ADHERENCE TO TUBERCULOSIS INFECTION CONTROL MEASURES: ADDRESSING THE “KNOWLEDGE-ACTION” GAP AMONG HEALTHCARE WORKERS IN THE DOMINICAN REPUBLIC

By

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To my parents
To public health professionals who investigate and prevent disease globally

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LIST OF ABBREVIATIONS

AIC	Akaike Information Criterion
BCG	Bacillus Calmette-Guérin
CDC	Centers for Disease Control and Prevention
CI	Confidence Interval
DOTS	Directly Observed Treatment, Short-course
DR	Dominican Republic
FDOH	Florida Department of Health
HCW	Healthcare Worker
HIV	Human Immunodeficiency Virus
HMS	Health Management System
IGRA	Interferon-Gamma Release Assay
LTBI	Latent Tuberculosis Infection
MDG	Millennium Development Goals
MDR-TB	Multidrug-Resistant Tuberculosis
MTB	*Mycobacterium tuberculosis*
NTP	National Tuberculosis Program
OR	Odds Ratios
TB	Tuberculosis
TIMS	Tuberculosis Information Management System
TST	Tuberculin Skin Test
WHO	World Health Organization

Abstract of Dissertation Presented to the Graduate School
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ADHERENCE TO TUBERCULOSIS INFECTION CONTROL MEASURES: ADDRESSING THE "KNOWLEDGE-ACTION" GAP AMONG HEALTHCARE WORKERS IN THE DOMINICAN REPUBLIC

By

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Healthcare workers (HCWs), due to occupational exposure, have an increased risk of infection with *Mycobacterium tuberculosis*, including drug-resistant strains. They are challenged to remain up-to-date, not only with current clinical standards but also with evidence-based infection control practices, and translate that knowledge into effective infection control measures. This "knowledge-action" gap, which describes observed inconsistencies in the application of clinical knowledge to practice, may reflect barriers at individual- or systems-levels, thus influencing healthcare service delivery. In the Dominican Republic (DR), a country of high tuberculosis (TB) burden and drug resistance levels, one national study documented nosocomial *M. tuberculosis* transmission in HCWs employed at tertiary-level health institutions, but the rates of nosocomial transmission in HCWs remain unknown. Thus, driven by increased utilization of healthcare services by persons who are evaluated and managed for TB disease, occupational exposure among HCWs is overlooked. This dissertation aims to improve understanding of advanced TB clinical presentation that can influence infectiousness and occupational *M. tuberculosis* exposure in health institutions as well

as examine the “knowledge-action” gap among HCWs in their use of recommended *M. tuberculosis* infection control measures. First, we examine associations of clinical, demographic and epidemiological characteristics of *M. tuberculosis* infection and pulmonary cavitation to understand infectiousness and occupational risk. Then, we conduct a two-phase study to explore the use of *M. tuberculosis* infection control practices among DR HCWs. By identifying HCWs’ perceived barriers that influence their adherence to *M. tuberculosis* infection control measures, we then explore the specific intrinsic and extrinsic processes that impact their clinical decision-making process to use these measures, thus adding to the “knowledge-action” gap in clinical practice. We also present recommendations that HCWs propose as potential strategies to enhance TB infection control. This theoretical framework can guide the development of evidence-based recommendations at institutional and national levels. Finally, we describe the public health implications of our findings related to *M. tuberculosis* infection control measures in tertiary-level health institutions in a high TB burden country, like the DR.

CHAPTER 1
BACKGROUND

Introduction

Tuberculosis (TB) is historically known as one of the leading infectious causes of global mortality. Transmitted through aerosol droplets from an individual with active pulmonary TB disease, an estimated 10.4 million new TB cases and 1.4 million TB fatalities were reported in 2015 (World Health Organization, 2016a). However, one-third of the global population is infected with *Mycobacterium tuberculosis* and at risk of reactivation (Glaziou, Falzon, Floyd, & Raviglione, 2013), where up to 10 percent may progress to active TB disease during the lifetime (Zumla, Raviglione, Hafner, & von Reyn, 2013). Early identification of high-risk population groups and initiation of anti-TB chemotherapy are key to curtail *M. tuberculosis* transmission and improve global TB control.

Global Epidemiology of Tuberculosis

Discovered by Robert Koch in 1882, *M. tuberculosis* has successfully adapted its pathogenicity over time as a leading cause of morbidity and mortality. Over the past two decades, global prevalence and morality rates have continued to fall, but incidence rates have only began to decrease since 2001 (Glaziou, Floyd, & Raviglione, 2009). These trends are attributed to multiple factors, including roll-out of the cost-effective, directly observed treatment, short-course (DOTS), strategy in the 1990s for optimal anti-TB pharmacological management (Hargreaves et al., 2011), new diagnostic strategies (Dorman, 2010), and interventions that reach communities and target social determinants of health (Rasanathan, Sivasankara Kurup, Jaramillo, & Lönnroth, 2011). However, challenges in access to healthcare services, development of drug resistance,

reactivation of TB infection, and co-morbidities, including co-infection with human immunodeficiency virus (HIV), remain concerns for global TB control (Dye & Floyd, 2006). More specifically, healthcare workers (HCWs) have historically been recognized as one vulnerable group with increased risk of nosocomial *M. tuberculosis* transmission (Baussano et al., 2011), including multidrug-resistant strains (Nathanson et al., 2010).

Nosocomial Transmission of Tuberculosis

Evidence of nosocomial *M. tuberculosis* transmission was noted in high-income countries during the mid-1980s through epidemiological investigations to describe the emergence of multidrug-resistant *M. tuberculosis* outbreaks in health institutions (Frieden et al., 1996). The emerging HIV epidemic and ineffective infection control measures related to environmental and respiratory protection controls within health institutions accounted for increased nosocomial *M. tuberculosis* transmission (Harries, Maher, & Nunn, 1997). The World Health Organization (WHO) infection control guidelines were revised by the Centers for Disease Control and Prevention (CDC), WHO and the International Union Against Tuberculosis and Lung Disease for improved infection control in limited-resource settings (World Health Organization, 1999). *M. tuberculosis* infection control guidelines should consider the disease process, such as susceptible, infection and disease, and ideal areas for appropriate interventions. However, with potential limitations in hospital infrastructure, increased patient flow, reduced number of HCW staff for operations, or limited resources for biosafety measures (Alp, Leblebicioglu, Doganay, & Voss, 2011), limited-resource health institutions may be unable to implement some or all of the categories of the *M. tuberculosis* infection control measures.

Previous studies have evaluated the use of *M. tuberculosis* infection control guidelines in high TB burden settings, concluding that guidelines are not universally implemented across health institutions (Harries, Hargreaves, Gausi, Kwanjana, & Salaniponi, 2002; Malangu & Mngomezulu, 2015). Health institutions with inadequate infection control policies, together with inaccurate understanding of TB risk, can encounter complications in TB management (Malangu & Mngomezulu, 2015; von Delft et al., 2015). In addition, studies recommended that direct observation in health institutions is key to complement quantitative approaches to evaluate adherence to infection control guidelines (Harries et al., 2002; Malangu & Mngomezulu, 2015). However, neither study determined which specific component of the administrative, environmental or respiratory protection controls that plays an integral role in the successful implementation of *M. tuberculosis* infection control guidelines. In comparison to high-resource health institutions, which depend primarily on environmental and respiratory protection control measures, low-resource health institutions may only focus on administrative control measures (Nardell, 2003).

