n=24$) and nearly all household contacts were fully evaluated that lived in Brooklyn (97.65%, $n=332$). The lowest proportion of household contacts that were fully evaluated lived in Manhattan (92.11%, $n=70$) and Queens (93.62%, $n=499$).

Table 16. Demographic Characteristics of Household Contacts Fully Evaluated Versus Not Fully Evaluated by Borough

	Fully Evaluated	Not Fully Evaluated	Total
<i>Bronx</i>	112 95.73%	5 4.27%	117
<i>Brooklyn</i>	332 97.65%	8 2.35%	340
<i>Manhattan</i>	70 92.11%	6 7.89%	76
<i>Queens</i>	499 93.62%	34 6.38%	533
<i>Staten Island</i>	24 100.00%	0 0.00%	24
<i>Total</i>	1,037 95.14%	53 4.86%	1,090

Accepted and Refused LTBI Treatment

Among the $N=863$ household contacts that were offered LTBI treatment, over three-fourths (76.13%, $n=657$) of household contacts accepted and completed LTBI treatment while less than a quarter of household contacts refused LTBI treatment (23.87%, $n=206$).

The proportion of household contacts that accepted treatment did not significantly differ by gender, in Table 17. A chi-squared test of independence looking at the relationship between accepting LTBI treatment by gender ($\chi^2(1)=0.01$, $p=0.91$) was not significant.

Table 17. Demographic Characteristics of Household Contacts Accepted Versus Refused LTBI Treatment by Gender

	Accepted	Refused	Total
<i>Male</i>	324	100	424
	76.42%	23.58%	
<i>Female</i>	333	106	439
	75.85%	24.15%	
<i>Total</i>	657	206	863
	76.13%	23.87%	

The proportion of household contacts that accepted treatment significantly differed by age group, in Table 18. A chi-squared test of independence looking at the relationship between accepting treatment by age group ($\chi^2(3)=45.22, p<.001$) was significant. Across age groups, the highest proportion accepted and completed LTBI treatment among household contacts aged 0-17 (95.86%, $n=162$). A similar proportion of household contacts accepted and completed LTBI treatment for age groups aged 18 and above: 18-44 years old (71.96%, $n=290$), 45-64 years old (70.51%, $n=165$), 65+ years old (70.18%, $n=40$).

Table 18. Demographic Characteristics of Household Contacts Accepted Versus Refused LTBI Treatment by Age Group

	Accepted	Refused	Total
<i>0-17</i>	162	7	169
	95.86%	4.14%	
<i>18-44</i>	290	113	403
	71.96%	28.04%	
<i>45-64</i>	165	69	234
	70.51%	29.49%	
<i>65+</i>	40	17	57
	70.18%	29.82%	
<i>Total</i>	657	206	863
	76.13%	23.87%	

The proportion of household contacts that accepted treatment significantly differed by country of birth, in Table 19. A chi-squared test of independence looking at the relationship between accepting treatment by country of birth ($\chi^2(1)=19.53$, $p<.001$) was significant. A higher proportion accepted and completed LTBI treatment among household contacts born in the US (89.94%, $n=143$) than among household contacts born outside the US (73.01%, $n=514$).

Table 19. Demographic Characteristics of Household Contacts Accepted Versus Refused LTBI Treatment by Country of Birth

	Accepted	Refused	Total
<i>US-Born</i>	143	16	159
	89.94%	10.06%	
<i>Non-US-Born</i>	514	190	704
	73.01%	26.99%	
<i>Total</i>	657	206	863
	76.13%	23.87%	

The proportion of household contacts that accepted treatment significantly differed by race/ethnicity, in Table 20. A chi-squared test of independence looking at the relationship between accepting treatment by race/ethnicity ($\chi^2(4)=17.88, p<.001$) was significant. Across race/ethnicity, the highest proportion of household contacts that accepted and completed LTBI treatment identified as Hispanic (84.21%, $n=224$). The lowest proportion of household contacts that accepted and completed LTBI treatment identified as non-Hispanic White (62.16%, $n=23$). Nearly three-quarters of household contacts identifies as Asian (74.23%, $n=291$) and identified as non-Hispanic Black (72.66%, $n=93$) accepted and completed LTBI treatment.

Table 20. Demographic Characteristics of Household Contacts Accepted Versus Refused LTBI Treatment by Race/Ethnicity

	Accepted	Refused	Total
<i>Non-Hispanic Black</i>	93	35	128
	72.66%	27.34%	
<i>Hispanic</i>	224	42	266
	84.21%	15.79%	
<i>Asian</i>	291	101	392
	74.23%	25.77%	
<i>Non-Hispanic White</i>	23	14	37
	62.16%	37.84%	
<i>Other</i>	26	14	40
	65.00%	35.00%	
<i>Total</i>	657	206	863
	76.13%	23.87%	

The proportion of household contacts that accepted treatment significantly differed by borough, in Table 21. A chi-squared test of independence looking at the relationship between accepting treatment by borough ($\chi^2(4)=16.73, p<.01$) was significant. Across borough, the highest proportion of household contacts that accepted and completed LTBI treatment lived in the Bronx (92.05%, $n=81$). The lowest proportion of household contacts that accepted and completed LTBI treatment lived in Brooklyn (71.28%, $n=206$), Staten Island (71.43%, $n=15$), or Manhattan (72.55%, $n=37$). Over three-quarters of household contacts that lived in Queens (76.81%, $n=318$) accepted and completed LTBI treatment.

Table 21. Demographic Characteristics of Household Contacts Accepted Versus Refused LTBI Treatment by Borough

	Accepted	Refused	Total
<i>Bronx</i>	81	7	88
	92.05%	7.95%	
<i>Brooklyn</i>	206	83	289
	71.28%	28.72%	
<i>Manhattan</i>	37	14	51
	72.55%	27.45%	
<i>Queens</i>	318	96	414
	76.81%	23.19%	
<i>Staten Island</i>	15	6	21
	71.43%	28.57%	
<i>Total</i>	657	206	863
	76.13%	23.87%	

Household Contacts Tested, Fully Evaluated, and Accepted/Completed LTBI treatment between Two Periods from September 2010-July 2012 and July 2012-December 2014

To address the secondary aim, which is to evaluate the proportion of contacts tested and evaluated based on type of provider, difference in outcomes at the three points (TB testing, full evaluation, and LTBI treatment) were compared based on two time periods. During the first time period September 2010 through June 2012, nurses were the primary case managers while those in the second time period, July 2012 through December 2014, PHAs were the primary case managers.

The proportion of household contacts being tested did not significantly differ by time period, in Table 22. A chi-squared test of independence looking at the relationship between testing by time period ($\chi^2(1)=0.21$, $p=0.65$) was not significant.

Table 22. Household Tested Treatment Between September 2010-July 2012 Versus July 2012-December 2014

	Tested	Not Tested	Total
<i>Sept. 2010-June 2012</i>	1,220	62	1,282
	95.16%	4.84%	
<i>July 2012-Dec. 2014</i>	1,630	96	1,726
	94.44%	5.56%	
<i>Total</i>	2,850	158	3,008
	94.75%	5.25%	

The proportion of household contacts that tested positive significantly differed by time period, in Table 23. A chi-squared test of independence looking at the relationship between TB results by time period ($\chi^2(1)=28.81$, $p<.001$) was significant. A lower proportion of household contacts that were tested for TB tested positive in July 2012-December 2014 (33.99%, $n=554$) than household contacts that were tested for TB and tested positive in September 2010-June 2012 (43.93%, $n=536$).

Table 23. TB Results Between September 2010-July 2012 Versus July 2012-December 2014

	Positive	Negative	Total
<i>Sept. 2010-June 2012</i>	536	684	1,220
	43.93%	56.07%	
<i>July 2012-Dec. 2014</i>	554	1,076	1,630
	33.99%	66.01%	
<i>Total</i>	1,090	1,760	2,850
	38.25%	61.75%	

The proportion of household contacts that were fully evaluated did not significantly differ by time period, in Table 24. A chi-squared test of independence looking at the relationship between evaluation by time period ($\chi^2(1)=2.35$, $p=0.13$) was not significant.

Table 24. Fully Evaluated Between September 2010-July 2012 Versus July 2012-December 2014

	Fully Evaluated	Not Fully Evaluated	Total
<i>Sept. 2010-June 2012</i>	504	32	536
	94.03%	5.97%	
<i>July 2012-Dec. 2014</i>	533	21	554
	96.21%	3.79%	
<i>Total</i>	1,037	53	1,090
	95.14%	4.86%	

The proportion of household contacts that accepted treatment did not significantly differ by time period, in Table 25. A chi-squared test of independence looking at the

relationship between treatment by time period ($\chi^2(1)=1.90, p=0.17$) was not significant. A higher proportion of household contacts that were fully evaluated, accepted treatment in July 2012-December 2014 (78.15%, $n=354$) than household contacts that were fully evaluated and accepted treatment in September 2010-June 2012 (73.90%, $n=303$).

Table 25. LTBI Treatment Between September 2010-July 2012 Versus July 2012-December 2014

	Accepted	Refused	Total
<i>Sept. 2010-June 2012</i>	303	107	410
	73.90%	26.10%	
<i>July 2012-Dec. 2014</i>	354	99	453
	78.15%	21.85%	
<i>Total</i>	657	206	863
	76.13%	23.87%	

Appendix Tables A8-A13 provide a summary of all univariate analyses.

Multivariate Analyses

Logistic regression was used to analyze predictor variables (demographic characteristics) associated with the three outcome variables at three time points: TB testing, full evaluation, and LTBI treatment.

The logistic regressions are used to examine the effects of multiple variables on the outcome variable and isolate each individual variable's effect on the outcome variable while controlling for the others. Interpretation of the statistical results and a discussion of them as they relate to the hypotheses will follow.

TB Testing

The factors impacting likelihood of a household contact being tested for TB are explored. Logistic regression models were fit to the data to see if age group, country of birth, race/ethnicity, and borough of residence impacted likelihood of a household contact being tested for TB and to explore how these variables interact.

As illustrated in Table 26, age is the only demographic characteristic that was found to be significant predictors of accepting TB testing after controlling for all other variables. The following explains the stepwise logistic regression models.

Model 1 – Age

A model was fit to the data which looked at the household contact age as a predictor of whether the household contact was tested or not for TB. The model was a significantly better fit than a model which did not include age as a predictor variable, $\chi^2(3)=41.18, p<.001$.

Age group was a significant predictor of whether a household contact would be tested for TB. Household contacts aged 18-44 are significantly less likely to be tested than household contacts younger than 18 are to be tested for TB, $\beta=-1.86$, $SE(\beta)=0.40$, $z=-4.65$, $p<.001$. They are 0.16 times (OR 95% CI: 0.07, 0.34) as likely to be tested than minors. Household contacts aged 45-64 are significantly less likely to be tested than household contacts less than 18 are to be tested for TB, $\beta=-1.96$, $SE(\beta)=0.42$, $z=-4.69$, $p<.001$. They are 0.14 times (OR 95% CI: 0.06, 0.32) as likely to be tested than minors. Household contacts aged 65+ are significantly less likely to be tested than household contacts less than 18 are to be tested for TB, $\beta=-2.01$, $SE(\beta)=0.49$, $z=-4.09$, $p<.001$. They are 0.13 times (OR 95% CI: 0.05, 0.35) as likely to be tested than minors.

Therefore, age is a significant predictor of TB testing. Adult household contacts are significantly less likely to be tested than minors. The older the person, the less likely tested.

Model 2 – Country of Birth

A second model was fit to the data which looked at the household contact country of birth as a predictor of whether the household contact was tested or not for TB in addition to the variables in model 1. The model was not a significantly better fit than a model which did not include country of birth as a predictor variable, $\chi^2(1)=0.32$, $p=.86$. Country of birth was not a significant predictor of whether a household contact was tested or not for TB, controlling for age.

Model 3 – Race/Ethnicity

A third model was fit to the data which looked at the household contact race/ethnicity as a predictor of whether the household contact was tested or not for TB in addition to the variables in model 2. The model was not a significantly better fit than a model which did not include race/ethnicity as a predictor variable, $\chi^2(4)=5.29$, $p=.26$. Race/Ethnicity was not a significant predictor of whether a household contact was tested or not for TB, controlling for age, and country of birth.

Model 4 – Borough (Full Model)

A fourth model was fit to the data which looked at the household contact borough of residence as a predictor of whether the household contact was tested or not for TB in

addition to the variables in model 4. The model was not a significantly better fit than a model which did not include borough of residence as a predictor variable, $\chi^2(4)=3.41$, $p=.49$. Borough of residence was not a significant predictor of whether a household contact was tested or not for TB, controlling for age, country of birth, and Race/Ethnicity. However, the full model with age, country of birth, race/ethnicity, and borough of residence was a significantly better fit than the null intercept-only model, $\chi^2(12)=49.91$, $p<.001$.

Age group was a significant predictor of whether a household contact would be tested for TB. Household contacts aged 18-44 are significantly less likely to be tested than household contacts younger than 18 are to be tested for TB, $\beta=-1.77$, $SE(\beta)=0.44$, $z=-4.04$, $p<.001$. They are 0.17 times (OR 95% CI: 0.07, 0.38) as likely to be tested than minors. Household contacts aged 45-64 are significantly less likely to be tested than household contacts less than 18 are to be tested for TB, $\beta=-1.87$, $SE(\beta)=0.46$, $z=-4.06$, $p<.001$. They are 0.15 times (OR 95% CI: 0.06, 0.36) as likely to be tested than minors. Household contacts aged 65+ are significantly less to be likely tested than household contacts less than 18 are to be tested for TB, $\beta=-1.95$, $SE(\beta)=0.53$, $z=-3.66$, $p<.001$. They are 0.14 times (OR 95% CI: 0.05, 0.40) as likely to be tested than minors.

Although household contacts born outside the US are less likely to be tested than household contacts born in the US ($\beta=-0.17$, $SE(\beta)=0.29$, $z=-0.58$, $p=.56$), this difference was not significant.

Race was not a significant predictor of whether a household contact would be tested. Household contacts that identified as Asian were more likely to be tested than household contacts that identified as White ($\beta=0.67$, $SE(\beta)=0.38$, $z=1.75$, $p=.08$) although

this difference only approached significance. Household contacts that identified as Asian are 1.95 times (OR 95% CI: 0.88, 4.00) more likely tested than household contacts that identified as White. Although household contacts that identified as Black were slightly more likely to be tested than household contacts that identified as White ($\beta=0.08$, $SE(\beta)=0.39$, $z=0.21$, $p=.83$), this difference was not significant. Although household contacts that identified as Hispanic were slightly more likely to be tested than household contacts that identified as White ($\beta=0.47$, $SE(\beta)=0.39$, $z=1.22$, $p=.22$), this difference was not significant. Although household contacts that identified as Other race were slightly more likely to be tested than household contacts that identified as White ($\beta=0.07$, $SE(\beta)=0.53$, $z=0.14$, $p=.89$), this difference was not significant.

Borough of residence was not a significant predictor of whether a household contact would be tested. Although household contacts that lived in Brooklyn were slightly more likely to be tested than household contacts that lived in the Bronx ($\beta=0.09$, $SE(\beta)=0.31$, $z=0.30$, $p=.76$), this difference was not significant. Although household contacts that lived in Manhattan were slightly more likely to be tested than household contacts that lived in the Bronx ($\beta=0.21$, $SE(\beta)=0.46$, $z=0.45$, $p=.65$), this difference was not significant. Although household contacts that lived in Queens were slightly less likely to be tested than household contacts that lived in the Bronx ($\beta=-0.23$, $SE(\beta)=0.29$, $z=-0.81$, $p=.42$), this difference was not significant. Although household contacts that lived in Staten Island were slightly more likely to be tested than household contacts that lived in the Bronx ($\beta=0.75$, $SE(\beta)=1.05$, $z=0.71$, $p=.48$), this difference was not significant.

Therefore, non-US born, race/ethnicity & borough did not affect the age of the household contacts tested for TB.

Table 26. Demographic Characteristics Associated with TB Testing (Beta Coefficient and Standard Error in Parentheses)

Dependent Variable: Tested vs Not Tested				
Model	(1)	(2)	(3)	(4)
Independent Variable:				
Age Group				
0-17 (Reference)				
18-44	-1.863*** (0.400)	-1.832*** (0.436)	-1.752*** (0.436)	-1.768*** (0.438)
45-64	-1.958*** (0.418)	-1.924*** (0.459)	-1.843*** (0.459)	-1.869*** (0.461)
65+	-2.014*** (0.493)	-1.979*** (0.531)	-1.926*** (0.531)	-1.954*** (0.534)
Country of Birth				
US Born (Reference)				
Non-US born		-0.048 (0.273)	-0.209 (0.284)	-0.166 (0.286)
Race/Ethnicity				
White (Reference)				
Asian			0.539 (0.374)	0.669* (0.383)
Black			0.053 (0.388)	0.083 (0.391)
Hispanic			0.361 (0.378)	0.475 (0.389)
Other			-0.115 (0.522)	0.074 (0.533)
Borough				
Bronx (Reference)				
Brooklyn				0.093 (0.306)
Manhattan				0.208

				(0.462)
Queens				-0.234 (0.288)
Staten Is				0.748 (1.052)
Constant	4.484*** (0.380)	4.493*** (0.384)	4.232*** (0.497)	4.178*** (0.553)

Observations	2,257	2,257	2,257	2,257
Log Likelihood	-454.020	-454.004	-451.358	-449.655
Akaike Inf. Crit.	916.039	918.008	920.717	925.311
=====				
Note:	*p<0.1; **p<0.05; ***p<0.01			

TB Results: Positive or Negative

The factors impacting likelihood of a household contact testing positive for TB are explored. Logistic regression models were fit to the data to see if age group, country of birth, race/ethnicity, and borough of residence impacted likelihood of a household contact testing positive for TB and to explore how these variables interact.

Three demographic variables were found to be significant predictors of TB test positive, after controlling for all other variables in the model: age-group, non-US born, and borough. As illustrated in Table 27, the only demographic characteristic that was found to be significant predictors of TB test positive vs TB test negative after controlling for all other variables are age, non-US born, and borough. The following explains the stepwise logistic regression models.

Model 1 – Age

A model was fit to the data which looked at the household contact age as a predictor of whether the household contact test positive for TB. The model was a significantly better fit than a model which did not include age as a predictor variable, $\chi^2(3)=125.19, p<.001$.

Age group was a significant predictor of whether a household contact would test positive for TB. Household contacts aged 18-44 are significantly more likely to test positive for TB than household contacts younger than 18 are to test positive for TB, $\beta=0.98, SE(\beta)=0.11, z=8.69, p<.001$. They are 2.66 times (OR 95% CI: 2.15, 3.3) as likely to test positive for TB than minors. Household contacts aged 45-64 are significantly more likely to test positive than household contacts less than 18 are to test positive for TB, $\beta=1.25, SE(\beta)=0.13, z=9.56, p<.001$. They are 3.49 times (OR 95% CI: 2.7, 4.5) as likely to test positive for TB than minors. Household contacts aged 65+ are significantly more likely to test positive than household contacts less than 18 are to test positive for TB, $\beta=1.35, SE(\beta)=0.19, z=6.98, p<.001$. They are 3.86 times (OR 95% CI: 2.66, 5.6) as likely to test positive for TB than minors.

Therefore, age is associated with having a TB test positive. The older the person, the more likely for a person to have a TB test positive.

Model 2 – Country of Birth

A second model was fit to the data which looked at the household contact country of birth as a predictor of whether the household contact test positive for TB in addition to the variables in model 1. The model was a significantly better fit than a model which did not include country of birth as a predictor variable, $\chi^2(1)=78.19, p<.001$.

Age group residence was a significant predictor of whether a household contact would test positive for TB. Household contacts aged 18-44 are significantly more likely to test positive for TB than household contacts younger than 18 are to test positive for TB, $\beta=0.31$, $SE(\beta)=0.14$, $z=2.23$, $p<.05$. They are 1.36 times (OR 95% CI: 0.94, 1.98) as likely to test positive for TB than minors. Household contacts aged 45-64 are significantly more likely to test positive than household contacts less than 18 are to test positive for TB, $\beta=0.51$, $SE(\beta)=0.16$, $z=3.28$, $p<.01$. They are 1.67 times (OR 95% CI: 1.22, 2.28) as likely to test positive for TB than minors. Household contacts aged 65+ are significantly more likely to test positive than household contacts less than 18 are to test positive for TB, $\beta=0.59$, $SE(\beta)=0.21$, $z=2.77$, $p<.01$. They are 1.8 times (OR 95% CI: 1.20, 2.72) as likely to test positive for TB than minors.

Country of birth was a significant predictor of whether a household contact would test positive for TB. Household contacts born outside of the US were significantly more likely to test positive for TB than household contacts born in the US, $\beta=1.11$, $SE(\beta)=0.13$, $z=8.59$, $p<.001$. They are 3.03 times (OR 95% CI: 2.35, 3.91) as likely to test positive for TB than household contacts born in the US.

Model 3 – Race/Ethnicity

A third model was fit to the data which looked at the household contact race/ethnicity as a predictor of whether the household contact test positive for TB in addition to the variables in model 2. The model was not a significantly better fit than a model which did not include race/ethnicity as a predictor variable, $\chi^2(4)=5.76$, $p=.22$.

Race/Ethnicity was not a significant predictor of whether a household contact test positive for TB, controlling for age, and country of birth.

Model 4 – Borough

A fourth model was fit to the data which looked at the household contact borough of residence as a predictor of whether the household contact test positive for TB in addition to the variables in model 4. The model was a significantly better fit than a model which did not include borough of residence as a predictor variable, $\chi^2(4)=20.97, p<.001$.

Age group of household contact was a significant predictor of whether a household contact would test positive for TB. Household contacts aged 18-44 are significantly more likely to test positive for TB than household contacts younger than 18 are to test positive for TB, $\beta=0.31, SE(\beta)=0.14, z=2.23, p<.05$. They are 1.36 times (OR 95% CI: 1.04, 1.79) as likely to test positive for TB than minors. Household contacts aged 45-64 are significantly more likely to test positive than household contacts less than 18 are to test positive for TB, $\beta=0.53, SE(\beta)=0.16, z=3.35, p<.001$. They are 1.7 times (OR 95% CI: 1.24, 2.32) as likely to test positive for TB than minors. Household contacts aged 65+ are significantly more likely to test positive than household contacts less than 18 are to test positive for TB, $\beta=0.64, SE(\beta)=0.22, z=2.95, p<.01$. They are 1.9 times (OR 95% CI: 1.23, 2.92) as likely to test positive for TB than minors.

Country of birth residence was a significant predictor of whether a household contact would test positive for TB. Household contacts born outside of the US were significantly more likely to test positive for TB than household contacts born in the US,

$\beta=1.09$, $SE(\beta)=0.13$, $z=8.16$, $p<.001$. They are 2.97 times (OR 95% CI: 0.84, 3.84) as likely to test positive for TB than household contacts born in the US.

Race/Ethnicity was not a significant predictor of whether a household contact would test positive for TB. Although household contacts that identified as Asian were slightly less likely to test positive for TB than household contacts that identified as White ($\beta=-0.06$, $SE(\beta)=0.20$, $z=-0.32$, $p=.75$), this difference was not significant. Although household contacts that identified as Black were slightly more likely to test positive for TB than household contacts that identified as White ($\beta=0.03$, $SE(\beta)=0.21$, $z=0.16$, $p=.87$), this difference was not significant. Although household contacts that identified as Hispanic were slightly more likely to test positive for TB than household contacts that identified as White ($\beta=0.17$, $SE(\beta)=0.21$, $z=0.82$, $p=.41$), this difference was not significant. Household contacts that identified as Other race were more likely to test positive for TB than household contacts that identified as White ($\beta=0.52$, $SE(\beta)=0.30$, $z=1.69$, $p=.09$) although this difference only approached significance. Household contacts that identified as Other race are 1.68 times (OR 95% CI: 0.93, 3.03) more likely to test positive for TB than household contacts that identified as White.

Borough of residence was a significant predictor of whether a household contact would test positive for TB. Household contacts that lived in Brooklyn were significantly more likely to test positive for TB than household contacts that lived in the Bronx, $\beta=0.59$, $SE(\beta)=0.15$, $z=3.94$, $p<.001$. Household contacts that lived in Brooklyn are 1.8 times (OR 95% CI: 1.34, 2.42) more likely to test positive for TB than household contacts that lived in the Bronx. Household contacts that lived in Manhattan were significantly more likely to test positive for TB than household contacts that lived in the

Bronx, $\beta=0.44$, $SE(\beta)=0.21$, $z=2.08$, $p<.05$. Household contacts that lived in Manhattan are 1.55 times (OR 95% CI: 1.03, 2.34) more likely to test positive for TB than household contacts that lived in the Bronx. Household contacts that lived in Queens were significantly more likely to test positive for TB than household contacts that lived in the Bronx, $\beta=0.60$, $SE(\beta)=0.14$, $z=4.19$, $p<.001$. Household contacts that lived in Queens are 1.82 times (OR 95% CI: 1.38, 2.39) more likely to test positive for TB than household contacts that lived in the Bronx. Household contacts that lived in Staten Island were significantly more likely to test positive for TB than household contacts that lived in the Bronx, $\beta=0.83$, $SE(\beta)=0.36$, $z=2.34$, $p<.05$. Household contacts that lived in Staten Island are 2.3 times (OR 95% CI: 1.13, 4.64) more likely to test positive for TB than household contacts that lived in the Bronx.

Model 5 – Gender (Full Model)

A fifth model was fit to the data which looked at the household contact gender as a predictor of whether the household contact test positive for TB in addition to the variables in model 4. The model was not a significantly better fit than a model which did not include gender as a predictor variable, $\chi^2(1)=0.99$, $p=.32$. Gender was not a significant predictor of whether a household contact test positive or not for TB, controlling for age, country of birth, race/ethnicity, and borough of residence.

However, the full model which included age, country of birth, race/ethnicity, borough of residence, and gender was a significantly better fit than the null intercept-only model, $\chi^2(13)=231.1$, $p=<0.000$.

Age group was a significant predictor of whether a household contact would test positive for TB. Household contacts aged 18-44 are significantly more likely to test positive for TB than household contacts younger than 18 are to test positive for TB, $\beta=0.31$, $SE(\beta)=0.14$, $z=2.23$, $p<.05$. They are 1.36 times (OR 95% CI: 1.04, 1.79) as likely to test positive for TB than minors. Household contacts aged 45-64 are significantly more likely to test positive for TB than household contacts less than 18 are to test positive for TB, $\beta=0.54$, $SE(\beta)=0.16$, $z=3.37$, $p<.001$. They are 1.72 times (OR 95% CI: 1.25, 2.35) as likely to test positive for TB than minors. Household contacts aged 65+ are significantly more likely to test positive for TB than household contacts less than 18 are to test positive for TB, $\beta=0.65$, $SE(\beta)=0.22$, $z=3.01$, $p<.01$. They are 1.92 times (OR 95% CI: 1.24, 2.95) as likely to test positive for TB than minors.

Country of birth was a significant predictor of whether a household contact would test positive for TB. Household contacts born outside of the US were significantly more likely to test positive for TB than household contacts born in the US, $\beta=1.09$, $SE(\beta)=0.13$, $z=8.09$, $p<.001$. They are 2.97 times (OR 95% CI: 2.31, 3.84) as likely to test positive for TB than household contacts born in the US.

Race/Ethnicity was not a significant predictor of whether a household contact would test positive for TB. Although household contacts that identified as Asian were slightly less likely to test positive for TB than household contacts that identified as White ($\beta=-0.06$, $SE(\beta)=0.20$, $z=-0.28$, $p=.78$), this difference was not significant. Although household contacts that identified as Black were slightly more likely to test positive for TB than household contacts that identified as White ($\beta=0.04$, $SE(\beta)=0.21$, $z=0.18$, $p=.86$), this difference was not significant. Although household contacts that identified as

Hispanic were slightly more likely to test positive for TB than household contacts that identified as White ($\beta=0.17$, $SE(\beta)=0.21$, $z=0.82$, $p=.41$), this difference was not significant. Household contacts that identified as Other race were more likely to test positive for TB than household contacts that identified as White ($\beta=0.52$, $SE(\beta)=0.31$, $z=1.70$, $p=.09$) although this difference only approached significance. Household contacts that identified as Other race are 1.68 times (OR 95% CI: 0.93, 3.07) more likely to test positive for TB than household contacts that identified as White.

Borough of residence was a significant predictor of whether a household contact would test positive for TB. Household contacts that lived in Brooklyn were significantly more likely to test positive for TB than household contacts that lived in the Bronx, $\beta=0.59$, $SE(\beta)=0.15$, $z=3.95$, $p<.001$. Household contacts that lived in Brooklyn are 1.80 times (OR 95% CI: 1.35, 2.42) more likely to test positive for TB than household contacts that lived in the Bronx. Household contacts that lived in Manhattan were significantly more likely to test positive for TB than household contacts that lived in the Bronx, $\beta=0.44$, $SE(\beta)=0.21$, $z=2.09$, $p<.05$. Household contacts that lived in Manhattan are 1.55 times (OR 95% CI: 1.03, 2.34) more likely to test positive for TB than household contacts that lived in the Bronx. Household contacts that lived in Queens were significantly more likely to test positive for TB than household contacts that lived in the Bronx, $\beta=0.60$, $SE(\beta)=0.14$, $z=4.18$, $p<.001$. Household contacts that lived in Queens are 1.82 times (OR 95% CI: 1.38, 2.42) more likely to test positive for TB than household contacts that lived in the Bronx. Household contacts that lived in Staten Island were significantly more likely to test positive for TB than household contacts that lived in the Bronx, $\beta=0.83$, $SE(\beta)=0.36$, $z=2.35$, $p<.05$. Household contacts that lived in Staten Island

are 2.30 times (OR 95% CI: 1.14, 4.62) more likely to test positive for TB than household contacts that lived in the Bronx.

Gender was not a significant predictor of whether a household contact would test positive for TB. Although household contacts that identified as Male were slightly less likely to test positive for TB than household contacts that identified as Female ($\beta=0.09$, $SE(\beta)=0.09$, $z=1.00$, $p=.32$), this difference was not significant

Therefore, age, non-US born, and borough are significant predictors; gender and race/ethnicity are non-significant predictors of a TB test positive among contacts.

Table 27. Demographic Characteristics Associated with Positive Versus Negative TB Test Result (Beta Coefficient and Standard Error in Parentheses)

Dependent Variable: TB Test Positive vs TB Test Negative					
Model	(1)	(2)	(3)	(4)	(5)
Independent Variable:					
Age Group					
0-17 (Reference)					
18-44	0.984*** (0.113)	0.309** (0.139)	0.309** (0.140)	0.313** (0.140)	0.312** (0.141)
45-64	1.248*** (0.131)	0.512*** (0.156)	0.522*** (0.158)	0.533*** (0.159)	0.537*** (0.159)
65+	1.351*** (0.193)	0.590*** (0.214)	0.617*** (0.215)	0.638*** (0.216)	0.654*** (0.217)
Country of Birth					
US Born (Reference)					
Non-US Born		1.105*** (0.129)	1.094*** (0.133)	1.094*** (0.134)	1.086*** (0.134)
Race/Ethnicity					

White (Reference)					
Asian	-0.035 (0.198)	-0.063 (0.202)	-0.057 (0.202)		
Black	-0.071 (0.211)	0.034 (0.214)	0.038 (0.214)		
Hispanic	0.065 (0.200)	0.169 (0.205)	0.168 (0.205)		
Other Race	0.499* (0.300)	0.516* (0.305)	0.518* (0.305)		
Borough					
Bronx (Reference)					
Brooklyn		0.587*** (0.149)	0.589*** (0.149)		
Manhattan		0.436** (0.210)	0.438** (0.210)		
Queens		0.600*** (0.143)	0.599*** (0.143)		
Staten Is.		0.831** (0.355)	0.834** (0.355)		
Gender					
Female (Reference)					
Male				0.091 (0.091)	
Constant	-1.166*** (0.094)	-1.427*** (0.102)	-1.435*** (0.203)	-1.980*** (0.242)	-2.024*** (0.246)

Observations	2,257	2,257	2,257	2,257	2,257
Log Likelihood	-1,468.496	-1,429.399	-1,426.521	-1,416.034	-1,415.537
Akaike Inf. Crit.	2,944.992	2,868.799	2,871.042	2,858.068	2,859.074

Note: *p<0.1; **p<0.05; ***p<0.01

Fully Evaluated

The factors impacting likelihood of a household contact being fully evaluated are explored. Logistic regression models were fit to the data to see if age group, country of birth, race/ethnicity, and borough of residence impacted likelihood of a household contact being fully evaluated and to explore how these variables interact.

Four demographic variables were found to be significant predictors of fully evaluated contacts, after controlling for all other variables in the model: gender, age-group, non-US born, and race/ethnicity. As illustrated in Table 28, the only demographic characteristic that was found to be significant predictors of being fully evaluated after controlling for all other variables: gender, age-group, non-US born, and race/ethnicity. The following explains the stepwise logistic regression models.

Model 1 – Country of Birth

A model was fit to the data which looked at the household contact country of birth as a predictor of whether the household was fully evaluated. The model was a significantly better fit than a model which did not include country of birth as a predictor variable, $\chi^2(1)=19.23, p<.001$.

Country of birth was a significant predictor of whether a household contact was fully evaluated. Household contacts born outside of the US were significantly less likely to be fully evaluated than household contacts born in the US, $\beta=-0.65, SE(\beta)=0.16, z=-4.18, p<.001$. Household contacts born outside of the US are 0.52 times (OR 95% CI: 0.38, 0.71) as likely to be fully evaluated than household contacts born in the US.

Model 2 – Gender

A second model was fit to the data which looked at the household contact gender as a predictor of whether the household contact was fully evaluated in addition to the variables in model 1. The model was a significantly better fit than a model which did not include gender as a predictor variable, $\chi^2(1)=7.77, p<.01$.