Occupational Risk to Healthcare Workers

Identification of risk factors that are associated with increased *M. tuberculosis* transmission is another essential strategy to reduce *M. tuberculosis* disease or infection in HCWs. First, an individual with a weak or immunocompromised immune system will be more susceptible to *M. tuberculosis* transmission and disease progression. Second, pulmonary cavitation is a clinical sign of advanced disease, which is linked to increased number of *M. tuberculosis* bacilli or increased infectiousness (Gadkowski & Stout, 2008). Thus, disease management may require a longer treatment regimen for recovery (Wang et al., 2009). Third, *M. tuberculosis* strains vary by geographic diversity as well

as virulence. For example, the Beijing strain, which has been linked to the regions of East Asia (46% of cases), Oceania (17% of cases) and Middle-East-Central Asia (17% of cases), has been associated with increased *M. tuberculosis* transmission and drug resistance (Brudey et al., 2006; Sun et al., 2006). Higher virulence of the *M. tuberculosis* strain can increase transmission, disease progression and mortality (Smith, 2003). Thus, integrating effective *M. tuberculosis* infection control measures and knowledge about associated risk factors can reduce nosocomial transmission and occupational risk of HCWs.

Annual risk of TB disease in HCWs was two to three times higher across low, intermediate and high incidence regions (Baussano et al., 2011). In addition, global prevalence of TB infection in HCWs has been estimated at 63% (range 33–79%) in low- and middle-income countries, and 24% (range 4–46%) in high-income countries, with an annual risk of 5.8% (range 0–11%) and 1.1% (0.2–12%), respectively (Menzies, Joshi, & Pai, 2007). Historical studies have reported higher *M. tuberculosis* transmission risk in nursing and medical students (Baussano et al., 2011) as well as laboratory staff (Harries et al., 2002). One study, in particular, reported a 2% annual incidence rate of TB disease and 17% annual tuberculin skin test (TST) conversion rate in Peruvian medical residents (Bonifacio et al., 2002). Nurses had higher TB infection rates than other HCWs (Joshi, Reingold, Menzies, & Pai, 2006). However, individual studies reported varying prevalence rates of TB infection, including 43.4% in laboratory staff, 39.4% in technicians, 34.4% in physicians and 32.2% in nurses in China (Zhang et al., 2013); 21.8% in physicians and 19.6% in nurses in Cuba (Borroto et al., 2011); 26.3% in

clinical laboratory or respiratory ward staff in Chile (Hernández et al., 2014); and 10.6% in administrative and clinical ward staff in Malaysia (Rafiza, Rampal, & Tahir, 2011).

Epidemiology of Tuberculosis in the Dominican Republic

The Dominican Republic (DR) is a middle-income country of high TB incidence (60/100,000 in 2015) (World Health Organization, 2016c) and high levels of multidrug resistance identified from two national surveys (Espinal et al., 1998; Pérez-Then, Báez, García-Siragusa, & Medina, 2009). Reported TB incidence has been on the decline over the past 20 years (Pérez-Then, Acosta, Marcelino, & Espinal, 2007), with successful roll-out of DOTS in 1999 and expanded coverage to 85% of the country by 2009 (Dominican Republic Ministry of Health, 2010) and 94% by 2012 (Dominican Republic Ministry of Health, 2014). Figure 1-1 shows the declining TB incidence and prevalence rates between 2002 and 2014, and Figure 1-2 presents the total number of TB case notification rates between 2002 and 2015.

The DR Ministry of Health has revised and disseminated guidelines, based on WHO and CDC recommendations, to enhance TB prevention and control across DR communities (Dominican Republic Ministry of Health, 2010). In addition to DOTS coverage, the Bacillus Calmette-Guérin (BCG) immunization program aims to prevent advanced TB disease in children, such as tuberculous meningitis and miliary disease. They reported an excess of 90% BCG immunization coverage in children who were less than one year of age (United Nations Children's Fund, 2013). However, there are two national studies that contrasted this stated achievement for population health. First, one study reported inadequate BCG coverage in school-aged children (Pérez-Then, Shor-Posner, Crandall, & Wilkinson, 2007). Second, the only known study that measured *M. tuberculosis* infection in the DR reported prevalence of TB infection at 5% of the

participating 672 children between five and 15 years of age, who never received the BCG vaccination (Cruz Bournigal et al., 1986).

The DR National TB Program (NTP) has encountered three significant challenges for optimal TB control and prevention. First, due to treatment relapse or failure, primary drug resistance has ranged from 6.6% (1994-1995), 5.8% (2007-2008), and 6.6% (2012) (Espinal et al., 1998; Pérez-Then et al., 2009), recognizing the DR as a “hot zone” (multidrug-resistant TB prevalence of > 5%) (Blower & Chou, 2004). Second, due to decreased immunological protection, some high-risk populations such as immunocompromised patients may be more susceptible to developing TB disease from initial contact with an infectious case or experiencing reactivation of previous *M. tuberculosis* exposure to TB disease. Third, specific drivers of TB transmission, including the influence of the social determinants of health related to physical and social environments as well as health-seeking behaviors (Lönnroth, Jaramillo, Williams, Dye, & Raviglione, 2009), should be closely examined since *M. tuberculosis* transmission continues in DR communities. Accordingly, given the indispensable attention to these three challenges that contribute to the overall national TB burden, occupational *M. tuberculosis* exposure of HCWs to drug-susceptible and drug-resistant strains is minimized or disregarded.

Nosocomial Transmission of Tuberculosis in the Dominican Republic

Current DR guidelines for *M. tuberculosis* control in health institutions have adopted the three recommended infection control strategies – administrative controls, environmental controls and personal respiratory protection measures (Dominican Republic Ministry of Health, 2014). However, universal implementation in low- and

middle-income countries has been limited (Jones-López & Ellner, 2005; Pai, Kalantri, Aggarwal, Menzies, & Blumberg, 2006), which is suggested to be the case in the DR. As frontline agents in DR health centers with increased occupational exposure to drug-susceptible or drug-resistant *M. tuberculosis* strains, HCWs are susceptible to develop TB infection or disease. Their risk of *M. tuberculosis* exposure, in effect, can influence overall healthcare service delivery for ambulatory or hospitalized patient care, and ultimately, negatively affect patient outcomes. With limited efficacy of the BCG vaccine for lifetime immunological protection against *M. tuberculosis*, personal protection for HCWs is essential to prevent *M. tuberculosis* transmission. However, no governing DR agency actively monitors adherence to infection control policies or practices, albeit with reported *M. tuberculosis* transmission to HCWs in DR health institutions.

Occupational Risk to Healthcare Workers in the Dominican Republic

The estimated risk of *M. tuberculosis* nosocomial transmission to HCWs and prevalence of TB infection in HCWs are unknown. The only national study to address nosocomial *M. tuberculosis* transmission was conducted at 49 provincial and regional DR hospitals, reporting that of the 116 HCWs who developed TB disease between 2005 and 2012, 27% were nurses, 17% were janitorial staff and 11% were physicians (Genao & Rodríguez, 2013). Notably, these three HCW professions differ by the duration and scope of the respective clinical training. Nurses and physicians received academic coursework and supervised clinical rotations, and thus, are knowledgeable and skilled in TB pathology, diagnosis and management as well as *M. tuberculosis* infection control measures. As such, it is essential to identify the underlying factors that drive *M. tuberculosis* transmission in the clinical setting, especially where trained clinicians face

the daily risk of occupational exposure through their daily responsibilities in healthcare service delivery.