Country of birth was a significant predictor of whether a household contact was fully evaluated. Household contacts born outside of the US were significantly less likely to be fully evaluated than household contacts born in the US, $\beta=-0.64, SE(\beta)=0.16, z=-4.05, p<.001$. Household contacts born outside of the US are 0.53 times (OR 95% CI: 0.39, 0.72) as likely to be fully evaluated than household contacts born in the US.

Gender was a significant predictor of whether a household contact was fully evaluated. Household contacts that identified as Male were significantly less likely to be fully evaluated than household contacts that identified as Female, $\beta=-0.37, SE(\beta)=0.13, z=-2.78, p<.01$. Household contacts identified as Male are 0.69 times (OR 95% CI: 0.54, 0.89) as likely to be fully evaluated than household contacts identified as Female.

Model 3 – Age

A third model was fit to the data which looked at the household contact age as a predictor of whether the household contact was fully evaluated in addition to the variables in model 2. The model was a significantly better fit than a model which did not include age as a predictor variable, $\chi^2(3)=73.51, p<.001$.

Country of birth was not a significant predictor of whether a household contact was fully evaluated. Although household contacts born outside of the US were slightly

more likely to be fully evaluated than household contacts born in the US ($\beta=0.28$, $SE(\beta)=0.18$, $z=1.57$, $p=.12$), this difference was not significant.

Gender was a significant predictor of whether a household contact was fully evaluated. Household contacts that identified as Male were significantly less likely to be fully evaluated than household contacts that identified as Female, $\beta=-0.38$, $SE(\beta)=0.13$, $z=-2.84$, $p<.01$. Household contacts identified as Male are 0.68 times (OR 95% CI: 0.53, 0.88) as likely to be fully evaluated than household contacts identified as Female.

Age group was a significant predictor of whether a household contact was fully evaluated. Household contacts aged 18-44 are significantly less likely to be fully evaluated than household contacts younger than 18 are to be fully evaluated, $\beta=-2.09$, $SE(\beta)=0.29$, $z=-7.31$, $p<.001$. They are 0.12 times (OR 95% CI: 0.07, 0.22) less likely to be fully evaluated than minors. Household contacts aged 45-64 are significantly less likely to be fully evaluated than household contacts younger than 18 are to be fully evaluated, $\beta=-2.07$, $SE(\beta)=0.31$, $z=-6.77$, $p<.001$. They are 0.13 times (OR 95% CI: 0.07, 0.23) less likely to be fully evaluated than minors. Household contacts aged 65+ are significantly less likely to be fully evaluated than household contacts younger than 18 are to be fully evaluated, $\beta=-1.86$, $SE(\beta)=0.38$, $z=-4.84$, $p<.001$. They are 0.16 times (OR 95% CI: 0.07, 0.33) less likely to be fully evaluated than minors.

Therefore, age is associated with not being fully evaluated. The older the person, the less likely for a household contact to be fully evaluated.

Model 4 – Borough

A fourth model was fit to the data which looked at the household contact borough of residence as a predictor of whether the household contact was fully evaluated in addition to the variables in model 3. The model was not a significantly better fit than a model which did not include borough of residence as a predictor variable, $\chi^2(4)=3.16$, $p=.53$. Borough of residence was not a significant predictor of whether a household contact was fully evaluated, controlling for country of birth, gender, and age.

Model 5 – Race/Ethnicity (Full Model)

A fifth model was fit to the data which looked at the household contact race/ethnicity as a predictor of whether the household contact was fully evaluated in addition to the variables in model 4. The model was not a significantly better fit than a model which did not include race/ethnicity as a predictor variable, $\chi^2(4)=11.41$, $p<.05$. Additionally, the full model was a significantly better fit than the null intercept-only model, $\chi^2(13)=115.1$, $p=< 0.00001$.

Country of birth was not a significant predictor of whether a household contact was fully evaluated. Although household contacts born outside of the US were slightly more likely to be fully evaluated than household contacts born in the US ($\beta=0.12$, $SE(\beta)=0.19$, $z=0.65$, $p=.52$), this difference was not significant.

Gender was a significant predictor of whether a household contact was fully evaluated. Household contacts that identified as Male were significantly less likely to be fully evaluated than household contacts that identified as Female, $\beta=-0.38$, $SE(\beta)=0.14$, $z=-2.78$, $p<.01$. Household contacts identified as Male are 0.69 times (OR 95% CI: 0.52, 0.89) less likely to be fully evaluated than household contacts identified as Female.

Age group was a significant predictor of whether a household contact was fully evaluated. Household contacts aged 18-44 are significantly less likely to be fully evaluated than household contacts younger than 18 are to be fully evaluated, $\beta=-2.01$, $SE(\beta)=0.29$, $z=-7.02$, $p<.001$. They are 0.13 times (OR 95% CI: 0.07, 0.23) less likely to be fully evaluated than minors. Household contacts aged 45-64 are significantly less likely to be fully evaluated than household contacts younger than 18 are to be fully evaluated, $\beta=-1.98$, $SE(\beta)=0.31$, $z=-6.43$, $p<.001$. They are 0.14 times (OR 95% CI: 0.07, 0.25) less likely to be fully evaluated than minors. Household contacts aged 65+ are significantly less likely to be fully evaluated than household contacts younger than 18 are to be fully evaluated, $\beta=-1.76$, $SE(\beta)=0.39$, $z=-4.57$, $p<.001$. They are 0.17 times (OR 95% CI: 0.08, 0.37) less likely to be fully evaluated than minors.

Borough of residence was not a significant predictor of whether a household contact was fully evaluated. Although household contacts that lived in Brooklyn were slightly less likely to be fully evaluated than household contacts that lived in the Bronx ($\beta=-0.18$, $SE(\beta)=0.22$, $z=-0.85$, $p=.40$), this difference was not significant. Although household contacts that lived in Manhattan were slightly less likely to be fully evaluated than household contacts that lived in the Bronx ($\beta=-0.25$, $SE(\beta)=0.30$, $z=-0.83$, $p=.41$), this difference was not significant. Although household contacts that lived in Queens were slightly less likely to be fully evaluated than household contacts that lived in the Bronx ($\beta=-0.30$, $SE(\beta)=0.21$, $z=-1.44$, $p=.15$), this difference was not significant. Although household contacts that lived in Staten Island were slightly more likely to be fully evaluated than household contacts that lived in the Bronx ($\beta=0.77$, $SE(\beta)=0.76$, $z=1.01$, $p=.31$), this difference was not significant.

Race/Ethnicity was a significant predictor of whether a household contact was fully evaluated. Household contacts that identified as Asian were significantly more likely to be fully evaluated than household contacts that identified as White, $\beta=0.60$, $SE(\beta)=0.27$, $z=2.21$, $p<.05$. Household contacts identified as Asian are 1.81 times (OR 95% CI: 1.05, 3.04) more likely to be fully evaluated than household contacts identified as White. Although household contacts that identified as Black were slightly more likely to be fully evaluated than household contacts that identified as White ($\beta=0.004$, $SE(\beta)=0.28$, $z=0.02$, $p=.99$), this difference was not significant. Although household contacts that identified as Hispanic were slightly more likely to be fully evaluated than household contacts that identified as White ($\beta=0.48$, $SE(\beta)=0.27$, $z=1.74$, $p=.08$), this difference only approached significance. Household contacts identified as Hispanic are 1.61 times (OR 95% CI: 0.93, 2.73) more likely to be fully evaluated than household contacts identified as White. Although household contacts that identified as Other race were slightly more likely to be fully evaluated than household contacts that identified as White ($\beta=0.38$, $SE(\beta)=0.92$, $z=0.36$, $p=.60$), this difference was not significant.

Therefore, non-US born, male gender, and older household contacts are less likely to be fully evaluated. However, Asian as race/ethnicity of contacts are more likely fully evaluated.

Table 28. Demographic Characteristics Associated with Full Evaluation (Beta Coefficient and Standard Error in Parentheses)

Dependent Variable: Fully Evaluated					
Model	(1)	(2)	(3)	(4)	(5)
Independent Variable:					
Country of Birth:					
US Born (Reference)					
Non-US Born	-0.655*** (0.157)	-0.635*** (0.157)	0.284 (0.181)	0.298 (0.185)	0.124 (0.191)
Gender:					
Female (Reference)					
Male		-0.366*** (0.132)	-0.382*** (0.135)	-0.383*** (0.135)	-0.377*** (0.136)
Age Group:					
0-17 (Reference)					
18-44			-2.091*** (0.286)	-2.096*** (0.287)	-2.013*** (0.287)
45-64			-2.073*** (0.306)	-2.076*** (0.307)	-1.980*** (0.308)
65+			-1.857*** (0.383)	-1.847*** (0.385)	-1.760*** (0.386)
Borough:					
Bronx (Reference)					
Brooklyn				-0.186 (0.211)	-0.184 (0.217)
Manhattan				-0.199 (0.301)	-0.253 (0.305)
Queens				-0.166 (0.202)	-0.304 (0.211)
Staten Is.				0.808	0.765

				(0.752)	(0.758)
Race/Ethnicity:					
White (Reference)					
Asian					0.595** (0.270)
Black					0.004 (0.275)
Hispanic					0.477* (0.275)
Other					0.381 (0.414)
Constant	2.476*** (0.138)	2.657*** (0.155)	3.729*** (0.258)	3.860*** (0.303)	3.594*** (0.389)

Observations	2,257	2,257	2,257	2,257	2,257
Log Likelihood	-814.860	-810.972	-774.220	-772.638	-766.934
Akaike Inf. Crit.	1,633.720	1,627.945	1,560.440	1,565.277	1,561.867
=====					
Note:	*p<0.1; **p<0.05; ***p<0.01				

Accepted LTBI treatment

The factors impacting likelihood of a household contact accepting LTBI treatment are explored. Logistic regression models were fit to the data to see if age group, country of birth, race/ethnicity, and borough of residence impacted likelihood of a household contact accepting LTBI treatment and to explore how these variables interact.

Three demographic variables were found to be significant predictors of accepting LTBI treatment, after controlling for all other variables in the model: age-group, non-US born, and race/ethnicity. As illustrated in Table 29, the only demographic characteristic that was found to be significant predictors of accepting LTBI treatment after controlling

for all other variables are age, non-US born, race/ethnicity. The following explains the stepwise logistic regression models.

Model 1 – Age

A model was fit to the data which looked at the household contact age as a predictor of whether the household accepted LTBI treatment. The model was not a significantly better fit than a model which did not include age as a predictor variable, $\chi^2(3)=5.38, p=.15$. Age was not a significant predictor of whether a household contact accepted LTBI treatment

Model 2 – Country of Birth

A second model was fit to the data which looked at the household contact country of birth as a predictor of whether the household contact accepted LTBI treatment in addition to the variables in model 1. The model was a significantly better fit than a model which did not include country of birth as a predictor variable, $\chi^2(1)=32.39, p<.001$.

Age group was not a significant predictor of whether a household contact would accept LTBI treatment. However, household contacts aged 18-44 are significantly less likely to accept LTBI treatment than household contacts younger than 18 are to accept LTBI treatment, $\beta=-0.41, SE(\beta)=0.16, z=-2.56, p<.05$. They are 0.66 times (OR 95% CI: 0.49, 0.91) less likely to accept LTBI treatment than minors. Although household contacts aged 45-64 are slightly less likely to accept LTBI treatment than household contacts less than 18 are to accept LTBI treatment ($\beta=-0.25, SE(\beta)=0.18, z=-1.40, p=.16$), this difference was not significant. Although household contacts aged 65+ are slightly

less likely to accept LTBI treatment than household contacts less than 18 are to accept LTBI treatment ($\beta=-0.39$, $SE(\beta)=0.25$, $z=-1.59$, $p=.11$), this difference was not significant.

Country of birth was a significant predictor of whether a household contact would accept LTBI treatment. Household contacts born outside of the US were significantly more likely to accept LTBI treatment than household contacts born in the US, $\beta=0.85$, $SE(\beta)=0.15$, $z=5.50$, $p<.001$. Household contacts born outside of the US are 2.34 times (OR 95% CI: 1.74, 3.14) more likely to accept LTBI treatment than household contacts born in the US.

Model 3 – Borough of Residence

A third model was fit to the data which looked at the household contact borough of residence as a predictor of whether the household contact accepted LTBI treatment in addition to the variables in model 2. The model was not a significantly better fit than a model which did not include borough of residence as a predictor variable, $\chi^2(4)=3.91$, $p=.42$. Borough of residence was not a significant predictor of whether a household contact accepted LTBI treatment, controlling for age, and country of birth.

Model 4 – Race (Full Model)

A fourth model was fit to the data which looked at the household contact race/ethnicity as a predictor of whether the household contact accepted LTBI treatment in addition to the variables in model 3. The model was a significantly better fit than a model which did not include race/ethnicity as a predictor variable, $\chi^2(4)=11.21$, $p<.05$.

Additional, the full model which included age, country of birth, borough of residence, and race/ethnicity was a significantly better fit than the null intercept-only model, $\chi^2(12)=52.9, p<0.00001$.

Age group was not a significant predictor of whether a household contact would accept LTBI treatment. Household contacts aged 18-44 are significantly less likely to accept LTBI treatment than household contacts younger than 18 are to accept LTBI treatment, $\beta=-0.38, SE(\beta)=0.16, z=-2.32, p<.05$. They are 0.68 times (OR 95% CI: 0.50, 0.94) as likely to accept LTBI treatment than minors. Although household contacts aged 45-64 are slightly less likely to accept LTBI treatment than household contacts less than 18 are to accept LTBI treatment ($\beta=-0.20, SE(\beta)=0.18, z=-1.13, p=.26$), this difference was not significant. Although household contacts aged 65+ are slightly less likely to accept LTBI treatment than household contacts less than 18 are to accept LTBI treatment ($\beta=-0.33, SE(\beta)=0.25, z=-1.34, p=.18$), this difference was not significant.

Country of birth was a significant predictor of whether a household contact would accept LTBI treatment. Household contacts born outside of the US were significantly more likely to accept LTBI treatment than household contacts born in the US, $\beta=0.76, SE(\beta)=0.16, z=4.75, p<.001$. Household contacts born outside of the US are 2.14 times (OR 95% CI: 1.56, 2.93) more likely to accept LTBI treatment than household contacts born in the US.

Borough of residence was not a significant predictor of whether a household contact would accept LTBI treatment. Although household contacts that lived in Brooklyn were slightly more likely to accept LTBI treatment than household contacts that lived in the Bronx ($\beta=0.32, SE(\beta)=0.17, z=1.91, p=.06$), this difference only approached

significance. Household contacts that lived in Brooklyn are 1.38 times (OR 95% CI: 0.99, 1.92) more likely to accept LTBI treatment than household contacts that lived in the Bronx. Although household contacts that lived in Manhattan were slightly more likely to accept LTBI treatment than household contacts that lived in the Bronx ($\beta=0.08$, $SE(\beta)=0.25$, $z=0.34$, $p=.73$), this difference was not significant. Although household contacts that lived in Queens were slightly more likely to accept LTBI treatment than household contacts that lived in the Bronx ($\beta=0.19$, $SE(\beta)=0.16$, $z=1.14$, $p=.25$), this difference was not significant. Although household contacts that lived in Staten Island were slightly more likely to accept LTBI treatment than household contacts that lived in the Bronx ($\beta=0.39$, $SE(\beta)=0.40$, $z=0.97$, $p=.33$), this difference was not significant.

Race/Ethnicity was a significant predictor of whether a household contact would accept LTBI treatment. Household contacts that identified as Asian were significantly more likely to accept LTBI treatment than household contacts that identified as White, $\beta=0.52$, $SE(\beta)=0.26$, $z=2.02$, $p<.05$. Household contacts identified as Asian are 1.68 times (OR 95% CI: 1.01, 2.80) more likely to accept LTBI treatment than household contacts identified as White. Although household contacts that identified as Black were slightly more likely to accept LTBI treatment than household contacts that identified as White ($\beta=0.15$, $SE(\beta)=0.28$, $z=0.55$, $p=.58$), this difference was not significant. Household contacts that identified as Hispanic were significantly more likely to accept LTBI treatment than household contacts that identified as White, $\beta=0.57$, $SE(\beta)=0.26$, $z=2.19$, $p<.05$. Household contacts identified as Hispanic are 1.77 times (OR 95% CI: 1.06, 2.94) more likely to accept LTBI treatment than household contacts identified as White. Although household contacts that identified as Other race were slightly more

likely to accept LTBI treatment than household contacts that identified as White ($\beta=0.65$, $SE(\beta)=0.36$, $z=1.84$, $p=.07$), this difference only approached significance. Household contacts identified as Other race are 1.92 times (OR 95% CI: 0.95, 3.88) more likely to accept LTBI treatment than household contacts identified as White.

Therefore, among the race/ethnicity, Asian and Hispanic are significant predictors of accepting LTBI treatment.