Understanding the "Knowledge-Action" Gap

HCWs face daily challenges in order to remain up-to-date with evidence-based clinical practices and, in turn, translate the educational information into changes in healthcare service delivery. This "knowledge-action" gap in the health sector has been well-documented in low- and high-income countries (Haines, Kuruvilla, & Borchert, 2004). Multiple barriers may hinder how HCWs can translate their knowledge into practice, especially in a time-constrained or short-staffed health setting (Haines et al., 2004). Absence of financial resources can influence how HCWs are able to apply their knowledge into healthcare service delivery, thus fostering the development of health disparities in disease control (Farmer, 2013). One such example is the development of drug-resistant *M. tuberculosis*, where HCWs were unaware of the complex dynamics surrounding *M. tuberculosis* pathogen transmission and importance for establishing appropriate diagnostic and management measures for optimal infection control (Farmer, 2013). Thus, by increasing attention to the "knowledge-action" gap, where HCWs are educated and empowered to apply their knowledge into their clinical practices, health institutions can strengthen their application of optimal *M. tuberculosis* infection control measures.

Overview of the Dissertation

This dissertation aims to improve understanding of occupational *M. tuberculosis* exposure among HCWs in health institutions. Since HCWs are historically recognized to have increased risk of occupational *M. tuberculosis* exposure in their workplace, it is essential to explore pathogen infectiousness related to advanced clinical presentation

as well as application of infection control measures in clinical practice. In chapter two, we investigate the association of clinical, demographic and epidemiological characteristics of *M. tuberculosis* infection and pulmonary cavitation to understand infectiousness and occupational risk. We hypothesize that the *M. tuberculosis* Beijing strain, which has been linked to increased risk of transmission, will be more associated with lung cavitation, when compared to the non-Beijing strain. Then, using a qualitative approach and theoretical sampling, we conduct a two-phase data collection period to examine how HCWs understand their occupational *M. tuberculosis* risk and report their application of infection control measures in three tertiary-level health institutions in a high TB burden country, the DR. In chapter three, we identify the perceived barriers of HCWs that influence their use of *M. tuberculosis* infection control measures in clinical practice. In chapter four, we examine the intrinsic and extrinsic processes perceived by HCWs that influence the clinical decision-making process to use infection control measures. We develop a theoretical framework that will identify reasons for this "knowledge-action" gap in adherence to *M. tuberculosis* infection control measures. We also present several recommendations that HCWs suggested as potential strategies to enhance TB infection control within health institutions and the country.

To our knowledge, this is the first known study to explore the "knowledge-action" gap of HCWs in the application of *M. tuberculosis* infection control measures in clinical practice. Although TB incidence rates in the general DR population have declined over the past decade, the actual rate of nosocomial *M. tuberculosis* transmission in HCWs is unknown and overlooked. In our analyses, we identify HCWs' perceived barriers and comprehensively examine the intrinsic and extrinsic processes that hinder their

consistent application of *M. tuberculosis* infection control measures in clinical practice. These findings have the potential to propose specific target areas where future evidence-based interventions can be implemented in DR health institutions to empower HCWs in the application of *M. tuberculosis* infection control measures in practice, thus strengthening TB infection control while minimizing the “knowledge-action” gap. Collectively, these three studies contribute to improved understanding of the individual- and systems-level elements that enable the “knowledge-action” gap in *M. tuberculosis* infection control practices and provide a foundation for future studies to evaluate evidence-based interventions to empower HCWs as frontline agents to promote strategies to reduce nosocomial *M. tuberculosis* control in DR health institutions.

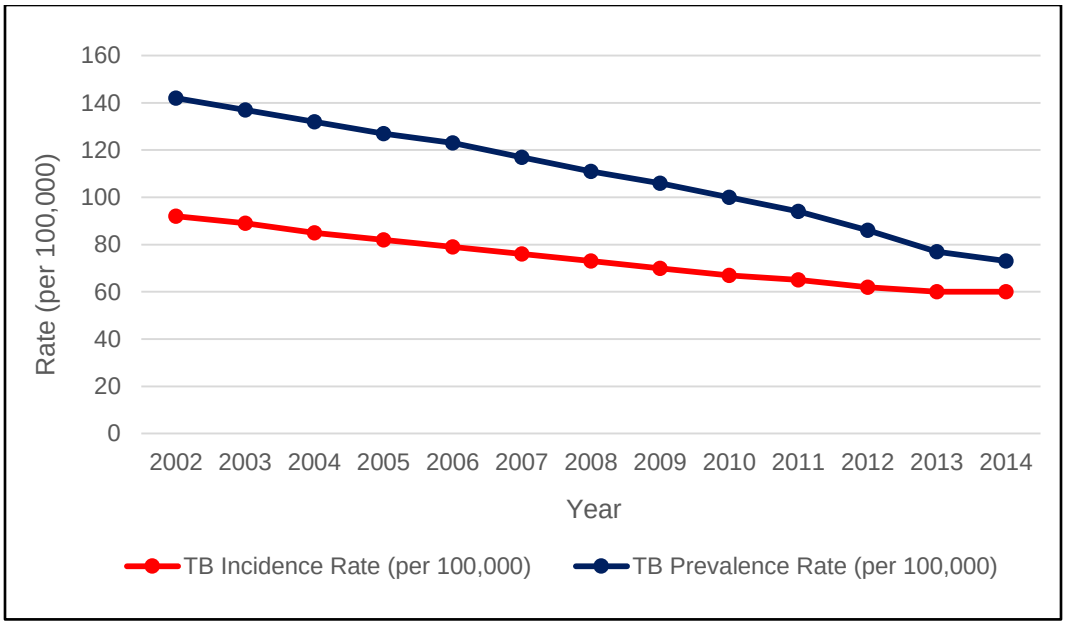

Figure 1-1. Tuberculosis (TB) incidence and prevalence rates (per 100,000 people) in the Dominican Republic, 2002-2014. [Data obtained from the World Health Organization Global Health Observatory data repository for TB incidence and prevalence data of the Dominican Republic.]

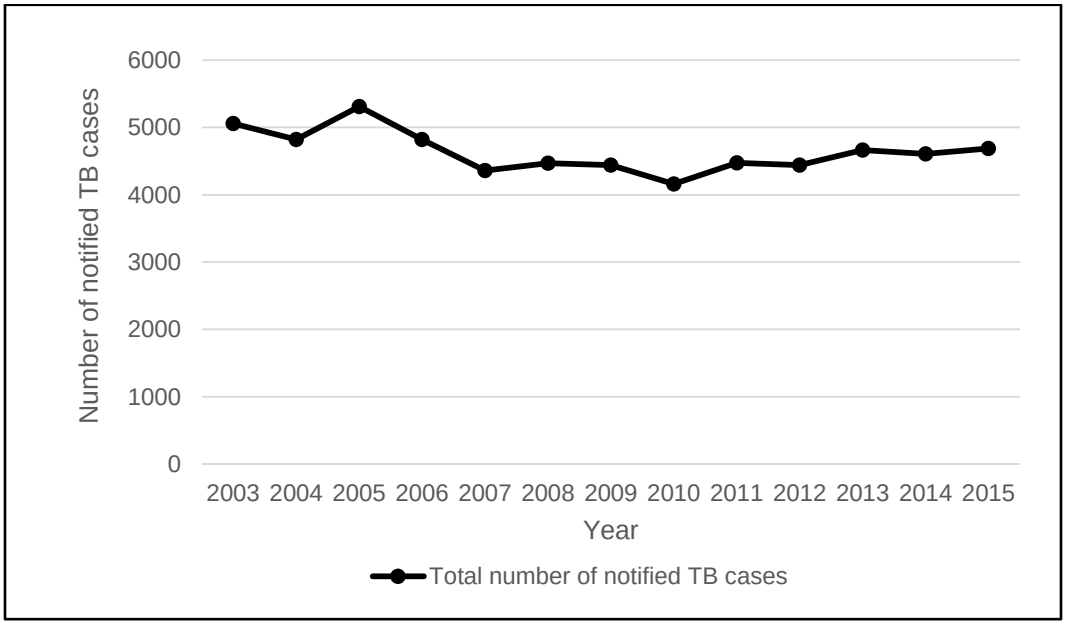

Figure 1-2. Total number of notified tuberculosis (TB) cases in the Dominican Republic, 2003-2015. [Data obtained from the World Health Organization Global Health Observatory data repository for TB data of the Dominican Republic.]