Table 29. Demographic Characteristics Associated with Accepted LTBI Treatment (Beta Coefficient and Standard Error in Parentheses)

Dependent variable: Accepted LTBI Treatment				
Model	(1)	(2)	(3)	(4)
Independent Variable:				
Age Group				
0-17 (Reference)				
18-44	0.127 (0.126)	-0.408** (0.159)	-0.406** (0.159)	-0.375** (0.162)
45-64	0.330** (0.144)	-0.249 (0.178)	-0.251 (0.178)	-0.205 (0.181)
65+	0.205 (0.223)	-0.393 (0.247)	-0.384 (0.248)	-0.335 (0.251)
Country of Birth				
US Born (reference)				
Non-US Born		0.849*** (0.154)	0.837*** (0.156)	0.761*** (0.160)
Borough				
Bronx (Reference)				
Brooklyn			0.287* (0.164)	0.326* (0.171)
Manhattan			0.102	0.085

			(0.243)	(0.246)
Queens			0.256 (0.157)	0.187 (0.164)
Staten Is.			0.346 (0.392)	0.385 (0.398)
Race/Ethnicity				
White (Reference)				
Asian				0.517** (0.256)
Black				0.151 (0.275)
Hispanic				0.569** (0.260)
Other				0.654* (0.357)
Constant	-1.390*** (0.100)	-1.589*** (0.110)	-1.800*** (0.165)	-2.205*** (0.296)

Observations	2,257	2,257	2,257	2,257
Log Likelihood	-1,195.909	-1,179.712	-1,177.755	-1,172.152
Akaike Inf. Crit.	2,399.818	2,369.425	2,373.511	2,370.303
=====				
Note:	*p<0.1; **p<0.05; ***p<0.01			

Refused LTBI treatment

The factors impacting likelihood of a household contact refusing LTBI treatment are explored. Logistic regression models were fit to the data to see if age group, country of birth, race/ethnicity, and borough of residence impacted likelihood of a household contact refusing LTBI treatment and to explore how these variables interact.

Two demographic variables were found to be significant predictors of refusing LTBI treatment, after controlling for all other variables in the model: age-group and

borough. As illustrated in Table 30, the only demographic characteristic that was found to be significant predictors of refused LTBI treatment after controlling for all other variables is age-group and borough. The following explains the stepwise logistic regression models.

Model 1 – Age

A model was fit to the data which looked at the household contact age as a predictor of whether the household refused LTBI treatment. The model was a significantly better fit than a model which did not include age as a predictor variable, $\chi^2(3)=155.88, p<.001$.

Age group was a significant predictor of whether a household contact would refuse LTBI treatment. Household contacts aged 18-44 are significantly more likely to refuse LTBI treatment than household contacts younger than 18 are to refuse LTBI treatment, $\beta=2.51, SE(\beta)=0.32, z=7.97, p<.001$. They are 12.3 times (OR 95% CI: 6.57, 23.04) as likely to refuse LTBI treatment than minors. Household contacts aged 45-64 are significantly more likely to refuse LTBI treatment than household contacts less than 18 are to refuse LTBI treatment, $\beta=2.75, SE(\beta)=0.32, z=8.50, p<.001$. They are 15.64 times (OR 95% CI: 8.35, 29.29) as likely to refuse LTBI treatment than minors. Household contacts aged 65+ are significantly more likely to refuse LTBI treatment than household contacts less than 18 are to refuse LTBI treatment, $\beta=2.63, SE(\beta)=0.37, z=7.10, p<.001$. They are 13.47 times (OR 95% CI: 6.72, 28.65) as likely to refuse LTBI treatment than minors.

Therefore, age is a significant predictor of refused LTBI treatment. Household contacts ages 45-64 are more likely to refuse LTBI treatment.

Model 2 – Country of Birth

A second model was fit to the data which looked at the household contact country of birth as a predictor of whether the household contact refused LTBI treatment in addition to the variables in model 1. The model was not a significantly better fit than a model which did not include country of birth as a predictor variable, $\chi^2(1)=0.01, p=.94$. Country of birth was not a significant predictor of whether a household contact refused LTBI treatment, controlling for age.

Model 3 – Borough of Residence

A third model was fit to the data which looked at the household contact borough of residence as a predictor of whether the household contact refused LTBI treatment in addition to the variables in model 2. The model was a significantly better fit than a model which did not include borough of residence as a predictor variable, $\chi^2(3)=14.30, p<.01$.

Age group was a significant predictor of whether a household contact would refuse LTBI treatment. Household contacts aged 18-44 are significantly more likely to refuse LTBI treatment than household contacts younger than 18 are to refuse LTBI treatment, $\beta=2.52, SE(\beta)=0.34, z=7.51, p<.001$. They are 12.43 times (OR 95% CI: 6.38, 24.2) as likely to refuse LTBI treatment than minors. Household contacts aged 45-64 are significantly more likely to refuse LTBI treatment than household contacts less than 18 are to refuse LTBI treatment, $\beta=2.75, SE(\beta)=0.35, z=7.89, p<.001$. They are 15.64 times

(OR 95% CI: 7.88, 31.06) as likely to refuse LTBI treatment than minors. Household contacts aged 65+ are significantly more likely to refuse LTBI treatment than household contacts less than 18 are to refuse LTBI treatment, $\beta=2.64$, $SE(\beta)=0.39$, $z=6.70$, $p<.001$. They are 14.01 times (OR 95% CI: 6.52, 30.1) as likely to refuse LTBI treatment than minors.

Country of birth was not a significant predictor of whether a household contact would refuse LTBI treatment. Although household contacts born outside of the US were slightly less likely to refuse LTBI treatment than household contacts born in the US ($\beta=-0.01$, $SE(\beta)=0.18$, $z=-0.03$, $p=.98$), this difference was not significant.

Borough of residence was a significant predictor of whether a household contact would refuse LTBI treatment. Household contacts that lived in Brooklyn were significantly more likely to refuse LTBI treatment than household contacts that lived in the Bronx, $\beta=0.72$, $SE(\beta)=0.22$, $z=3.29$, $p<.001$. Household contacts that lived in Brooklyn are 2.05 times (OR 95% CI: 1.33, 3.16) more likely to refuse LTBI treatment than household contacts that lived in the Bronx. Although household contacts that lived in Manhattan were slightly more likely to refuse LTBI treatment than household contacts that lived in the Bronx ($\beta=0.51$, $SE(\beta)=0.30$, $z=1.70$, $p=.09$), this difference only approached significance. Household contacts that lived in Manhattan are 1.67 times (OR 95% CI: 0.92, 3.00) more likely to refuse LTBI treatment than household contacts that lived in the Bronx. Household contacts that lived in Queens were significantly more likely to refuse LTBI treatment than household contacts that lived in the Bronx, $\beta=0.58$, $SE(\beta)=0.21$, $z=2.73$, $p<.01$. Household contacts that lived in Queens are 1.79 times (OR 95% CI: 1.18, 2.70) more likely to refuse LTBI treatment than household contacts that

lived in the Bronx. Household contacts that lived in Staten Island were significantly more likely to refuse LTBI treatment than household contacts that lived in the Bronx, $\beta=1.17$, $SE(\beta)=0.44$, $z=2.64$, $p<.01$. Household contacts that lived in Staten Island are 3.22 times (OR 95% CI: 1.36, 7.63) more likely to refuse LTBI treatment than household contacts that lived in the Bronx.

Model 4 – Race (Full Model)

A fourth model was fit to the data which looked at the household contact race/ethnicity as a predictor of whether the household contact refused LTBI treatment in addition to the variables in model 3. The model was not significantly better fit than a model which did not include race/ethnicity as a predictor variable, $\chi^2(4)=13.65$, $p<.01$. Race/ethnicity was not a significant predictor of whether a household contact refused LTBI treatment, controlling for age, country of birth, borough of residence. However, the full model which included age, country of birth, borough of residence, and race/ethnicity was a significantly better fit than the null intercept-only model $\chi^2(12)=183.8$, $p=<0.00001$.

Age group was a significant predictor of whether a household contact would refuse LTBI treatment. Household contacts aged 18-44 are significantly more likely to refuse LTBI treatment than household contacts younger than 18 are to refuse LTBI treatment, $\beta=2.45$, $SE(\beta)=0.34$, $z=7.31$, $p<.001$. They are 11.59 times (OR 95% CI: 5.95, 22.56) as likely to refuse LTBI treatment than minors. Household contacts aged 45-64 are significantly more likely to refuse LTBI treatment than household contacts less than 18 are to refuse LTBI treatment, $\beta=2.65$, $SE(\beta)=0.35$, $z=7.61$, $p<.001$. They are 14.15 times

(OR 95% CI: 7.13, 28.12) as likely to refuse LTBI treatment than minors. Household contacts aged 65+ are significantly more likely to refuse LTBI treatment than household contacts less than 18 are to refuse LTBI treatment, $\beta=2.54$, $SE(\beta)=0.39$, $z=6.45$, $p<.001$. They are 12.68 times (OR 95% CI: 5.90, 27.23) as likely to refuse LTBI treatment than minors.

Country of birth was not a significant predictor of whether a household contact would refuse LTBI treatment. Although household contacts born outside of the US were slightly more likely to refuse LTBI treatment than household contacts born in the US ($\beta=0.14$, $SE(\beta)=0.19$, $z=0.72$, $p=.47$), this difference was not significant.

Borough of residence was a significant predictor of whether a household contact would refuse LTBI treatment. Household contacts that lived in Brooklyn were significantly more likely to refuse LTBI treatment than household contacts that lived in the Bronx, $\beta=0.70$, $SE(\beta)=0.22$, $z=3.11$, $p<.01$. Household contacts that lived in Brooklyn are 2.01 times (OR 95% CI: 1.31, 6.24) more likely to refuse LTBI treatment than household contacts that lived in the Bronx. Although household contacts that lived in Manhattan were slightly more likely to refuse LTBI treatment than household contacts that lived in the Bronx ($\beta=0.57$, $SE(\beta)=0.30$, $z=1.88$, $p=.06$), this difference only approached significance. Household contacts that lived in Manhattan are 1.77 times (OR 95% CI: 0.98, 3.18) more likely to refuse LTBI treatment than household contacts that lived in the Bronx. Household contacts that lived in Queens were significantly more likely to refuse LTBI treatment than household contacts that lived in the Bronx, $\beta=0.65$, $SE(\beta)=0.22$, $z=2.93$, $p<.01$. Household contacts that lived in Queens are 1.92 times (OR 95% CI: 1.24, 2.95) more likely to refuse LTBI treatment than household contacts that

lived in the Bronx. Household contacts that lived in Staten Island were significantly more likely to refuse LTBI treatment than household contacts that lived in the Bronx, $\beta=1.24$, $SE(\beta)=0.45$, $z=2.78$, $p<.01$. Household contacts that lived in Staten Island are 3.46 times (OR 95% CI: 1.43, 8.35) more likely to refuse LTBI treatment than household contacts that lived in the Bronx.

Race/Ethnicity was not a significant predictor of whether a household contact would refuse LTBI treatment. Although household contacts that identified as Asian were slightly less likely to refuse LTBI treatment than household contacts that identified as White ($\beta=-0.08$, $SE(\beta)=0.27$, $z=-0.31$, $p=.76$), this difference was not significant. Although household contacts that identified as Black were slightly more likely to refuse LTBI treatment than household contacts that identified as White ($\beta=0.43$, $SE(\beta)=0.28$, $z=1.52$, $p=.13$), this difference was not significant. Although household contacts that identified as Hispanic were slightly less likely to refuse LTBI treatment than household contacts that identified as White ($\beta=-0.17$, $SE(\beta)=0.28$, $z=-0.61$, $p=.55$), this difference was not significant. Although household contacts that identified as Other race were slightly more likely to refuse LTBI treatment than household contacts that identified as White ($\beta=0.48$, $SE(\beta)=0.38$, $z=1.27$, $p=.20$), this difference was not significant.

Therefore, household contacts residing from Brooklyn, Queens, and Staten Island are more likely to refuse LTBI treatment.

Table 30. Demographic Characteristics Associated with Refused LTBI Treatment
(Beta Coefficient and Standard Error in Parentheses)

Dependent variable: Refused LTBI Treatment				
Model	(1)	(2)	(3)	(4)
Independent Variable:				
Age Group				
0-17 (Reference)				
18-44	2.512*** (0.315)	2.503*** (0.335)	2.521*** (0.335)	2.451*** (0.335)
45-64	2.749*** (0.323)	2.739*** (0.347)	2.747*** (0.348)	2.651*** (0.348)
65+	2.630*** (0.370)	2.620*** (0.392)	2.638*** (0.394)	2.544*** (0.395)
Country of Birth:				
US Born (Reference)				
Non-US Born		0.014 (0.178)	-0.005 (0.182)	0.136 (0.190)
Borough:				
Bronx (Reference)				
Brooklyn			0.720*** (0.219)	0.699*** (0.225)
Manhattan			0.512* (0.301)	0.573* (0.305)
Queens			0.582*** (0.213)	0.650*** (0.222)
Staten Is.			1.166*** (0.441)	1.245*** (0.449)
Race/Ethnicity:				
White (Reference)				
Asian				-0.083

				(0.271)
Black				0.427 (0.281)
Hispanic				-0.171 (0.282)
Other				0.480 (0.378)
Constant	-4.025*** (0.304)	-4.028*** (0.306)	-4.584*** (0.355)	-4.680*** (0.436)

Observations	2,257	2,257	2,257	2,257
Log Likelihood	-854.067	-854.064	-846.912	-840.089
Akaike Inf. Crit.	1,716.135	1,718.128	1,711.825	1,706.177
=====				
Note:	*p<0.1; **p<0.05; ***p<0.01			

Summary

The significant variables by time point in the univariate and multivariate analyses are presented in Appendix Table A14. The VIF score in this sample were all below 2, therefore, there was no problem with collinearity. For the bivariate analysis, the data at different time points appeared to differ across a number of variables. The multivariate analysis revealed a more limited set of variables predicted household contact behavior at different time points. Age is a significant predictor behavior at three time points, TB testing, evaluation, and LTBI treatment. On household contacts tested for TB, adults are significantly less likely tested than minors. The older the person, the less likely they are tested. Race/ethnicity & borough did not affect the age of the contacts tested for TB. On household contacts fully evaluated, older household contacts, male gender, non-US born are less likely to be fully evaluated. However, Asian and Hispanic as race/ethnicity of

household contacts are more likely fully evaluated. Household contacts who are non-US born that reside in Brooklyn, Queens, and Staten Island are more likely to have a TB test positive. Moreover, older household contacts are more likely to have a TB test positive. On accepting LTBI treatment, age of household contact alone is not a significant predictor. However, older household contacts who are non US born are less likely to accept LTBI treatment. Asian and Hispanic as race/ethnicity of household contacts are more likely to accept LTBI treatment. On refusing LTBI treatment, the older the household contacts from Brooklyn, Queens and Staten Island are more likely to refuse LTBI treatment. And, the proportion of contacts tested, evaluated, and accepted/completed or refused LTBI treatment did not significantly differ based on type of provider.

Chapter 5: Discussion

Most research has focused on active case finding and treatment of TB disease while there are few studies examining factors associated with TB testing and evaluation among TB contacts. This study addresses this gap by considering the demographic factors among household contacts of active TB cases associated with TB testing as well as evaluation and LTBI treatment.

Convincing asymptomatic household contacts to accept TB testing and evaluation is a significant challenge for public health agencies (Zenner et al., 2017). Gaps in knowledge about TB among contacts, and gaps in providers' knowledge of identifying and selecting contacts for testing are barriers to testing and evaluation of contacts (Anderson et al., 2014; Anger et al., 2012; Cates et al., 2015; Chakhaia et al., 2014; Dresser et al., 2012; Flood & Barry, 2017; Fox et al., 2015; Kambali et al., 2015; Ratovoson et al., 2014). The health promotion model (HPM) of Nola Pender guided the examination of factors that influence acceptance of TB testing and evaluation and the selection of variables for testing, evaluation and LTBI treatment. According to HPM understanding the factors of the major determinants of health behavior informed the counseling of healthy behavior, which was acceptance of TB testing and evaluation. In addition, the HMP implied that an individual was partially shaped by environment which in this case include the social determinants of TB, cultural beliefs, and stigma that posed as barriers that prevented contacts from getting tested and evaluated

The data from this study revealed several interesting patterns in the demographic characteristics of those that accepted versus those that refused testing and evaluation. Testing and evaluation are not effective if not linked to treatment of LTBI. Knowing the

factors associated with accepting or refusing LTBI treatment is vital in planning strategies to control TB.

TB Cases in US and New York City

In the United States (US), from 1993 to 2016, there has been an annual decline in the number of cases and incidence of TB. Since 2010, the total number of cases in the US has declined from 3.9 cases per 100,000 population to 2.9 cases per 100,000 population in 2016. Although, TB cases and rates have declined, non-US born and racial/ethnic minorities were disproportionately affected by TB in the U.S. (Stennis et al., 2015), yet the rates are also declining. In 2010, the rate of TB among the non-US born was 18.1 cases per 100,000 population compared to 14.6 cases per 100,000 in 2016 (CDC, 2010; CDC 2016). This decline in cases among the non-US born has been attributed to changes in the size of the non-US born entrants to the US, changes in the distribution of country of origin among the non-US born and changes in the rate of TB among non-US born subpopulations (Baker et al., 2016). Among the 50 states in the US, four states (California, Texas, New York, and Florida) accounted for most TB cases. The top five countries of origin for non-US born were Mexico, Philippines, India, Vietnam and China (CDC, 2016). Asians continue to be the racial/ethnic group with the largest number of TB cases (CDC2010; CDC 2016).

In New York City (N.Y.C.), from 1992 to 2016, there has been an 85% decrease in the number of TB cases. The top five countries with high rates of TB were China, U.S., Mexico, Philippines, and Bangladesh (BTBC, 2016). It is interesting to note that the U.S. was among the top five countries with high rate of TB. This can be attributed to high levels of population mobility among the non-US born that exposes the US born to

TB (Hargreaves et al., 2011); and a greater proportion of homelessness among the US born, together with other factors associated with homelessness such as HIV and substance abuse which are risk factors for TB (Bamrah et al., 2013). In 2017, there were 613 confirmed cases of TB disease reported to the Department of Health and Mental Hygiene (DOHMH) which corresponds to 7.5 per 100,000 population citywide, however, this is more than two times the national rate (2.8 per 100,000). And a ten percent increase in the number of TB cases from 2016 to 2017 (BTBC, 2017). Tuberculosis has affected all age groups, and races, and yet disproportionately affects the non-US born. Eighty six percent of all TB cases occurred among the non-US born (BTBC, 2017). The TB rates among Asians are five times higher than US-born non-Hispanic Whites. In 2017, the highest rates of TB are seen among patients 65 years of age and older which represents a 25% increase in the number of TB cases in these age groups (BTBC, 2017). The proportion of TB cases among 18-44 years of age was 41%, with 63% among males (BTBC, 2017). In addition, some neighborhoods in Queens and Brooklyn have TB rates higher than the citywide rate, which reflects the number of TB cases residing in those neighborhoods (BTBC, 2010; BTBC, 2016; BTBC, 2017).

In 2016, there were 3,595 contacts (household and non-household) identified in N.Y.C. Of these contacts, 2716 had been evaluated for TB, and 1,195 were started on treatment for LTBI (BTBC, 2016).

For this study, between the period of September 2010 and December 2014, there were 2,751 confirmed cases of active TB reported to DOHMH. The annual rate during this period decreased from 3.6 per 100,000 (2010) to 3.0 per 100,000 (2014). The DOHMH identified about 6,396 household contacts during this period, however, only

3,008 household contacts were included in data analysis. Of the 3,008 household contacts, 2,850 were tested for TB, 1,090 were positive on TB test as evidenced of LTBI, and 657 accepted and completed treatment. The rates from this sample differ by demographic factors (gender, age-group, race/ethnicity, non-US born, and residence borough) for acceptance by household contacts of TB testing, evaluation, and LTBI treatment.

Acceptance of TB testing

Fox and colleagues (2015) identified barriers to adherence with contact investigation including the knowledge, attitudes and practices of contacts. Gaps in knowledge about how TB is transmitted and why testing is important influences the likelihood to accepting testing (Anger et al., 2012; Chakhaia et al., 2014; Faccini et al., 2015; Fox et al., 2015; Fox et al., 2012; Gounder et al., 2014; Kwon et al., 2014). Ethical concerns regarding the harms of getting tested, confidentiality of information, language barrier, and/or a fear of getting deported can also play a role in testing of contacts (Dewan et al., 2006; Fox et al., 2012; Kambali et al., 2015). The multivariate analysis from this sample found that only age was significantly associated with testing in that the older the person the less likely to accept TB testing. Age may be a proxy for knowledge but might also reflect ingrained cultural beliefs, stigma or lack of access to health services (Chakhaia et al., 2014; Faccini et al., 2015; Fox et al., 2015; Hargreaves et al., 2011). Limited health literacy and language barrier is also common among older Asian American immigrants, which prevents them from seeking healthcare service (Kim & Keefe, 2010), such as TB screening.

Since the resurgence of TB in 1992, the focus on active case finding is among

vulnerable population such as those with HIV, diabetes, malnutrition, and substance abuse (WHO, 2013). The older (65 years of age and older) population was never a focus of attention of TB screening (Negin, Abimbda & Marais, 2015). This was because older adults were less likely to be part of TB outbreaks since their TB disease was more likely due to reactivation from an earlier infection in life (Lee, et al., 2014; Horsburgh et al., 2010; Winston and Navin, 2010). Increasing age, however, is significantly associated with a positive TB test (Li et al., 2010; Pareek et al., 2013), and accounts for 21.9% TB cases in the U.S. (Hochberg et al., 2013). This is due to increased reactivation of LTBI in older adults from a weakened immune system (Thrupp et al., 2004), as well as increased likelihood for co-morbidities that give rise to the development of active TB disease (Seddon et al., 2013; Tsai et al., 2008). Older adults are also more likely to develop extra-pulmonary TB such as tuberculous meningitis, renal or skeletal disease that often makes it more difficult to diagnose and treat than pulmonary TB (Negin, Abimbda & Marais, 2015). TB cases among older adults are associated with higher mortality rates with 57% of all TB deaths globally occurring among those older than 50 years of age (Negin, Abimbda & Marais, 2015). Therefore, enhanced testing and treatment of LTBI should target older contacts. The waning immunity in older adults, however, can lead to false-negative results on the TB skin test, thus either two-step testing or Interferon Gamma Release Assay blood test (IGRA) should be considered. The latter is preferred since results are less affected by age than TST (Hochberg et al., 2013; Seddon et al., 2013; Shapiro, 2013).

Acceptance of TB Evaluation

Full evaluation of household contacts include both a chest-ray and physical

examination at the DOHMH Chest Center, which takes about 2 to 3 hours. Non-acceptance of a full evaluation among household contacts in this sample was significantly associated with male gender and those between the ages of 18-44. Some practical issues such as difficulties in taking time off from work and school (Anger et al., 2012; Fox et al., 2015; Gounder et al., 2014) or other personal reasons such as job security can prevent a contact from coming for evaluation (Faccini et al., 2015). Since most males are head of the household and are more likely to be responsible for a major part of the family's income, there will be an economic burden if the husband misses work (Hargreaves et al., 2011).

An interesting finding in this study was that non-US born and Asian and Hispanic contacts were more likely to complete the full evaluation. This is contradictory to others who have reported that cultural barriers, stigma, and language barrier may play a role among non-US born not coming for evaluation (Collins et al., 2003; Fox et al., 2015). Asian American immigrants and Hispanics are more likely to have strong support system (family and friends) that is associated with less psychological distress (Singh, McBride, Kak, 2015; Alegria, Sribney, & Mulvaney-Day, 2012) in seeking solutions to obtain TB evaluation. Since Asians have the highest rate of TB in the U.S., they have been the focus of TB screening among the non-US born (Demlow, Oh, & Barry, 2015) and may be influenced by these targeted testing efforts over the last eight years to recruit them for full evaluation. The DOHMH Bureau of TB Control has a diversified workforce with public health advisors that speak different languages and dialects including Cantonese, Mandarin, Fujinese, Taiwanese, Bengali, Hindi, Punjabi, and Tagalog. These advisors address the language barrier and thus facilitate service for Asian immigrants.

Household Contacts with LTBI

It is well documented that household contacts have an increased risk of becoming tuberculin skin test (TST) and QuantiFERON test (QFT) positive (Lee et al., 2014; Padmanesan et al., 2013) which is consistent with this study's findings. A positive TB test (evidence of LTBI), among household contacts was significantly associated with age-group (18-44, 45-64, 65+), non-US born, race/ethnicity (Asian and Hispanic), and borough (Brooklyn, Queens, and Staten Island). These findings were consistent with the demographic characteristics of cases of active TB disease reported to the DOHMH from 2010 to 2016, except for male gender (BTBC, 2011; BTBC, 2012, BTBC, 2013, BTBC, 2014, BTBC, 2015, BTBC 2016). Contacts with LTBI in this study were not likely to be male as found among the active TB cases of DOHMH or in other studies of household contacts. This can be attributed to the fact that regardless of gender, proximity of the contact to an infectious case of TB inside the household is a risk factor for LTBI (CDC, 2013; Padmanesan et al., 2013).

Acceptance/Completion of LTBI Treatment

For household contacts accepting/completing LTBI treatment, the significant predictors were age-group (18-44), non-US born, and race/ethnicity (Asian and Hispanics). Previous research did not find that age, country of birth, and race affects adherence to treatment (Fiske et al., 2014; Naing et al., 2001), however, age was a significant predictor in the acceptance/completion of LTBI treatment in this sample. Those between the ages of 18-44 were less likely to accept/complete LTBI treatment. Initiation of LTBI treatment is more of a major challenge than completion of LTBI treatment (Goswami et al., 2012). Asians and Hispanics were more likely to

accept/complete LTBI treatment, which is similar to another study (Goswami et al., 2012). This can be attributed to the social support that Asians and Hispanics receive (Singh, McBride, Kak, 2015).

For household contacts refusing LTBI treatment, all age-groups and borough were significant predictors. Except minors, all-age groups, most especially those ages 45-64 were more likely to refuse LTBI treatment. Household contacts from all age-groups (except minors) who live in Staten Island, Brooklyn, and Queens were more likely to refuse LTBI treatment. The large proportion in Brooklyn and Queens is due to the large proportion of active TB cases, residing in these boroughs (BTBC, 2010; BTBC 2016). Since 2010, there were two outbreaks of TB in Brooklyn where the majority were from China. Between June 2010 and December 2014, there were a total of 23 confirmed outbreaks in the same neighborhood in Brooklyn (Yacisin et al., 2015). These outbreaks can be attributed to the social determinants of TB such as population mobility, and overcrowding, which influence exposure to developing TB infection (Hargreaves et al., 2011; Padmanesan et al., 2013). According to the US census from 2000-2010, there has been a 52% increase of Hispanics and 78% increase of Asians in Staten Island. This influx of non-US born contributes to overcrowding on Staten Island, which has had a 5.6% increase in population during this period (Lavis, 2013). Other factors described in the literature review such as cultural barriers, stigma, and language barrier among non-US born can give rise to poor communication between contacts and provider (Clough, Lee, & Chae, 2013; Dresser et al., 2012). And providers who do not speak the language of the patient may not effectively convey the importance of LTBI treatment (Global tuberculosis Institute, n.d.).

Demographic Characteristics

The significant findings in this study showed that the demographic characteristics of household contacts associated with testing, evaluation, and LTBI treatment were consistent with the demographic characteristics of active tuberculosis cases in NYC from 2010 to 2014 (BTBC 2011, BTBC, 2012, BTBC, 2013, BTBC, 2014, BTBC, 2015). TB has adversely affected specific groups such as non-US born, Asian and Hispanic men in the 18-44 age-group. The results of this study on older age group that was significant for not getting tested and evaluated supports the 2017 findings of an increase in the number of TB cases among 65 years old and older. TB is mostly found among those residing in Queens and Brooklyn. These disparities contribute to an unequal distribution of the TB prevalence in N.Y.C., and reflects the social determinants of TB, which influence exposure to LTBI (Hargreaves et al., 2011; Padmanesan et al., 2013).

The findings on LTBI among household contacts were similar to a study comparing several nationally representative cohorts of the US population participating in the 1971-1972 and 1999-2000 National Health and Nutrition examination surveys (Khan et al., 2008). The national study also identified sociodemographic factors such as increasing age, male gender, African Americans, Hispanic Americans, foreign-born individuals, and household contacts of active TB cases as having increased risk for LTBI. Individuals who were either recently infected, or had co-morbidities or certain medical conditions associated with progression from LTBI to active TB disease also were more at risk for TB (ATS, 2000; CDC, 2016; Horsburg & Rubin, 2011; Khan et al., 2008).

Previous studies have shown that contact investigation should focus on household contacts less than 5 years of age since they are more likely to get exposed to a case of TB

in the home. However, regardless of age, proximity of the contact to an infectious case of TB inside the household is the main factor in getting exposed to TB (CDC, 2013; Padmanesan et al., 2013). Another study had shown a significant burden of LTBI among males (Lee et al., 2014; Liang, et al., 1999). However, this study did not find gender as a significant predictor on LTBI treatment. Age was the main demographic characteristic that remained a significant predictor on all three points testing, evaluation, and LTBI treatment.

Provider Type

The tuberculosis nurse case manager has an important role in TB testing and evaluation in contact investigation (Mulder et al., 2012). In the Bureau of TB Control of the DOHMH, the public health nurse was the primary case manager that facilitated testing and evaluation of all contacts. In 2012, because of a shortage of nurses, the Bureau expanded the role of Public Health Advisors (PHAs) to conduct health risk assessment in contact investigation. This is similar to a study conducted by Shah that with basic training, lay workers can provide support in conducting a contact investigation (Shah et al., 2013). The finding from this study showed the proportion of household contacts tested and evaluated did not differ between nurses and public health advisors, which supports the policy of the Bureau of Tuberculosis Control to place PHAs as primary case managers in response to the shortage of nurses. Among household contacts testing positive, more contacts were not fully evaluated during the first period when nurses were the primary case managers. This may have been due to the shortage nurses to evaluate contacts. However, a higher proportion of household contacts that were fully evaluated accepted LTBI treatment in July 2012-december 2014 than household contacts

that were fully evaluated and accepted treatment in September 2010-June 2012.

Limitations

Since this is an analysis of secondary data collected for a TB registry, it does not capture all information necessary to conduct a comprehensive analysis of factors associated with household contacts accepting TB testing and evaluation, or completing LTBI treatment. The area-based poverty level was not analyzed since analysis of data was not done separately by year and area-based poverty level changes every year. The TB registry includes about 76 countries as the country of birth of cases but did not reflect the same number of countries as that of contacts. Country of birth of contacts did not represent the same number that of cases. The type of LTBI treatment was not determined since it was not part of the data set. Information that would be useful to a Department of Health TB registry is the number of household contacts who accepted but did not complete LTBI treatment, as well as other sociodemographic characteristics such as education, which has been found to be a significant predictor of adherence to LTBI treatment (Woimo et al, 2017). Another limitation was that almost half of the records for the identified household contacts had missing data resulting in only about half of the total sample available for data analysis. The TB registry consists of data collected for program evaluation and not for research; however, incomplete data collection needs to be addressed within the health department.

Research Recommendations

The next line of research after this study is to explore reasons for non-acceptance to TB testing and evaluation, and LTBI treatment among those identified at high risk such as age-group, male gender, non-US born, Asians and Hispanics. To properly

address the social determinants of TB, this data should be link to national census data to control for socio-economic status. Qualitative methods including focus groups and individual interviews in the contact's own language may reveal other social determinants for non-adherence to testing, evaluations and treatment. Also, age-specific and gender-specific comorbidities of TB and behavioral risk factors such as tobacco, alcohol and drug use would be useful to include in the registry. Knowing the health behavior of contacts can help develop policies to incorporate TB screening as part of their overall treatment. Environmental factors such as migration patterns, living conditions, access to food, and health service that influence TB testing and evaluation should also be explored. Digital analysis of testing, evaluation & LTBI treatment can be explored most especially in boroughs where most outbreaks occurred. Adding new information to be collected will need to be piloted to evaluate the PHA's ability to accurately capture this information and the time and cost implications of additional data collections. This can also be part of effort to determine the effectiveness of non-nurse TB case manager in TB Control program and what is needed in their training, continuing education and supervision to improve their practice.

Practice Implications

The NYC DOHMH is similar to other Department of Health in the US in the use of risk assessments forms in contact investigation (CDC, 2006; California Department of Public Health, 2017; Virginia Department of Health, 2016; Minnesota Department of Health, 2013; Missouri Department of Health and Senior Services, 2009). Risk assessment of household contacts of active TB disease should be the standard practice with an inclusion of older adults followed by appropriate testing, evaluation, and

completion of LTBI treatment. Age and gender related barriers including comorbidities, and contraindication to testing, evaluation, and treatment of LTBI should be identified; and plans should be in place to address access needs for DOHMH services. Foreign, and exchange students should follow immigration requirements on TB testing, evaluation & LTBI treatment.

The goal of TB control should be to provide patient centered-care (Frieden, 2018) and support outreach activities to bring TB screening to the community level such as the use of a mobile screening unit (Morano et al., 2014; Morishita et al, 2017) and broader educational effort on TB focused in high risk populations. This will promote awareness in the community about the needs for TB screening and LTBI treatment. Health care providers should be proactive in testing household contacts since delay on testing can sustain TB transmission within the household and to the community (Padmanesan et al., 2013; WHO, 2010). Health care providers need to be aware of the importance of LTBI treatment in the prevention of active TB disease among household contacts.

Implementing socio-cultural intervention such as development of educational materials that are culturally sensitive. Nurses should be able to provide coaching, and counseling in the language the contacts speaks to enhance adherence to treatment, especially among non-US born contacts (Clough, Lee, & Chae, 2013; Kim & Keefe, 2010). These interventions must be combined with the use of a shorter regimen (rifampin for 4 months or the once a week treatment of isoniazid & rifapentine for 12 weeks) to enhance LTBI treatment completion.

The TB registry included considerable incomplete data. A follow-up with clients should be documented when records are incomplete. New innovative tools with the use

of telecommunication technologies can be adopted to help track clients from testing to evaluation, to initiation and completion of LTBI treatment. A study on the use of two-way text messaging to follow-up adherence to LTBI treatment among contacts has shown promising results and thus should be further explored (Hermans et al., 2017; Johnston et al., 2018).