CHAPTER 2
IS THE BEIJING STRAIN OF *Mycobacterium tuberculosis* ASSOCIATED WITH CAVITARY LUNG DISEASE?[1]

Introduction

The global emergence of the Beijing genotype, or "W" strain, of *Mycobacterium tuberculosis* has been linked to an increased risk of tuberculosis (TB) transmission and drug resistance (Bifani, Mathema, Kurepina, & Kreiswirth, 2002; Drobniewski et al., 2005; European Concerted Action on New Generation Genetic Markers and Techniques for the Epidemiology and Control of Tuberculosis, 2006; Langlois-Klassen et al., 2012; Sun et al., 2006). TB caused by the Beijing strain is associated with 45.9% of cases of TB in East Asia, 17.2% in Oceania, and 16.5% in the Middle-East-Central Asia (Brudey et al., 2006). Although the selective advantage of the Beijing strain has been noted, the specific clinical characteristics that might be associated with and hence promote transmission are unknown and have been for some time (Mathema, Kurepina, Bifani, & Kreiswirth, 2006).

Pulmonary cavitation presents in less than 50% of TB patients, more commonly in advanced disease, which corresponds to increased infectiousness or quantity of *M. tuberculosis* bacilli (Gadkowski & Stout, 2008). Cavitation can increase the risk of TB transmission to susceptible individuals, facilitate the emergence of spontaneous mutations that may lead to drug resistance, and is an independent risk factor for relapse

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after treatment completion (Yoder, Lamichhane, & Bishai, 2004). With high pathogen presence in cavitation, studies have demonstrated that individuals with cavitation on initial treatment will take a longer period of time for negative sputum conversion (Wang et al., 2009). Further review of risk factors that play a role in the pathogenesis of advanced TB disease will be key to improve clinical management.

It remains uncertain, however, whether the Beijing strain promotes the presence of cavitation which in turn could account for the strain's increased prevalence. One study in Russia reported increased risk of cavitation (Drobniewski et al., 2005), while another study in Singapore found decreased risk of cavitation and presence of constitutional symptoms (Sun et al., 2006). The objective of our study is to determine whether the Beijing strain is associated with evidence of lung cavitation on radiological imaging. A second objective is to describe key demographic and clinical characteristics of TB disease caused by Beijing strains as compared to non-Beijing strains.

Materials and Methods

A cross-sectional study was conducted using the Florida Department of Health (FDOH) TB Registry to examine culture-confirmed *M. tuberculosis* Beijing and non-Beijing strains, reported in Florida, between January 1, 2008 and November 1, 2011. Data were extracted from the Florida's Health Management System (HMS) and the Tuberculosis Information Management System (TIMS) databases. Genotyping is performed routinely for the FDOH through the National Tuberculosis Genotyping and Surveillance Network and retrospective data were used (Crawford, Braden, Schable, & Onorato, 2002). Spoligotyping and MIRU-VNTR (12-MIRU) were performed utilizing methods previously described (Allix-Béguec, Harmsen, Weniger, Supply, & Niemann, 2008; Kamerbeek et al., 1997).

Demographic and epidemiological variables included age, sex, race/ethnicity, region of birth, homelessness, residency in a long-term care facility or correctional institution, substance or illicit drug use, human immunodeficiency virus (HIV) status, previous TB infection, presence of cavitation on chest radiograph, presence of miliary disease, status at diagnosis (alive vs dead), and treatment completion. Due to sparse observations, we collapsed the race/ethnicity categories of Native Hawaiians and American Indians into the Asian/Other category. We dichotomized region of birth as “Americas” vs “Other regions”, using the World Health Organization (WHO) definition (World Health Organization, 2014). Laboratory variables included sputum and culture smear results, drug susceptibility results, and genotyping lineage.

Data were analyzed using SAS Version 9.3 (SAS Institute Inc, Cary, NC, USA). Chi-square or Fisher’s exact test were used to calculate associations between categorical variables. In the case of covariates missing more than 5.0% observations, we evaluated the influence of missingness on our predictor (Beijing strain) and outcome (cavitation). We used logistic regression to examine the unadjusted and adjusted associations between each covariate and the outcome of interest, cavitation. We selected the final model using backward manual selection (Bursac, Gauss, Williams, & Hosmer, 2008). We started with a fully adjusted model which included all the covariates of interest. Covariate influence on the association between the Beijing strain and cavitation was assessed using changes in model estimates as compared to the fully adjusted model. Indicators which when removed only changed parameter estimates for the Beijing strain by less than 10.0% and did not significantly affect model fit were considered to not be a confounder and were dropped from the final model. Final model

fit was tested using change in the Akaike Information Criterion (AIC). Significant odds ratios (ORs) were evaluated at a 0.05 alpha level and 95% confidence intervals (CIs). The study was approved by the Institutional Review Boards of the University of Florida and the FDOH and funding was provided by the University of Florida.

Results

Between January 1, 2008, and November 1, 2011, a total of 1,582 *M. tuberculosis* cases were recorded in the FDOH TB registry. A total of 476 (30.1%) cases were of extra-pulmonary origin or negative-confirmed culture results, 45 (2.8%) cases did not have spoligotyping, and 170 (10.8%) cases lacked radiographic imaging, and were excluded from the analyses. Our study analyzed the remaining 975 cases, where 144 (14.8%) isolates were classified as the Beijing strain. Table 2-1 shows descriptive statistics of the selected clinical and epidemiologic variables of TB disease associated with the exposure (Beijing strain) and outcome (cavitation).

Our results show that cavitation was not associated with infection with the Beijing strain. In the unadjusted analyses, alcohol use (OR=1.7; 95%CI: 1.249-2.313; p=0.0007) was significantly associated with increased risk of cavitation. Older age (≥65 years) (OR=0.5; 95%CI: 0.294-0.847; p=0.0100), being black (OR=0.7; 95%CI: 0.470-0.914; p=0.0127), Hispanic (OR=0.6; 95%CI: 0.390-0.814; p=0.0022) or foreign-born (OR=0.7; 95%CI: 0.568-0.970; p=0.0290), and co-infection with HIV (OR=0.2; 95%CI: 0.121-0.371; p<0.0001) were significant protective predictors of pulmonary cavitation. In the adjusted analyses, although alcohol use (OR=1.5; 95%CI: 0.980-2.289) was not statistically significant, we observed an increased risk of cavitation among those who reported alcohol use compared to those who did not. Older age (≥65 years) (OR=0.5; 95% CI: 0.233-0.871), Hispanic ethnicity (OR=0.6; 95% CI: 0.312-0.962), and co-

infection with HIV (OR=0.1; 95%CI: 0.068-0.295) continued to have protective effects for cavitation. Due to sparse observations, status at diagnosis was not included in the predictive model. Table 2-2 presents unadjusted and adjusted estimates.

Discussion

There are several potential reasons why the Beijing strain has been successful in establishing itself in populations around the world. A propensity to cause extensive disease as manifested by cavitation on chest radiograph is one way since patients with extensive disease and cavitation are more infectious (Lohmann et al., 2012; Nava-Aguilera et al., 2009). This study found that the presence of cavitation at diagnosis of pulmonary TB was not significantly associated with the Beijing strain. This is consistent with other investigations that have shown a similar lack of association in a similar relatively low incidence area as the United States (Langlois-Klassen et al., 2012). Foreign-born individuals were more likely to have the Beijing strain, which most likely reflects the ubiquitous presence of the Beijing strains among those who immigrated from the Western Pacific where the Beijing strain is more prevalent.