In order to improve data quality accuracy of the TB registry, the data entry process should be limited to designated staff assigned for data entry. Supervisors need to ensure that staff entering data are not overburdened and have limits on data entry input per day. This may include efficient delegation to other cross-trained staff, if the bulk of data entry exceeds a daily limit. In addition, quality assurance staff should conduct regularly scheduled data review and double-check the data entered. A data entry quality control method to increase accuracy of data entry such as double key entry verification or two-pass verification can be useful for the correction of random and miskeyed strokes (Coleman Data Solutions, 2014).

Policy Implications

The new WHO guidelines recommend adults, adolescents, and children who are household contacts of confirmed pulmonary TB should be systematically tested and treated for LTBI (WHO, 2018). Previous studies demonstrate the cost-effectiveness of testing and treating non-US born for LTBI. Testing and treatment of LTBI is cost effective regardless of age compared with no testing (Flood and Barry, 2017; Tasillo et al., 2017) and only effective when administered to contacts of active TB (Zammarchi et al., 2015). To enhance testing among the non-US born, hiring of more bilingual staff should be promoted to address the language barrier, and possible use of mobile apps to

assist follow-up contacts for evaluation. The new recommendation for testing LTBI include either a TST or Interferon Gamma Release Assay except in contacts with HIV or less than 5 years of age who can be started on LTBI treatment without testing (WHO, 2018).

It is expected that testing and LTBI treatment will reduce the overall incidence of TB (Denholm & McBryde, 2014; Dye et al., 2013; Hill, Becerra & Castro, 2012; Houben et al., 2016; Varughese et al., 2014). However, providing TB testing to all non-US born persons requires extensive resources, and may not be feasible because of inadequate funding. Therefore, it is critical to identify factors that will contribute to acceptance of testing, evaluation, and treatment of LTBI among non-US born.

In addition, the rapid population growth and mobility of the immigrant population in N.Y.C. gives rise to the unequal distribution of the social determinants of TB such as overcrowding, cultural barriers, and access to health care. Scaling up of interventions such as testing and LTBI treatment by addressing the specific social determinants of TB, including undocumented immigrants, and refugees will likely improve the health situation of non-US born population (Hargreaves et al., 2011; Lonnroth et al., 2009; Reid et al., 2015). Educating legislators and stakeholders to the disparities of TB most especially among the Asian and Hispanic groups will help reduce racial disparities of TB in these groups (CDC, 2004). Adequate social support can prevent delays in the diagnosis of person with symptoms of TB and prevent spread transmission of TB to household members (Bonadonn et al., 2017; Padmanesan et al., 2013). Moreover, developing interventions to address other risk factors associated with TB such as homelessness, HIV, and substance abuse will help reduce TB morbidity. Policy

recommendation to public health agencies include allocating funding for TB screening to the community level such as the use of mobile testing unit. The DOHMH would benefit from expanding partnerships with both public and private sectors in promoting TB testing, evaluation, and treatment for LTBI. For example, community based-organizations need to be empowered to participate in TB screening. In some high risk populations, agencies may consider promoting adherence by providing incentives for clients to complete LTBI treatment.

Conclusion

Understanding factors associated with TB testing and evaluation, and LTBI treatment will enable public health agencies to streamline the process of contact investigation and plan for effective strategies that will increase the number of household contacts to accept TB testing and evaluation, as well as accepting/completing LTBI treatment. LTBI treatment is essential in decreasing the incidence of TB disease, which is critical in TB elimination. Standardization of data entry processes to improve data collection not just for program planning but for operational research is also essential in TB control.

Appendix
Appendix Figures

Figure A1. Evolution in roles of nurses and Public Health Advisors (PHAs) over time in the New York City Department of Health and Mental Hygiene Bureau of Tuberculosis Control (NYC DOHMH BTBC). Medical management means monitoring adherence to treatment.

Figure A2. Health Promotion Model formulated by Nola Pender.

Figure A3. Results of the search according to PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses).

Appendix Tables

Table A1a. Search Terms Used for the Literature Review

Active Tuberculosis	Contact Investigation	Contacts of TB Case	Case Management	Testing	Barriers
<ul style="list-style-type: none"> • <i>Mycobacterium tuberculosis</i> • Pulmonary tuberculosis • Active tuberculosis • Latent tuberculosis infection • Multi-drug-resistant TB • Tuberculosis control 	<ul style="list-style-type: none"> • Contact tracing • Screening of contacts • Risk assessment • Case finding • Case detection • Disease outbreak • Surveillance • Cluster analysis • Community • Workplace • Prisons 	<ul style="list-style-type: none"> • Contacts of tuberculosis case • Contacts of index case • Household contacts • Non-household contacts • Close contacts • Casual contacts 	<ul style="list-style-type: none"> • Case Manager • TB nurse manager • TB case manager • TB nurse case manager • Health care provider • Health care worker 	<ul style="list-style-type: none"> • Tuberculin skin testing • Interferon-gamma release assays • Sputum microscopy • Nucleic acid amplification • DNA fingerprinting 	<ul style="list-style-type: none"> • Obstacles • Difficulties • Refused • Lost to follow-up

Table A1b. Databases Used for the Literature Review and Data Synthesis

	<u>Proquest</u> Dissertation	MEDLINE	CTNAHL	PubMed	PLOS ONE	Total
Results found	2	17	6	55	11	91
Duplicates removed	0	5	2	7	1	15
Screened based on inclusion criteria	2	12	4	48	10	76
Screened based on exclusion criteria	1	7	1	21	6	36
Relevant articles synthesized	1	5	3	27	4	40

Table A2a. Critical Appraisal Checklist: Qualitative Studies (Pearson, 2004)

Criteria:	Carlsson et al. (2014)	Fedotkina & Williams (2013)	Mulder et al. (2012)	Shimamura et al. (2012)	Oblitas et al (2010)
1. Congruity between:	+	+	+	+	+
a. Stated philosophical perspective and research methodology					
b. Methodology and research question or objectives	+	+	+	+	+
c. Methodology and methods used to collect data	+	+	+	+	+
d. Methodology and representation and analysis of data	+	+	+	+	+
e. Methodology and interpretation of results	+	+	+	+	+
2. There is a statement locating the researcher culturally or theoretically	+	+	+	+	+
3. The influence of the researcher on the research, and vice-versa is addressed	+	+	+	+	+

Table A2b. Critical Appraisal Checklist: Quantitative Studies (Bowling, 2009)

Author	Aim	Hypothesis	Var Stated	Var Op	Design	Method	Rel/Val	Sample	Stat Err	Ethics	Pilot	Stat Anal	Res Rep	Res Hypoth	Limit	Conc	Gen	Imp
Cates et al. (2015)	+	+	+	+	+	+	+	+	-	-	-	+	+	+	+	+	-	+
Fox et al. (2015)	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+
Zellweger et al. (2015)	+	+	+	+	+	+	+	+	-	+	-	+	+	+	+	+	+	+
Kambali et al. (2015)	+	+	+	+	+	+	-	-	-	+	-	-	+	+	+	+	-	+
Faccini et al. (2015)	+	+	+	+	+	+	-	-	-	-	-	-	+	+	+	+	-	+
Moyo, Tay, & Denholm. (2015)	+	+	+	+	+	+	+	+	-	-	-	+	+	+	+	+	+	+
Anderson et al. (2014)	+	+	+	+	+	+	+	+	-	-	-	+	+	+	+	+	-	+
Grounder et al. (2014)	+	+	+	+	+	+	+	+	-	-	-	+	+	+	+	+	-	+
Kwon et al. (2014)	+	+	-	-	+	-	-	-	-	-	-	-	-	+	+	+	-	+
Chakhaia et al. (2014)	+	+	+	+	+	+	+	+	+	-	-	+	+	+	+	+	-	+
Ratovoson et al. (2014)	+	+	+	+	+	+	-	+	+	+	-	+	+	+	+	+	-	+
Shapiro (2013)	+	+	+	+	+	+	+	+	-	+	-	+	+	+	+	+	-	+
Shah et al. (2013)	+	+	+	+	+	+	+	+	-	+	-	+	+	+	+	+	-	+
Seddon et al. (2013)	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	-	+
Anger et al. (2012)	+	+	+	+	+	+	+	+	-	+	-	+	+	+	+	+	+	+
Fox et al. (2012)	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	-	+
Atif et al. (2012)	+	+	+	-	+	+	-	+	-	-	-	+	+	+	+	+	-	+
Yoshiyama	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	-	+

discussed; Ethics = ethical considerations discussed; Pilot = study piloted; Stat Anal = statistical analysis appropriate; Res Rep = results reported and clear; Res Hypoth = results related to hypothesis and literature; Limit = limitations reported; Conc = conclusions within limit of data and results; Gen = findings able to be generalized; Imp = implications discussed.

Table A3a. Data Extraction Table: Study Design and Methods

Author	Study design	Sample size	State/Country	Location of exposure	Selection criteria for index case	Selection criteria for contacts	Screening method employed
Cates et al. (2015)	Retrospective	1096 contacts	New York City	Household, non-household	TST, CXR, IGRA, sputum smear & culture, NAA test	All contacts identified by index case, NYC TB registry	TST, IGRA, CXR
Fox et al. (2015)	Nested case-control (mixed method) RCT	812 contacts	Vietnam	Household	Case notification, symptom screening, sputum smear, CXR, interview with use of structured questionnaire	Contacts identified by index case	Symptom screening, sputum smear, CXR, interview with the use of structured questionnaire
Zellweger et al. (2015)	Prospective	5029 contacts	Western Europe	Household, non-household	IGRA (QFT or T-SPOT)	Contacts recruited from European healthcare facilities	IGRAs (QFT & T-SPOT)
Kambali et al. (2015)	Retrospective	402 contacts	Texas	Workplace, household	TB symptoms, sputum smear & culture	Contacts identified by NTCA/CDC	IGRA (T-SPOT), CXR
Faccini et al. (2015)	Retrospective	210 contacts	Italy	Household, workplace, school, recreational	Sputum smear & culture positive, PCR positive, genotyping	Concentric-circle approach	Clinical exam, TST, IGRA, CXR
Moyo, Tay, & Denholm. (2015)	Retrospective	13427 contacts	Australia	Household	Sputum culture, DNA testing, Clinical diagnosis	Contacts identified by index case	TST
Anderson et al. (2014)	Retrospective	1650 contacts	United Kingdom	Household, community	MIRU-VNTR	National Laboratory & Surveillance data	MIRU-VNTR
Gounder et al. (2014)	Retrospective	30,561 contacts	New York City	Household, non-household, congregate	Sputum smear & culture, genotyping analysis	All contacts identified from NYC TB registry	TST, CXR
Kwon et al. (2014)	Retrospective	149,166 contacts	Korea	Congregate (school, military, correctional, welfare facilities, workplace)	NDA	Integrated System for Disease & Public Health Management	TST, IGRA, CXR
Chakhaia et al. (2014)	Retrospective	839 contacts	Tbilisi, Georgia	Household, non-household	AFB, sputum smear & culture	"Invitation model"; ambulatory department at National Center for TB and Lung Disease	Clinical symptoms, TST, CXR
Ratovoson et al. (2014)	Prospective	433 contacts	Madagascar, Africa	School, household	Sputum smear	Screening of first-year schoolchildren	TST, CXR
Shapiro. (2013)	Retrospective	2837 contacts	South Africa	Household	Sputum smear & culture, HIV counseling & testing	Contacts identified by index case	Sputum smear, symptom screening
Shah et al. (2013)	Prospective cohort	19191 contacts	Pakistan	Household	Sputum exam	Sputum microscopy	Sputum smear
Seddon et al. (2013)	Cross-sectional	281 contacts	South Africa	Household	TST, CXR, sputum smear	Contacts recruited at pediatric TB clinic	TST, TB symptom screening, CXR
Anger et al. (2012)	Retrospective	30,561 contacts	New York City	Household, non-household	TST, sputum smear & sputum culture	NYC TB registry	TST, CXR

Fox et al. (2012)	Prospective	545 contacts	Hanoi, Vietnam	Household	Sputum smear & culture, MIRU-VNTR	Contacts identified by index case, patient-directed approach	Sputum smear, CXR, MIRU-VNTR
Aluf et al. (2012)	Retrospective	1024 contacts	Malaysia	Household, non-household	Sputum smear & culture	Contact tracing log book	TST, CXR
Yoshiyama et al. (2010)	Retrospective	5676 contacts	Tokyo, Japan	Household, workplace, hospital	QFT, CXR, sputum smear & culture, PCR, gastric washing, CT scan	Contacts identified based on source case characteristics	TST, QFT, CXR
Marienu et al. (2010)	Retrospective	4550 contacts	US	Aircraft	Sputum smear & culture, CXR, drug susceptibility	Contacts identified according to proximity of exposure	TST, IGRA
Kettunen et al. (2007)	Case report	97 contacts	Ohio	Community, household	Sputum smear & culture, CXR	Concentric-circle approach	TST, CXR
Dewan et al. (2006)	Retrospective	77 contacts	San Francisco, California	Child care facility; workplace, household	Sputum smear & culture, CXR	Contacts identified by reviewing patient medical records	TST DNA fingerprinting
Diel et al. (2006)	Prospective	311 contacts	Hamburg, Germany	Household, workplace, school	TST, QFT, sputum smear	Close contacts of sputum-smear-positive source cases prospectively enrolled	TST, QFT, gastric aspirate
Chee et al. (2005)	Case-control	704 contacts (CF), 2729 (C)	Singapore	Congregate, correctional facilities, community	Sputum smear & culture	Contacts identified by index case	TST, two-step testing, CXR
Singh et al. (2005)	Prospective	281 contacts	India	Household	Sputum smear, CXR	Contacts identified by index case	TST, CXR
Ruddy et al. (2004)	Retrospective	440 contacts	London	Prison	Sputum culture, DNA fingerprinting, PCR	TB surveillance database	DNA fingerprinting
Bur et al. (2003)	Retrospective	344 contacts (jail), 67 (community)	Maryland	Jail, community	CXR, sputum smear & culture, DNA fingerprinting	Concentric-circle approach, TST registry	TST, CXR
Kiter et al. (2003)	Retrospective	3074 contacts	Nazilli, Turkey	Prison	CXR, sputum smear & culture	Case records of TB prisoners	CXR (miniature), sputum smear
Driver et al. (2003)	Retrospective	1202 close contacts	New York City	Congregate (school, workplace)	TST, CXR, sputum smear & culture	Contacts identified by index case	TST, CXR
Davidow et al. (2003)	Retrospective	724 contacts	US (Massachusetts, Mississippi, Maryland, Colorado, New Jersey)	Workplace	TST, sputum smear & culture	Review of existing case records, contacts identified by index case/employer	TST, CXR
Collins et al. (2003)	Case report	150 contacts (108 employees, 42 patients)	Illinois	VA hospital	MTD, sputum smear & culture, Gen-Probe	Concentric-circle approach	Two-step testing (TST)
Yun et al. (2003)	Retrospective	479 contacts (355 shelter,	US	Shelter, non-shelter	TST, CXR, sputum smear & culture	Concentric-circle approach, data on CDC TB National	TST, CXR

Suggaravetsiri et al. (2003)	Cross-sectional	124 non-shelter) 1200 contacts	Thailand	Household		CXR, sputum smear & culture, ELISA	Surveillance System Contacts identified by index case from three main hospitals Chart review	TST, CXR, sputum smear, ELISA
Bayona et al. (2003)	Retrospective	945 contacts	Lima, Peru	Household		Sputum smear, drug susceptibility testing		Respirator symptoms, sputum smear, drug susceptibility testing
Wares et al. (2000)	Retrospective	3051 contacts	Nepal	Household		Sputum smear & culture	TB registry, contacts identified by index case	Sputum smear
Marks et al. (2000)	Retrospective	6225 contacts	US	Household, non-household		Sputum smear positive	Data reported to CDC by TB programs	TST, CXR

AFB, acid-fast bacilli; C, community; CDC, Centers for Disease Control and Prevention; CF, correctional facility; CT, computed tomography; CXR, chest x-ray; ELISA, enzyme-linked immunosorbent assay; HIV, human immunodeficiency virus; IGRA, interferon-gamma release assay; MIRU-VNTR, Mycobacterial interspersed repetitive unit-variable number tandem repeat; MTD, *Mycobacterium tuberculosis* direct test; NAA, nucleic acid amplification; NDA, no details available; NTCA, National TB Control Association; NYC, New York City; PCR, polymerase chain reaction; QFT, QuantiFERON-TB test; RCT, randomized controlled trial; TB, tuberculosis; T-SPOT, ELISPOT assay; TST, tuberculin skin test.