Although HIV status has not been clearly associated with the Beijing strain (Drobniewski et al., 2005; European Concerted Action on New Generation Genetic Markers and Techniques for the Epidemiology and Control of Tuberculosis, 2006; Middelkoop et al., 2009), our study showed that co-infection with HIV and older age ($\geq$65 years) had significant protective effects on cavitation, both of which are likely to result in a weakened immune system making cavitation less likely (Gadkowski & Stout, 2008). Also, we observed that alcohol use may be a significant predictor of cavitation, an association that has been observed in other bacterial infections and is most likely

due to the fact that alcohol use may be associated with delayed presentation and hence advanced disease (Gadkowski & Stout, 2008).

This is a cross-sectional analysis and as such our results should not be interpreted as causal relationships. In addition, our study did not account for many other factors that could explain the association between infection with the Beijing strain and pulmonary cavitation. There are multiple explanations for the wide dissemination of the Beijing strain throughout the world and its association with drug resistance. Increased virulence, increased transmissibility, characteristics of the population at risk, historically poor TB control in the countries where the Beijing strain is common, or any combination of these factors could account for the near ubiquitous presence of this strain. Furthermore, there is evidence that there is a difference between sub-lineages of Beijing strains and the more modern lineages may be associated with factors that increase virulence or transmissibility (Iwamoto, Yoshida, Suzuki, & Wada, 2008; Mokrousov et al., 2005, 2006; Ribeiro et al., 2014). Future studies looking more closely at clinical features among the various sub-lineages of Beijing strains may yield important answers.

We also evaluated the effect of excluding for all covariates of the final sample, and two covariates, region of birth and co-infection with HIV, showed a significant association with the Beijing strain and cavitation, respectively. The association between region of birth and Beijing can be attributed to the robust phylogeographical structure of *M. tuberculosis* (Gagneux, 2012). Second, although co-infection with HIV has been strongly linked to reactivation or progression of TB infection or disease, respectively (Diedrich & Flynn, 2011), it may predispose individuals to infection with other fitter *M.*

tuberculosis strains, such as the Beijing strain (Bekker & Wood, 2010). Lastly, differentiating the clinical characteristics attributable to the strain from the clinical characteristics attributable to the patient is a vexing problem but can be done with a prospective study powered to address issues not effectively dealt with in cross-sectional study design.

Conclusions

Between 2008 and 2011, the Beijing strain was isolated in 144 (14.8%) of the 975 culture-confirmed TB cases reported in the state of Florida. In this cross-sectional study, our hypothesis that cavitation would be associated with the Beijing strain in a low incidence area such as the United States was not confirmed. Cavitation was not significantly associated with infection with the Beijing strain. Understanding the clinical and epidemiological characteristics of the Beijing strain as well as the characteristics of the ancient and modern Beijing sub-lineages will be essential for improved TB management and control.

Table 2-1. Clinical and epidemiologic characteristics of 975 culture-confirmed tuberculosis cases in Florida, 2008-2011.

Characteristic	Sample Total (%)	Beijing n=144 (14.8%)	non-Beijing n=831 (85.2%)	p value	Cavitation n=331 (34.0%)	No cavitation n=644 (66.0%)	p value
		n (%)	n (%)		n (%)	n (%)	
Age							
≤ 24 years	116 (11.9)	20 (17.2)	96 (82.8)	0.4250	47 (40.5)	69 (59.5)	0.0639
25-44 years	321 (32.9)	39 (12.2)	282 (87.8)		114 (35.5)	207 (64.5)	
45-64 years	396 (40.6)	62 (15.7)	334 (84.3)		134 (33.8)	262 (66.2)	
≥ 65 years	142 (14.6)	23 (16.2)	119 (83.8)		36 (25.4)	106 (74.6)	
Sex							
Male	692 (71.0)	105 (15.2)	587 (84.8)	0.5780	238 (34.4)	454 (65.6)	0.6468
Female	283 (29.0)	39 (13.8)	244 (86.2)		93 (32.9)	190 (67.1)	
Race/ethnicity							
White	244 (25.0)	36 (14.8)	208 (85.2)	<0.0001	103 (42.2)	141 (57.8)	0.0137
Black	383 (39.3)	20 (5.2)	363 (94.8)		124 (32.4)	259 (67.6)	
Hispanic	264 (27.1)	32 (12.1)	232 (87.9)		77 (29.2)	187 (70.8)	
Asian/Other	84 (8.6)	56 (66.7)	28 (33.3)		27 (32.1)	57 (67.9)	
Foreign-born							
Yes	454 (46.6)	90 (19.8)	364 (80.2)	<0.0001	138 (30.4)	316 (69.6)	0.0288
No	521 (53.4)	54 (10.4)	467 (89.6)		193 (37.0)	328 (63.0)	
Region of birth							
Americas region	800 (82.0)	73 (9.1)	727 (90.9)	<0.0001	266 (33.3)	534 (66.7)	0.2733
Other regions	110 (11.3)	67 (60.9)	43 (39.1)		37 (33.6)	73 (66.4)	
Missing	65 (6.7)	4 (6.2)	61 (93.8)		28 (43.1)	37 (56.9)	
Homeless							
Yes	102 (10.5)	14 (13.7)	88 (86.3)	0.8207	34 (33.3)	68 (66.7)	0.7158
No	862 (88.4)	128 (14.8)	734 (85.2)		292 (33.9)	570 (66.1)	
Missing	11 (1.1)	2 (18.2)	9 (81.8)		5 (45.5)	6 (54.5)	

Table 2-1. Continued

Characteristic	Sample Total (%)	Beijing n=144 (14.8%)	non-Beijing n=831 (85.2%)	p value	Cavitation n=331 (34.0%)	No cavitation n=644 (66.0%)	p value
Correctional institution							
Yes	50 (5.1)	3 (6.0)	47 (94.0)	0.0983	14 (28.0)	36 (72.0)	0.3618
No	925 (94.9)	141 (15.2)	784 (84.8)		317 (34.3)	608 (65.7)	
Long-term care facility							
Yes	11 (1.1)	3 (27.3)	8 (72.7)	0.2134	3 (27.3)	8 (72.7)	0.7582
No	964 (98.9)	141 (14.6)	823 (85.4)		328 (34.0)	636 (66.0)	
Alcohol use							
Yes	220 (22.6)	26 (11.8)	194 (88.2)	0.2942	96 (43.6)	124 (56.4)	<0.0001
No	751 (77.0)	118 (15.7)	633 (84.3)		235 (31.3)	516 (68.7)	
Missing	4 (0.4)	0 (0)	4 (100)		0 (0)	4 (100)	
Non-intravenous drug use							
Yes	122 (12.5)	8 (6.6)	114 (93.4)	0.0109	45 (36.9)	77 (63.1)	0.1751
No	847 (86.9)	136 (16.1)	711 (83.9)		286 (33.8)	561 (66.2)	
Missing	6 (0.6)	0 (0)	6 (100)		0 (0)	6 (100)	
Intravenous drug use							
Yes	20 (2.1)	2 (10.0)	18 (90.0)	0.7143	9 (45.0)	11 (55.0)	0.1129
No	949 (97.3)	142 (15.0)	807 (85.0)		322 (33.9)	627 (66.1)	
Missing	6 (0.6)	0 (0)	6 (100)		0 (0)	6 (100)	
HIV status							
Positive	127 (13.0)	10 (7.9)	117 (92.1)	0.0019	15 (11.8)	112 (88.2)	<0.001
Negative	731 (75.0)	107 (14.6)	624 (85.4)		283 (38.7)	448 (61.3)	
Refused	76 (7.8)	14 (18.4)	62 (81.6)		24 (31.6)	52 (68.4)	
Missing	41 (4.2)	13 (31.7)	28 (68.3)		9 (22.0)	32 (78.0)	