Table A3b. Data Extraction Table: Populations and Results

Author	No. index cases	No. contacts tested/ screened	No. contacts not tested/not screened	No. contacts w/ LTBI	No. contacts w/ active TB (secondary case)	No. contacts initiated LTBI treatment	Barriers in testing/screening	Key findings
Cates et al. (2015)	374	620	166 refused, 83 lost to follow-up, 111 incomplete testing, 9 moved	136	2	94	Inability to confirm the source transmission of index case	The need for continuing CI in patients without positive respiratory culture with clinical characteristics of infectiousness
Fox et al. (2015)	162	703	109	0	NDA	NDA	Attitudes & knowledge about TB, misconceptions about the natural history of TB, distance from clinic, taking off from work or study, forgetting scheduled appointments, stigma	Perceived prejudice against people with TB, lack of knowledge and understanding about TB transmission & pathogenesis are barriers in CI
Zellweger et al. (2015)	1023	3895 (QFT), 1125 (T-SPOT)	507 lost to follow-up	1068 (QFT), 299 (T-SPOT)	25	971	Procedures for CI not standardized, technical differences in IGRA procedure among centers, selection bias in registering of contacts	Progression to TB among contacts is poorly predicted by IGRA; in contacts without signs of infection, the risk is even lower
Kambali et al. (2015)	1	47	27	12	3	12	Language barrier created difficulties in history taking; immigrants may be reluctant to provide information, especially if undocumented	Language/communication barriers and fear of losing job or immigrant status can hinder screening; involvement of community leaders who understood workers' concerns would overcome obstacles in CI
Faccini et al. (2015)	4	156	NDA	33	3	NDA	TB-related stigma	TB stigma led to incomplete CI & three cases of active TB outbreak; precarity & job security played important role in the outbreak
Moyo, Tay, & Denholm. (2015)	1629	13427	1667	2616	152	NDA	Contacts who did not attend at least one TST reading	The strongest predictor of both positive TST at baseline & conversion was history of BCG vaccination. BCG should be considered as part of an evaluation of risk of LTBI acquisition
Anderson et al. (2014)	204	1472	NDA	70	13	NDA	Reluctance to disclose household contacts, nondisclosure of visiting household contacts, failure to identify temporary residents who had moved on	Epidemiologic investigation of MDR-TB MIRU-VNTR clusters was more successful in identifying secondary cases than was conventional contact tracing
Gounder et al. (2014)	39	27, 363	3198	2933	15	642	Contacts relocated outside NYC, death during CI, unknown date of birth, health care-associated exposure	Supports guidelines that all contacts should be evaluated for treatment regardless of TST results
Kwon et al.	1547	149,166	NDA	14,286	259	NDA	Prejudice about the index patient	CI is a meaningful strategy for preventing TB

(2014)																		outbreaks in congregate settings and decreasing prevalence of TB in young people; results could be used to establish LTBI management policy
Chakhaia et al. (2014)	396	402	437	212	47	14												High prevalence of LTBI and active TB disease among contacts of TB cases; "invitation" model of CI was an effective method of CI; timely CI may efficiently enhance TB case finding among recent contacts
Ratovoson et al. (2014)	NDA	376	NDA	NDA	11	NDA												Screening children in first year is a potential strategy to identify the source case; timely identification of infectious cases will control the spread of TB
Shapiro (2013)	878	2164	604	167	25	167												Targeted active case finding detects high rates of undiagnosed TB & HIV
Shah et al. (2013)	3037	19191	NDA	NDA	490	NDA												Lay workers given basic training can conduct active contact investigations & provide treatment support to improve case detection & treatment outcomes in urban & rural areas in Pakistan
Seddon et al. (2013)	15	228	53	102	15	NDA												Vigilance in clinical evaluation of child household contacts following exposure to MDR- TB source case; alcohol use, ethnicity, & socioeconomic factors are risk factors for infection & disease, requiring further evaluation
Anger et al. (2012)	5182	27,293	NDA	7597	268	6001												CI is a useful tool for early identification of active TB cases; every TB case prevented among contacts can break a chain of transmission
Fox et al. (2012)	212	NDA	NDA	287	5	NDA												Household CI is a feasible strategy to reduce TB transmission; pilot testing is important to learn lessons about CI
Atif et al. (2012)	38	1024	439	38	5	0												Policymakers need to revise CI guidelines to reduce costs; cost of CI can be reduced if CXR is done only in TST- or IGRA-positive contacts
Yoshivama et al. (2010)	196	3102	2574	419	20	323												QFT has moderate sensitivity in predicting clinical breakdown to TB and directing targeted LTBI treatment; QFT-negative index cases are at some risk of developing active TB & should be carefully followed
Mariénau et al. (2010)	131	758	490	182	0	86												Risk of TB transmission during air travel remains difficult to quantify; effectiveness of contact tracing requires cohort studies
Kettunen et al. (2007)	6	87	NDA	7	NDA	NDA												Training, education, & effective communication are crucial for maintaining provider competence; importance of collaborating in CI with the health department

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Dewan et al. (2006)	1	67	6	36	11	27	patient is diagnosed properly	Primary care provider played a critical role in case detection and CI, provider's adherence to pediatric TB screening guidelines may control future outbreaks; systematic improvement in data management by TB programs
Diel et al. (2006)	15	309	2	137	15	15	False-positive reactions on TST can be due to BCG or NTM	QFT was not affected by BCG and is a more valid testing method than TST; QFT is recommended in BCG-vaccinated close contacts or contacts from countries where NTM infections are prevalent
Chee et al. (2005)	32 (CF), 679 (C)	696 (CF), 1064 (C)	103 (CF)	455 (CF), 118 (C)	8 (CF), 20 (C)	455	Contacts from CF to be released within 6 months were not tested	Significantly higher rates of TST conversion among CF contacts compared with community; shows merit of contact screening & treatment of LTBI in CF and vigilance for early detection, isolation, & treatment of cases
Singh et al. (2005)	200	281	NDA	95	9	NDA	Malnutrition in children may interfere with accurate interpretation of TST results	High prevalence of infection among children in household contact with adult cases of TB; significant transmission of infection from sputum smear-negative adult patients to children in household contact
Ruddy et al. (2004)	70	269	21	27	29	27	Assessment of symptoms by TB nurse has not been standardized	Role of DNA fingerprinting in mapping and unravelling an outbreak in prison; prompt detection of outbreaks in prison
Bur et al. (2003)	18	221 (CF)	123 (CF)	32 (CF)	6 (CF)	12 (CF)	Inaccurate information and high turnover rates of inmates	Collaboration with health department facilitated CI; low completion rates on LTBI treatment in CF; no standard guidelines regarding duration of exposure that triggers contact screening
Kiter et al. (2003)	13	3067	7	99 abnormal CXR	11	NDA	Reluctant prisoners	Importance of screening using appropriate method, treatment of cases, and collaboration with health care & administrative units
Driver et al. (2003)	427	996	206	197	1	197	Sites with fewer than 15 persons were not included in the CI	Systematic approach for conducting CI in congregate setting is useful for assessing transmission and avoiding waste of resources
Davidow et al. (2003)	349	494	40	144	42	65	Differences in the selection of target group for screening between risk groups	CI to intervene in TB transmission, reduce incidence of active TB, and educate the workplace about TB
Collins et al. (2003)	1	98 (employees), 27 (patients)	NDA	2	NDA	NDA	Stigma; some contacts believe that they can get in trouble if they get tested	Early recognition & treatment of cases and their contacts are essential to reduce transmission
Yun et al. (2003)	27 (12 shelter, 15 non-shelter)	394	85	67 (46 shelter, 21 non-shelter)	6 (2 shelter, 4 non-shelter)	61	Failure to perform initial evaluation due to error or lack of resources, lack of documentation of medical records, late identification of contacts (beyond 3 months after exposure)	Complete documentation of contacts is necessary in homeless population; ongoing screening for active TB and prompt detection among the homeless reduce transmission and the need for CI
Suggaravets	499 (197)	1192	8	19	6	NDA	Previous history of TB at the time	Importance of prompt reporting of infectious TB

iri et al. (2003)	HIV- positive	(890 HIV testing)						of CI; interpretation of higher TST results is complicated by BCG immunization in >90% of the population	patients to facilitate household CI; include HIV counseling and testing among household contacts; home visits facilitate rapport & lead to greater adherence to LTBI treatment
Bayona et al. (2003)	192	945	NDA	72 (42 drug sensitive, 35 MDR-TB)	NDA	NDA	NDA	Timing and duration of exposure to index MDR-TB case in the household	Prompt CI protocol is useful in MDR-TB; effective therapy of contacts with MDR-TB requires knowledge of drug susceptibility of index case
Wares et al. (2000)	668	2298	673	14	0	NDA	NDA	Inconsistency in asking index patients to identify contacts (some were not asked)	Sputum examination of household contacts of smear- negative & extrapulmonary TB is not justified; restricting CI to contacts of cases with high bacterial loads (>2+)
Marks et al. (2000)	1080	4793	633	134	1725	1259		Lack of consistent definition of contacts	Emphasis on CI to find cases and ensure LTBI treatment; improved training of TB program staff for effective CI

BCG, Bacille Calmette-Guerin; C, community; CF, correctional facility; CI, contact investigation; CXR, chest x-ray; HCWs, health care workers; HIV, human immunodeficiency virus; IGRA, interferon-gamma release assay; LTBI, latent TB infection; MDR-TB, multi-drug-resistant TB; MIRU-VENTR, Mycobacterial interspersed repetitive unit-variable number tandem repeat; NDA, no details available; NTM, non-tuberculosis mycobacteria; NYC, New York City; QFT, QuantiFERON-TB test; TB, tuberculosis; T-SPOT, ELISPOT assay; TST, tuberculin skin test.

Table A4. Definitions Used in the Integrative Review

Term	Definition	References
Case Management	Dynamic and systematic collaborative approach to providing and coordinating health care services to meet an individuals' health needs	New Jersey Medical school National Tuberculosis Center, n.d.
Case managers	A person in charge of managing and coordinating health care needs of the patient	New Jersey Medical school National Tuberculosis Center, n.d.
Close contact	A person who is not in the household but shares an enclosed space with the index case	BTBC, 2008; CDC, 2011; Fair et al., 2015; WHO, 2008
Concentric circle	A method of testing close contacts in order of their intensity and time of exposure and risk of being infected	BTBC, 2008; CDC, 2005; CDC, 2011; Erkens et al., 2010; European CDC, 2013
Contact	Any person who has been exposed to an index case or was in the same place as the index case during the infectious period	BTBC, 2008; CDC, 2011; Chakhaia et al., 2014; Fair et al., 2015; Gounder et al., 2014; Kwon et al., 2014; WHO, 2008; WHO, 2012
Contact investigation (CI)	A process of identifying, testing, evaluating, and treating all persons who are at risk for infection with <i>M. tb</i> due to recent exposure to an index case	BTBC, 2008; CDC, 2005; CDC, 2011; WHO, 2008; WHO 2012
Contact with active TB/Secondary case	A contact person with confirmed positive sputum culture for <i>M. tb</i> during the baseline CI. A new case of active TB disease	BTBC, 2008; CDC, 2011; Chakhaia et al., 2014
Contact with LTBI	Any contact person with a positive TST/IGRA and normal x-ray finding who did not have active TB disease during baseline CI	BTBC, 2008; CDC, 2011
Evaluation	Is when a person with positive results on TB testing accepts evaluation	CDC, 2011
Household contact	A person who shared the same household as the index case during the 3 months before initiation of treatment	CDC, 2011; Fair et al., 2015; Kwon et al., 2014; WHO, 2008
Index case/active TB disease	A person with confirmed infectious active pulmonary, laryngeal, or pleural TB disease with positive sputum smear and culture	BTBC, 2008; CDC, 2005; CDC, 2011; Gounder et al., 2014
Infectious period	The infectious period is 3 months before the index case started anti-TB treatment, based on guidelines for CI	Anger et al., 2012; BTBC, 2008; Cates, et al., 2015; CDC, 2005; CDC, 2011; Chakhaia et al., 2014; Gounder et al., 2014; Kwon et al., 2014; WHO, 2012
Invitation model	A method in which an index case is	Chakhaia et al., 2014

	asked to invite his or her contacts to be examined at a health care facility	
Latent TB infection	An infection with <i>M. tb</i> organisms that causes no signs or symptoms and no radiographic or bacteriologic evidence of TB disease	BTBC, 2008; CDC, 2011
MDR-TB	Multi-drug-resistant TB; active TB disease resistant to more than one drug	Anderson et al., 2014; BTBC, 2008; CDC, 2011
Non-household contact	A contact not in the same household as the index case. It can be any congregate setting such as a school, military facility, office or workplace, jail or prison, social welfare facility, etc.	CDC, 2011; Kwon et al., 2014
Nurse case manager	A nurse who uses the nursing process to develop, implement, and evaluate individualized patient care plans	CDC, 2011
Outbreak	Two or more contacts are identified as having active TB during a CI regardless of their assigned priority	CDC, 2005
QuantiFERON	A blood test administered to know if the person has been exposed to TB	CDC, 2011
Targeted Testing	TB control strategy used to identify, evaluate, and treat persons who are at risk for LTBI or at high risk for developing Tb disease once infected with <i>M. tb</i>	CDC, 2011
TB evaluation	Evaluation of persons with positive TB test results that include Chest-x-ray and medical evaluation made by health care provider	CDC, 2011
Testing	Is when a person accepts TB tests to know if she/he has been exposed to TB	CDC, 2011
Tuberculin Skin Test	A test that is administered under the layer of the skin to know if the person has been exposed to TB	CDC, 2011

CI, contact investigation; IGRA, interferon-gamma release assay; MDR-TB, multi-drug-resistant TB; *M. tb*, Mycobacterium tuberculosis; TB, tuberculosis; TST, tuberculin skin test.

Table A5. Percentage of Contacts Not Tested and Evaluated and Percentage Who Initiated Treatment for Latent

Tuberculosis Infection

Authors	Contacts not tested & evaluated		Percent	Contacts who initiated treatment		Percent
	Total contacts	Total contacts not tested & evaluated		Total eligible for LTBI	Total initiated LTBI treatment	
Cates et al. (2015)	1096	166	15	136	94	69
Fox et al. (2015)	812	109	13	NDA	NDA	
Zellweger et al. (2015)	5029	507	10	1068	971	90
Kambali et al. (2015)	402	27	7	12	12	100
Faccini et al. (2015)	210	NDA		33	NDA	
Anderson et al. (2014)	1650	NDA		13	NDA	
Gounder et al. (2014)	30,561	3198	10	2933	642	22
Kwon et al. (2014)	149,166	NDA		14,286	NDA	
Chakhaia et al. (2014)	839	437	52	212	14	7
Ratovoson et al. (2014)	433	NDA		78	NDA	
Shapiro, A. (2013)	2837	604	21	167	167	100
Seddon et al. (2010)	281	53	19	102	NDA	
Anger et al. (2012)	30,561	NDA		7597	6001	79
Fox et al. (2012)	545	NDA		287	NDA	
Atif et al. (2012)	1024	439	43	38	0	
Yoshiyama et al. (2010)	5676	2574	45	419	323	77
Marienau et al. (2010)	4550	490	11	182	86	47
Kettunen et al. (2007)	97	NDA		7	NDA	
Dewan et al. (2006)	77	6	8	36	27	75
Diel et al. (2006)	311	2	0.6	137	15	11
Chee et al. (2005)	704	103	15	455	455	100
Singh et al. (2005)	281	0	0	95	NDA	
Ruddy et al. (2004)	440	21	5	27	27	100

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Bur et al. (2003)	344	123	36	32	12	37
Kiter et al. (2003)	3074	7	0.22	99	NDA	
Driver et al. (2003)	1202	206	17	197	197	100
Davidow et al. (2003)	724	40	6	144	65	45
Collins et al. (2003)	150	NDA		NDA	NDA	
Yun et al. (2003)	479	85	18	67	61	91
Sugaravetsiri et al. (2003)	1200	8	0.7	19	NDA	
Bayona et al. (2003)	945	NDA		NDA	NDA	
Wares et al. (2000)	3051	673	22	0	NDA	
Marks et al. (2000)	6225	633	2	1725	1259	72

NDA, no details available.

Table A6. Barriers to Testing of Contacts

Type of Barrier	Definition	References
Patient factors	Gaps in knowledge, stigma attached to TB, poor communication, language barriers, ethical concerns, confidentiality issues, fear of deportation, long distance of travel, and moving or relocation of patients	Anger et al., 2012; Chakhaia et al., 2014; Collins et al., 2003; Dewan et al., 2006; Faccini et al., 2015; Fox et al., 2012; Fox et al., 2015; Gounder et al., 2014; Kambali et al., 2015; Kiter et al., 2003; Kwon et al., 2014
Provider factors	Gaps in knowledge; inability to confirm the index case; and problems in identification, selection, and assessment of contacts	Anderson et al., 2014; Anger et al., 2012; Cates et al., 2015; Chakhaia et al., 2014; Chee et al., 2005; Davidow et al., 2003; Kambali et al., 2015; Marks et al., 2000; Ratovoson et al., 2014; Wares et al., 2000; Yoshiyama et al., 2010
Medical and technical factors	Comorbidities in TB patients such as HIV, malnutrition, and alcohol dependence; homelessness; MDR-TB; boosting effect due to BCG vaccine and NTM; and differences in test procedures of TST, QuantiFERON-TB (QFT), and sputum microscopy that only includes sputum smear	Bayona et al., 2003; Diel et al., 2006; Seddon et al., 2013; Singh et al., 2005; Suggaravetsiri et al., 2003
Health system factors	Lack of standard guidelines for CI, cost and lack of resources, incomplete data, and inconsistent definition of contacts	Atif et al., 2012; Bayona et al., 2003; Bur et al., 2003; Chee et al., 2005; Driver et al., 2003; Yun et al., 2003

BCG, Bacille Calmette-Guérin; CI, contact investigation; HIV, human immunodeficiency virus; MDR-TB, multi-drug-resistant TB; NTM, non-tuberculosis mycobacteria; TB, tuberculosis; TST, tuberculin skin test.