Table 2-1. Continued

Characteristic	Sample Total (%)	Beijing n=144 (14.8%)	non-Beijing n=831 (85.2%)	p value	Cavitation n=331 (34.0%)	No cavitation n=644 (66.0%)	p value
Previous TB infection							
Yes	32 (3.3)	3 (9.4)	29 (90.6)	0.6678	14 (43.7)	18 (56.3)	0.4090
No	942 (96.6)	141 (15.0)	801 (85.0)		317 (33.6)	625 (66.4)	
Missing	1 (0.1)	0 (0)	1 (100)		0 (0)	1 (100)	
Any drug resistance							
Yes	3 (0.3)	2 (66.7)	1 (33.3)	0.0089	1 (33.3)	2 (66.7)	0.5938
No	953 (97.7)	136 (14.3)	817 (85.7)		326 (34.2)	627 (65.8)	
Missing	19 (2.0)	6 (31.6)	13 (68.4)		4 (21.0)	15 (79.0)	
Multidrug resistance							
Yes	13 (1.3)	4 (30.8)	9 (69.2)	0.0162	6 (46.2)	7 (53.9)	0.5218
No	940 (96.4)	133 (14.2)	807 (85.8)		319 (33.9)	621 (66.1)	
Missing	22 (2.3)	7 (31.8)	15 (68.2)		6 (27.3)	16 (72.7)	
Miliary TB							
Yes	51 (5.2)	9 (17.7)	42 (82.3)	0.2531	18 (35.3)	33 (64.7)	0.0023
No	910 (93.3)	135 (14.8)	775 (85.2)		302 (33.2)	608 (66.8)	
Missing	14 (1.5)	0 (0)	14 (100)		11 (78.6)	3 (21.4)	
Status at diagnosis							
Alive	964 (98.9)	141 (14.6)	823 (85.4)	0.2134	330 (34.2)	634 (65.8)	0.1101
Dead	11 (1.1)	3 (27.3)	8 (72.7)		1 (9.1)	10 (90.9)	
Treatment completion							
Completed	840 (86.2)	125 (14.9)	715 (85.1)	0.8590	285 (33.9)	555 (66.1)	0.5853
Did not complete	92 (9.4)	12 (13.0)	80 (87.0)		34 (37.0)	58 (63.0)	
Missing	43 (4.4)	7 (16.3)	36 (83.7)		12 (27.9)	31 (72.1)	

Abbreviation: TB, tuberculosis.
Bold values refer to significant p-values for chi-square test of comparison between the groups.

Table 2-2. Unadjusted and adjusted associations between clinical and epidemiologic characteristics and cavitation in 975 culture-confirmed tuberculosis cases in Florida, 2008-2011.

Characteristic	Unadjusted OR (95%CI)	Unadjusted p value	Adjusted OR (95%CI)[a]	Adjusted p value[a]
Beijing strain				
No	1.0 (referent)		1.0 (referent)	
Yes	0.87 (0.592, 1.267)	0.4591	1.14 (0.683, 1.884)	0.6253
Age				
≤ 24 years	1.0 (referent)		1.0 (referent)	
25-44 years	0.81 (0.523, 1.250)	0.3387	1.05 (0.629, 1.749)	0.8537
45-64 years	0.75 (0.491, 1.149)	0.1865	0.74 (0.430, 1.254)	0.2579
≥ 65 years	0.50 (0.294, 0.847)	0.0100	0.45 (0.233, 0.871)	0.0177
Sex				
Male	1.0 (referent)		1.0 (referent)	
Female	0.93 (0.696, 1.252)	0.6469	1.03 (0.717, 1.468)	0.8889
Race/ethnicity				
White	1.0 (referent)		1.0 (referent)	
Black	0.66 (0.470, 0.914)	0.0127	0.76 (0.489, 1.195)	0.2389
Hispanic	0.56 (0.390, 0.814)	0.0022	0.55 (0.312, 0.962)	0.0362
Asian/Other	0.65 (0.384, 1.095)	0.1049	0.91 (0.333, 2.474)	0.8498
Foreign-born				
No	1.0 (referent)		1.0 (referent)	
Yes	0.74 (0.568, 0.970)	0.0290	0.89 (0.559, 1.403)	0.6045
Region of birth				
Americas region	1.0 (referent)		1.0 (referent)	
Other regions	1.02 (0.667, 1.552)	0.9356	0.69 (0.273, 1.759)	0.4407
Homeless				
No	1.0 (referent)		1.0 (referent)	
Yes	0.98 (0.632, 1.508)	0.9132	0.77 (0.430, 1.385)	0.3852
Correctional institution				
No	1.0 (referent)		1.0 (referent)	
Yes	0.75 (0.396, 1.403)	0.3634	0.54 (0.230, 1.271)	0.1585
Long-term care facility				
No	1.0 (referent)		1.0 (referent)	
Yes	0.73 (0.192, 2.759)	0.6396	0.30 (0.032, 2.852)	0.2959

Table 2-2. Continued

Characteristic	Unadjusted OR (95%CI)	Unadjusted p value	Adjusted OR (95%CI)[a]	Adjusted p value[a]
Alcohol use				
No	1.0 (referent)		1.0 (referent)	
Yes	1.70 (1.249, 2.313)	0.0007	1.50 (0.980, 2.289)	0.0617
Illicit drug use				
No	1.0 (referent)		1.0 (referent)	
Yes	1.19 (0.805, 1.753)	0.3851	0.89 (0.528, 1.501)	0.6618
HIV status				
Negative	1.0 (referent)		1.0 (referent)	
Positive	0.21 (0.121, 0.371)	<0.0001	0.14 (0.068, 0.295)	<0.0001
Refused	0.73 (0.440, 1.212)	0.2242	0.88 (0.490, 1.585)	0.6730
Previous TB infection				
No	1.0 (referent)		1.0 (referent)	
Yes	1.53 (0.753, 3.123)	0.2388	1.38 (0.603, 3.171)	0.4441
Any drug resistance				
No	1.0 (referent)		1.0 (referent)	
Yes	1.35 (0.846, 2.138)	0.2109	1.50 (0.877, 2.554)	0.1395
Miliary TB				
No	1.0 (referent)		1.0 (referent)	
Yes	1.10 (0.608, 1.982)	0.7561	0.89 (0.417, 1.911)	0.7697
Treatment completion				
Completed	1.0 (referent)		1.0 (referent)	
Did not complete	1.14 (0.730, 1.785)	0.5614	1.55 (0.854, 2.793)	0.1502

Abbreviations: OR, odds ratio; CI, confidence interval.
Bold values refer to significant associations between cavitation and covariates, evaluated at $p < 0.05$.
[a] Sample size for the final adjusted model is n = 777.

CHAPTER 3
BARRIERS RELATED TO ADHERENCE TO TUBERCULOSIS INFECTION CONTROL MEASURES AMONG HEALTHCARE WORKERS IN THE DOMINICAN REPUBLIC[2]

Introduction

Healthcare workers (HCWs) have an increased risk of infection due to occupational *Mycobacterium tuberculosis* exposure, including multidrug-resistant strains. HCWs may be exposed and subsequently develop tuberculosis (TB) infection or active disease (Menzies et al., 2007). Annual risk of TB disease in HCWs was two to three times higher across low, intermediate and high TB incidence regions (Baussano et al., 2011). Compliance with infection control measures, including personal protective equipment, administrative and environmental conditions, is essential to reduce risk of *M. tuberculosis* transmission between suspected TB patients and HCWs (Jensen, Lambert, Iademarco, Ridzon, & CDC, 2005). However, in limited-resource settings, ineffective infection control strategies within health institutions coupled with erroneous understanding or perceptions of TB risk complicate TB management (von Delft et al., 2015).

The Dominican Republic (DR) is a middle-income country in the Caribbean with high TB incidence (60/100,000 in 2014) (World Health Organization, 2016b). The directly observed treatment, short-course (DOTS), which began in 1999, has been successful in reaching 94% of the population as of 2012 (Dominican Republic Ministry

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of Health, 2014). DOTS has been demonstrated to reduce TB incidence rate estimates. However, high reported levels of multidrug resistance still have been reported (Espinal et al., 1998), especially for HCWs who may be in contact with patients susceptible or resistant to *M. tuberculosis* strains. For example, according to one study, 116 HCWs [31(27%) nurses, 20(17%) janitorial services, 13(11%) physicians], who were employed at 49 provincial and regional hospitals, developed active TB disease between 2005 and 2012 (Genao & Rodríguez, 2013). Thus, to reduce occupational risk of nosocomial *M. tuberculosis* transmission, it is essential to examine the "knowledge-action" gap about how HCWs understand their occupational risk and reported use of preventive strategies in their clinical practices. This is especially important since there is no established national surveillance program that reports the number of HCWs who become exposed and develop latent TB infection (LTBI) or active TB disease.

With advancements in TB diagnostics, treatment and prevention, qualitative research studies are scarce, yet may add value to collaborative methods used for global TB control (Engel & Pai, 2013). Using a qualitative approach, the study purpose was to identify perceived barriers related to adherence to TB infection control measures among HCWs in the DR.

Methods

Setting and Sample

During August 2014, a qualitative study was conducted in two tertiary-level health institutions within two regions of the DR. Table 3-1 shows the demographic and administrative variables of the two selected institutions. A purposive sample of nine HCWs (seven physicians, two nurses), from emergency and internal medicine specialties, who were involved in TB prevention, control or management within the

health institution, was recruited for this study. Inclusion criteria included: a) physicians who had completed at least one year of their medical specialty; and b) nurses who had completed at least one year (technical training) of their nursing education. Exclusion criteria included any physician or nurse with part-time employment, or less than 25 hours per week. Table 3-2 describes the demographic characteristics of the study participants.

Data Collection

The socio-ecological framework, adapted for social science and behavioral research in TB, guided the study design, methods and data analysis (Centers for Disease Control and Prevention, 2005). A semi-structured interview guide was developed and used to facilitate data collection in Spanish. Topics included a) clinical experiences related to *M. tuberculosis* infection and disease; b) knowledge about disease transmission and utilized preventive practices; c) clinical management strategies; and d) perceptions related to DOTS effectiveness and disease coping strategies. Questions were written in English and translated into Spanish, and then verified by a bilingual Dominican physician. Each interview was conducted by the principal author, a general physician trained in the DR, and digitally recorded at the main desk of the closest clinical ward or in a private office. The duration of the interview varied based on the length of responses provided by the participant. Field notes were made by hand after the completion of each interview. Data collection was finalized when no new emerging themes were observed, thus reaching data saturation (Charmaz, 2000).

Data Analysis

Data were transcribed and de-identified by the principal author and verified by the co-author. QSR International's NVivo 10 qualitative data analysis software (QSR International Inc., Burlington, MA) was used to manage transcripts and facilitate the coding process. Based on knowledge and experiences in TB, both researchers developed initial categories prior to the start of the interviews. They coded the interview transcripts separately and then met to discuss all coded nodes and discrepancies to enhance inter-observer reliability. Using thematic analysis, they analyzed these coded notes and developed emerging themes with illustrating quotations (Ryan & Bernard, 2003; Sandelowski & Barroso, 2003). Card sorting and peer debriefing were used to ensure reliability and validity in the analytical process (Lincoln & Guba, 1985; Ryan & Bernard, 2003). A descriptive and illustrative model was developed to represent the emerging themes.

Ethical Aspects

This study was approved by the Institutional Review Boards of the University of Florida (Gainesville, Florida, USA) and O&M Medical School (O&MED) (Santo Domingo, DR). The protocol was evaluated and authorized by the National Tuberculosis Program (NTP) (Santo Domingo, DR). Finally, the protocol was approved by the Department of Academics of Hospital A (Santo Domingo, DR) and the Institutional Review Board of Hospital B (Santiago de los Caballeros, DR). Written informed consent was obtained from all participants.

Results

A total of nine HCWs (seven physicians, two nurses) participated in the study. Of the physicians (five males, two females), five were attending physicians and two were

resident physicians. Both nurses were female and had university-level training. Interviews ranged from nine to 25 minutes (average of 15 minutes) in duration. Perceived barriers were described as: 1) sense of invincibility of HCWs; 2) personal beliefs of HCWs related to direct patient communication; 3) low provider-to-patient ratio at health centers; 4) absence of TB isolation units for patients within health centers; and 5) limited availability of protective masks for HCWs. Figure 3-1 presents the illustrative model of the emerging themes.

Sense of Invincibility of Healthcare Workers

Most participants conveyed only a minor concern for nosocomial TB transmission in the health center, alluding to their prior *M. tuberculosis* exposure by the Bacillus Calmette-Guérin (BCG) vaccine, clinical exposure due to their short- or long-term employment at the center or both. One female nurse mentioned that all HCWs most likely have LTBI: “I imagine that all [healthcare workers] who have worked in clinical wards, I believe we all have [TB] sensitivity.” One male physician reiterated this sentiment that all physicians will most likely have a positive result if given the tuberculin skin test (TST), suggesting that previous *M. tuberculosis* exposure has resulted in LTBI:

> Normally, we [physicians] are positive for TB [infection]. In the majority of health centers, physicians who work in these centers will have a positive result to the tuberculin skin test. We do not have prophylaxis for this. Well, we take care of ourselves enough, some of us.

In fact, two physicians used humor to express their belief that little could be done if the entire country has been infected with *M. tuberculosis*. One male physician stated, “Here in the Dominican Republic, we represent 10 million people who have a positive result of the tuberculin skin test. How can we act when the source [*M. tuberculosis*] is next to us?” One female physician mentioned,

> The majority of the population (laughs) of this country, you can classify as latent tuberculosis. What are we going to do with this group? We are not going to do anything because the majority of the population has it [latent tuberculosis], where I even include myself.

Three participants mentioned that they did not develop TB disease, even though they had clinical responsibilities caring for TB patients. One female nurse mentioned, “I worked for five years on the women’s clinical ward with patients who were diagnosed with TB. I did not even develop the flu (laughs).” However, two participants commented that they have observed that HCWs had developed TB disease due to confirmed occupational exposure and successfully completed prescribed treatment regimens. One female nurse stated, “Here, we have also had nurses who have been released from the center and were confirmed to be cured [of TB disease].”

Participants mentioned that one primary preventive measure is placing the protective mask on TB patients. One female nurse commented that aside from the BCG vaccination used as one preventive methods within the institution, “[placing] masks on patients in order to protect the healthcare worker” is fundamental. However, one male physician remained optimistic and added that HCWs are knowledgeable and conscious of the TB transmission cycle and do not want to continue transmission to family members at home.

Personal Beliefs of Healthcare Workers Related to Direct Patient Communication

Physicians and nurses emphasized that as HCWs, they genuinely aim to provide the best attention and quality of clinical care services to patients. They expressed, however, that their personal beliefs about direct patient communication influence how they choose to protect themselves from the risk of possible occupational exposure to *M. tuberculosis*. In one example, effective provider-patient dialogue was maximized when

the protective respiratory mask, a physical barrier, was removed. When caring for patients in the Emergency Department, one male physician responded that empathy associated with building patient rapport is a greater priority than wearing personal protective equipment such as a mask:

> It is more cultural than anything. It looks ugly when you are in the Emergency Room. I put on a mask as if I am going to become infected [by a patient]. It looks ugly, so we do not do this. We do, however, keep our distance from patients and avoid speaking closely face-to-face.