Table A7a. Role of Nurses in TB Case Management

Nurses' Role	Carlsson et al. (2014)	Fedotkina & Williams (2013)	Shimamura et al. (2012)	Mulder et al. (2012)	Oblitas et al. (2010)
Contact Investigation	NDA	NDA	NDA	Identify & prioritize contacts; adhere to CI guidelines	NDA
TB Treatment	Support adherence, DOT, prevent relapse	Support adherence, DOT	Support adherence, prevent relapse	NDA	Support adherence, DOT
Psychological/Social	Emotional, food, transportation support	Home visits, food, transportation, social services support	Empathy, emotional support, provide housing, food support	NDA	Individual & family spending, income generation
Education/Training	Educate patients about TB	Training of nurses	Training of nurses	Educate contacts, training of TB workforce	Educate patients about TB
Political	NDA	Elicit politicians' support	Support to rebuild patient's life	Collaborate between policy makers & TB workforce	Empowerment, respect for human rights, & participatory actions
Professional	NDA	Multi-disciplinary approach (MD, nurse, pharmacist, lab personnel)	NDA	Research on CI, collaborate with MDs in solving adherence problems with CI guidelines	Research on TB

CI, contact investigation; DOT, directly observed therapy; NDA, no details available; TB, tuberculosis.

Table A7b. The Role of Nurses and Public Health Advisors as TB Case Manager in DOHMH Chest Clinics

Year	Nurses Role	Specific Tasks	PHA Role	Specific Tasks
1940	Medical management	Focused on patient adherence to TB treatment	Assisted in TB screening	Participated in screening of contacts exposed to TB
1970	Medical management	Focused on patient adherence to TB treatment	Assisted in contact investigation	Located contacts exposed to an index case
1980	Medical management	Focused on patient adherence to TB treatment	Main person in contact investigation	Interviewed contacts, administered TST, returned patient lost to follow-up, performed chart review
Early-1990	Medical management	Focused on patient adherence to TB treatment	Primary case manager	Managed and coordinated health needs of TB patients, reviewed epidemiological data; conducted health risk assessment of contacts
Mid-1990	Primary case manager	Managed and coordinated health needs of TB patients, assessed contacts risk, adherence to TB treatment	Secondary case manager	Assisted nurses in management of cases & focused more on finding patient lost to follow-up & returned patient to medical care
2010	Primary case manager	Managed and coordinated health needs of TB patients, assessed contacts risk, adherence to TB treatment	Secondary case manager	Assisted nurses in management of cases & focused more on finding patient lost to follow-up & returned patient to medical care
2012-Present	Medical management	Focus on patients adherence to TB treatment	Primary case managers	Manage and coordinate health needs of patients, review epidemiological data; conduct health risk assessment of contact patient lost to follow-up & returning patient to medical care

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Table A8. Demographic Characteristics of All Household Contacts of Active TB Cases (n=3,008)

Demographics	Frequency N=3008	Percentage
Gender		
<i>Male</i>	1493	49.63
<i>Female</i>	1515	50.37
Age-Group		
<i>0-17</i>	865	28.76
<i>18-44</i>	1322	43.95
<i>45-64</i>	640	21.28
<i>65+</i>	181	6.02
Country of Birth		
<i>US-Born</i>	1006	33.44
<i>Non-US Born</i>	2002	66.56
Race/Ethnicity		
<i>Non-Hispanic Black</i>	583	19.38
<i>Hispanic</i>	969	32.21
<i>Asian</i>	1175	39.06
<i>Non-Hispanic White</i>	176	5.85
<i>Other</i>	105	3.49
Borough		
<i>Bronx</i>	482	16.02
<i>Brooklyn</i>	934	31.05
<i>Manhattan</i>	216	7.18
<i>Queens</i>	1311	43.58
<i>Staten Island</i>	65	2.16

Table A9. Demographic Characteristics of Household Contacts Tested/Not Tested for TB (n = 3,008)

Demographics	# of Contacts N=3008	# Tested N= 2850	# Not Tested N=158	p-Value
Gender				0.505
<i>Male</i>	1493	1410 (94.44%)	83 (5.56%)	
<i>Female</i>	1515	1440 (95.05%)	75 (4.95%)	
Age-Group				0.001
<i>0-17</i>	865	854 (98.73%)	11 (1.27%)	
<i>18-44</i>	1322	1234 (93.34%)	88 (6.66%)	
<i>45-64</i>	640	595 (92.97%)	45 (7.03%)	
<i>65+</i>	181	167 (92.27%)	14 (7.73%)	
Country of Birth				0.001
<i>US-Born</i>	1006	973 (96.72%)	33 (3.28%)	
<i>Non-US Born</i>	2002	1877 (93.76%)	125 (6.24%)	
Race/Ethnicity				0.022
<i>Non-Hispanic Black</i>	583	543 (93.14%)	40 (6.86%)	
<i>Hispanic</i>	969	922 (95.15%)	47 (4.85%)	
<i>Asian</i>	1175	1127 (95.91%)	48 (4.09%)	
<i>Non-Hispanic White</i>	176	162 (92.05%)	14 (7.95%)	
<i>Other</i>	105	96 (91.43%)	9 (8.57%)	
Borough				0.452
<i>Bronx</i>	482	459 (95.23%)	23 (4.77%)	
<i>Brooklyn</i>	934	888 (95.07%)	46 (4.93%)	
<i>Manhattan</i>	216	206 (95.37%)	10 (4.63%)	
<i>Queens</i>	1311	1233 (94.05%)	78 (5.95%)	
<i>Staten Island</i>	65	64 (98.46%)	1 (1.54%)	

Table A10. Demographic Characteristics of Household Contacts Testing Positive versus Negative (n=2,850)

Demographics	Total N=2850	Positive N=1090	Negative N=1760	p-Value
Gender				0.0295
<i>Male</i>	1410	568 (40.28%)	842 (59.72%)	
<i>Female</i>	1440	522 (36.25%)	918 (63.75%)	
Age-Group				0.000
<i>0-17</i>	854	187 (21.90%)	667 (78.10%)	
<i>18-44</i>	1234	528 (42.79%)	706 (57.21%)	
<i>45-64</i>	595	296 (49.75%)	299 (50.25%)	
<i>65+</i>	167	79 (47.31%)	88 (52.69%)	
Country of Birth				0.000
<i>US-Born</i>	973	178 (18.29%)	795 (81.71%)	
<i>Non-US Born</i>	1877	912 (48.59%)	965 (51.41%)	
Race/Ethnicity				0.000
<i>Non-Hispanic Black</i>	543	159 (29.28%)	384 (70.72%)	
<i>Hispanic</i>	922	355 (38.50%)	567 (61.50%)	
<i>Asian</i>	1127	475 (42.15%)	652 (57.85%)	
<i>Non-Hispanic White</i>	162	51 (31.48%)	111 (68.52%)	
<i>Other</i>	96	50 (52.08%)	46 (47.92%)	
Borough				0.000
<i>Bronx</i>	459	117 (25.49%)	342 (74.51%)	
<i>Brooklyn</i>	888	340 (38.29%)	548 (61.71%)	
<i>Manhattan</i>	206	76 (36.89%)	130 (63.11%)	
<i>Queens</i>	1233	533 (43.23%)	700 (56.77%)	
<i>Staten Island</i>	64	24 (38.50%)	40 (62.50%)	

Table A11. Demographic Characteristics of Household Contacts Fully Evaluated versus Not Fully Evaluated (n=1,090)

Demographics	Total N=1090	Fully Evaluated N=1037	Not Fully Evaluated N=53	p-Value
Gender				0.002
<i>Male</i>	568	529 (93.13%)	39 (6.87%)	
<i>Female</i>	522	508 (97.32%)	14 (2.68%)	
Age-Group				0.014
<i>0-17</i>	187	186 (99.47%)	1 (0.53%)	
<i>18-44</i>	528	494 (93.56%)	34 (6.44%)	
<i>45-64</i>	296	281 (94.93%)	15 (5.07%)	
<i>65+</i>	79	76 (96.20%)	3 (3.80%)	
Country of Birth				0.002
<i>US-Born</i>	178	178 (100.00%)	0 (0.00%)	
<i>Non-US Born</i>	912	859 (94.19%)	53 (5.81%)	
Race/Ethnicity				0.513
<i>Non-Hispanic Black</i>	159	153 (96.23%)	6 (3.77%)	
<i>Hispanic</i>	355	335 (94.37%)	20 (5.63%)	
<i>Asian</i>	475	455 (95.79%)	20 (4.21%)	
<i>Non-Hispanic White</i>	51	47 (92.16%)	4 (7.84%)	
<i>Other</i>	50	47 (94.00%)	3 (6.00%)	
Borough				0.039
<i>Bronx</i>	117	112 (95.73%)	5 (4.27%)	
<i>Brooklyn</i>	340	332 (97.65%)	8 (2.35%)	
<i>Manhattan</i>	76	70 (92.11%)	6 (7.89%)	
<i>Queens</i>	533	499 (93.62%)	34 (6.38%)	
<i>Staten Island</i>	24	24 (100.00%)	0 (0.00%)	

Table A12. Demographic Characteristics of Household Contacts Accepted versus Refused LTBI Treatment (n=863)

Demographics	Total N=863	Accepted/Completed LTBI Tx N=657	Refused LTBI Tx N=206	p-Value
Gender				0.910
<i>Male</i>	424	324 (76.42%)	100 (23.58%)	
<i>Female</i>	439	333 (75.85%)	106 (24.15%)	
Age-Group				0.001
<i>0-17</i>	169	162 (95.86%)	7 (4.14%)	
<i>18-44</i>	403	290 (71.96%)	113 (28.04%)	
<i>45-64</i>	234	165 (70.51%)	69 (29.49%)	
<i>65+</i>	57	40 (70.18%)	17 (29.82%)	
Country of Birth				0.001
<i>US-Born</i>	159	143 (89.94%)	16 (10.06%)	
<i>Non-US Born</i>	704	514 (73.01%)	190 (26.99%)	
Race/Ethnicity				0.001
<i>Non-Hispanic Black</i>	128	93 (72.66%)	35 (27.34%)	
<i>Hispanic</i>	266	224 (84.21%)	42 (15.79%)	
<i>Asian</i>	392	291 (74.23%)	101 (25.77%)	
<i>Non-Hispanic White</i>	37	23 (62.16%)	14 (37.84%)	
<i>Other</i>	40	26 (65.00%)	14 (35.00%)	
Borough				0.002
<i>Bronx</i>	88	81 (92.05%)	7 (7.95%)	
<i>Brooklyn</i>	289	206 (71.28%)	83 (28.72%)	
<i>Manhattan</i>	51	37 (72.55%)	14 (27.45%)	
<i>Queens</i>	414	318 (76.81%)	96 (23.19%)	
<i>Staten Island</i>	15	15 (71.43%)	6 (28.57%)	

Table A13. Household Tested, Fully Evaluated, and Accepted/Completed LTBI treatment between September 2010-July 2012 versus July 2012-December 2014

Variables	Contacts N=3008	Sept. 2010-June 2012	July 2012-Dec. 2014	p-Value
Testing				0.424
<i>Tested</i>	2850	1220 (95.16%)	1630 (94.44%)	
<i>Not Tested</i>	158	62 (4.84%)	96 (5.56%)	
Test Result				0.001
<i>Positive</i>	1090	536 (44.93%)	554 (33.99%)	
<i>Negative</i>	1760	684 (56.07%)	1076 (66.01%)	
Evaluation				0.126
<i>Fully Evaluated</i>	1037	504 (94.03%)	533 (96.21%)	
<i>Not Fully Evaluated</i>	53	32 (5.97%)	21 (3.79%)	
LTBI Treatment				0.101
<i>Accepted</i>	657	303 (73.90%)	354 (78.15%)	
<i>Refused</i>	206	107 (26.10%)	99 (21.85%)	

Table A14. Summary of Significant Predictors

	Univariate Analysis		Multivariate Analysis	
	Characteristic	Table	Characteristic	Table
<i>Tested for TB</i>	Age-group	3	Age-group	26
	Non-US born	4		
	Race/Ethnicity	5		
<i>TB +/- (evidenced of LTBI)</i>	Male	7		
	Age Group	8	Age Group	27
	Non-US born	9	Non-US born	27
	Race/Ethnicity	10	Borough	27
	Borough	11		
<i>Fully Evaluated/ Not Fully Evaluated</i>	Male Gender	12	Male Gender	28
	Age-group	13	Age-group	28
	Non-US born	14	Non-US born	28
	Borough	16	Race/Ethnicity	28
<i>Accepted LTBI Tx</i>	Age-group	18	Age-group	29
	Non-US born	19	Non-US born	29
	Race Ethnicity	20	Race/Ethnicity	29
	Borough	21		
<i>Refused LTBI Tx</i>	Age-group	22	Age-group	30
	Non-US born	19		
	Race/Ethnicity	20		
	Borough	21	Borough	30

IRB Letters

NEW YORK CITY DEPARTMENT OF
HEALTH AND MENTAL HYGIENE
Mary T. Bassett, M.D., M.P.H.
Commissioner

Institutional Review Board
NYC Department of Health and Mental Hygiene
Gotham Center – 31A
42-09 28th Street, 14th Floor
Queens, New York 11101-4132
Tele: 347-396-6118
Fax: 347-396-6088
irbadmin@health.nyc.gov

April 12, 2017

Re: 17-036, Factors Associated with Testing and Evaluation among Household Contacts Exposed to Tuberculosis

Principal Investigator: Elvy Barroso, MD, MSc, MS, MPH, RN

This Action: Exemption Procedures

Elvy Barroso
Bureau of Tuberculosis Control
42-09 28th Street, WS 21-1
Queens, NY 11101

Dear Dr. Barroso:

The Institutional Review Board (IRB) reviewed the above mentioned activity titled, **Factors Associated with Testing and Evaluation among Household Contacts Exposed to Tuberculosis**. Based on the information provided, the IRB determined that this activity is exempt from the federal regulations under 45 CFR §46.101 (b)(4).

In the event there are any changes to the design or intent of this study, as Principal Investigator (PI), you are required to notify the IRB in writing prior to implementation. The IRB will determine if the changes affect the initial categorization of this study.

The IRB appreciates your commitment towards the ethical conduct of research involving human subjects. If you have any questions, please contact the IRB.

Regards,

A handwritten signature in black ink, appearing to be "Diana Wong", written over a horizontal line.

Diana Wong, Chair
Institutional Review Board
New York City Department of Health and Mental Hygiene

University Integrated Institutional Review Board
 205 East 42nd Street
 New York, NY 10017
<http://www.cuny.edu/research/compliance.html>

Exemption Granted

07/12/2017

Elvy Barroso,

Hunter College

RE: IRB File #2017-0473

Factors Associated with TB Testing and Evaluation among Household Contacts Exposed to Tuberculosis

Dear Elvy Barroso,

Your Exemption Request was reviewed on 07/12/2017, and it was determined that your research protocol meets the criteria for exemption, in accordance with CUNY HRPP Procedures: Human Subject Research Exempt from IRB Review (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects. You may now begin your research.

Please note the following information about your approved research protocol:

Expiration Date: 07/11/2020

Documents / Materials:

Type	Description	Version #	Date
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Initial Imported IRBNet Application	Elvy Barroso	1	06/20/2017
Initial Imported IRBNet Application	CITI certificates-EC.webarchive	1	06/29/2017
Initial Imported IRBNet Application	CITI certificates-EB.webarchive	1	06/19/2017
Initial Imported IRBNet Application	1IRB-7-036_ExemptionApproval_04_12_17.pdf	1	06/19/2017

Although this research is exempt, you have responsibilities for the ethical conduct of the research and must comply with the following:

University Integrated Institutional Review Board
205 East 42nd Street
New York, NY 10017
<http://www.cuny.edu/research/compliance.html>

Amendments: You are responsible for reporting any amendments or changes to your research protocol that may affect the determination of exemption and/or the specific category to the HRPP. The amendment(s) or change(s) may result in your research no longer being eligible for the exemption that has been granted.

Continuing Review: You are responsible for completing and submitting a continuing review form every three years. The information in this form will keep us up to date on the progress of the study and help to ensure that the study continues to meet the requirements for exemption.

Final Report: You are responsible for submitting a final report to the HRPP at the end of the study.

Please remember to:

- Use **the HRPP file number** 2017-0473 on all documents or correspondence with the HRPP concerning your research protocol.
- Review and comply with CUNY Human Research Protection Program [policies and procedures](#).

If you have any questions, please contact:

Alyssa Wheeler

alyssa.wheeler@hunter.cuny.edu

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