In a second example, these provider-patient communication strategies during medical appointments or ward rounds appeared to be more effective by relying simply on spiritual faith. Whether considered as an organized religion or a source of hope and peace, this invisible form of defense from *M. tuberculosis* transmission was one last protective measure. As one female physician described her clinical experiences with direct care of TB patients, she credits her spiritual faith for not having developed TB disease over time: “In consult, we do not use any type of preventive measures for TB transmission in patients who have the bacillus… counting on the divine presence to help us (laughs) with the prevention, unfortunately.”

Low Provider-to-Patient Ratio at Health Centers

Physicians and nurses were knowledgeable about the high burden of TB cases in the DR as well as the clinical protocol of patients with respiratory symptoms who seek medical services at their health center. They noted that the typical flow of patients to be evaluated for TB disease at medical consults is high. In particular, one physician stated that her consult receives new and follow-up cases for evaluation and management, respectively, of TB disease:

> The day to day [flow] of persons who arrive as new cases… in our consult, I see approximately 20 to 25 patients, just as (name of physician), that we

> function here in the department, with new patients ranging from one to five in each consult… and then we see follow-up tuberculosis cases.

Another female physician expanded this view to illustrate the increased patient admissions to clinical wards who are probable or confirmed TB cases, often maximizing hospital capacity for patient admissions:

> Right now, of patients admitted to the clinical ward of eight [patients], four are probable tuberculosis, two are confirmed tuberculosis. The patient who just arrived is probable tuberculosis. Many times, the entire clinical ward of eight beds for men and eight beds for women is full of tuberculosis.

Participants mentioned that many patients who develop respiratory symptoms will self-medicate with over-the-counter antibiotics or home remedies, and thus, remain undetected and untreated, thus continuing to transmit *M. tuberculosis*. They stated that TB patients will commonly present with severe clinical manifestations, which are associated with increased risk of severe consequences or death. One female physician emphasized that TB patients who remain undiagnosed in the communities will succumb to the disease if they are not evaluated and admitted to the hospital with aggressive TB management: "…here, we generally treat tuberculosis that is advanced, I mean, the patient comes, and if you do not admit the patient [to the hospital], he or she will die."

Absence of Tuberculosis Isolation Units for Patients within Health Centers

Participants responded that their health centers do not have appropriate isolation units to separate probable or confirmed TB patients from other patients of other pathologies. They were aware that the absence of this environmental control placed them at increased risk of *M. tuberculosis* exposure, which was not the "ideal" situation for personal protection. As such, one nurse described the current "non-ideal" scenario in her health institution: "One thing is what should be done and another is what we can do,

because what should be done is that there would be an isolation area [for the patient], but sometimes it is not like that…"

One male physician expressed that as the frontline agents to *M. tuberculosis* exposure, HCWs lack the necessary protective measures to reduce nosocomial TB transmission between HCW to patient or even between patients: "We live in a country with high transmission of pulmonary TB, and in this health center, we do not have the appropriate protective resources or specific isolation unit in order to control [TB] transmission." In turn, another male physician further illustrated how the absence of a TB isolation unit in the health center may place other patients at risk for nosocomial TB transmission.

Limited Availability of Protective Masks for Healthcare Workers

Physicians and nurses recognized that health centers have limited budgets to manage daily functions, including administrative, clinical and laboratory responsibilities. Participants mentioned that protective masks are inconsistently available for use by HCWs or patients. One female physician described the protective function of masks when they are available in the clinical environment: "[Protective masks] are ideal, but you know, the costs of masks should be provided by the government. Here, we do not have masks. We are not provided masks, unless you have a cloth mask." One nurse mentioned that she was quite aware of the limited protection of using surgical-type masks in her health center: "The masks that we have are the surgical type, which do not protect us [as HCWs] but rather them [patients]. We place these masks on them [patients], and thus, we are 'half-way' protected (laughs)."

Recognizing that TB is one of multiple diseases that HCWs encounter in their workplace, one nurse admitted that HCWs are unable to fully protect themselves from

nosocomial *M. tuberculosis* transmission in the health center. She mentioned that her health center has not prioritized the use of specialized masks as the best preventive approach to reduce possible *M. tuberculosis* transmission among HCWs and patients:

> We should use the N95 [mask], but all health personnel, physicians like nurses, use the simple [surgical] mask. Real 'prevention, prevention', we use because immediately we know that there is a TB patient. We take precaution measures, but in the general sense, what should be done, is using the correct mask, isolation area for patients, really we lack [these measures].

Discussion

This is the first known study to explore perceived barriers of HCWs related to adherence to TB infection control measures in DR health institutions. As a high TB burden country, where TB incidence and prevalence rates have decreased over the last decade (World Health Organization, 2016b), four common challenges in TB control have been reported by the DR NTP. These include reaching marginalized populations living in high TB burden geographical provinces; assessing influence of domestic (rural to urban regions) and international migration from Haiti; understanding social determinants of health associated with impoverished living conditions; and promoting community participation in "Estrategia Alto a la TB" initiatives that reduce TB-associated stigma and discrimination in vulnerable populations (Dominican Republic Ministry of Health, 2014). Occupational exposure of HCWs, however, remains overlooked, driven by increased utilization of medical services by persons who are undiagnosed and untreated for susceptible or resistant *M. tuberculosis* strains.

Over the past two decades, published international guidelines have focused on a hierarchal strategy – administrative, environmental and personal respiratory protection – as effective strategies to reduce nosocomial *M. tuberculosis* transmission in healthcare

institutions (Jensen et al., 2005; World Health Organization, 1999). The World Health Organization (WHO) in 1999 disseminated recommendations for low-resource health institutions (World Health Organization, 1999). In addition, in 2005, the Centers for Disease Control and Prevention (CDC) distributed guidelines for preventing *M. tuberculosis* transmission in healthcare settings (Jensen et al., 2005). However, the elaborate infrastructure required to build, finance, manage and sustain these infection control strategies was a limiting factor in the universal utilization within low-income countries (Pai et al., 2006). Although these guides are ideal for healthcare settings, they fail to consider the perceived barriers of those HCWs who serve as the frontline clinical support for their healthcare institutions.

In our study, participants expressed individual-level barriers that they perceive to hinder their ability to adhere to recommended *M. tuberculosis* infection control measures. They expressed that exposure to *M. tuberculosis* is inevitable, whether by prior history of BCG vaccination or their duration of employment in the healthcare environment. This presents a three-fold challenge. First, although the BCG vaccine has shown immunological protection for the development of advanced TB disease in children, studies have shown that immunological protection is estimated to be less than 10 years with no protective effect in adult (Abubakar et al., 2013; Brouwer et al., 2014). Second, HCWs expressed self-reassurance that they had not developed TB, but rather only the common cold or flu, although employed in TB-endemic settings. Thus, they may erroneously perceive that their habitual occupational exposure to the pathogen has produced “immunity” or “invincibility” against developing TB disease (von Delft et al., 2015). Third, HCWs described the essential concept of the “human touch” in direct

patient communication, aiming to improve patient rapport by avoiding close contact with patients, as a basic, but not necessarily most effective, protective measure. Thus, HCWs may decide to relinquish protective precautions, such as a mask, and maximize perceived communication and delivery of compassionate care to patients while reducing associated stigma (Brouwer et al., 2014).

They also reported perceived institutional-level barriers that reflected the limited availability of institutional funding to provide appropriate and effective protection for HCWs from *M. tuberculosis*. One fundamental risk of nosocomial *M. tuberculosis* transmission in healthcare institutions is the failure to promptly diagnose and implement appropriate infection control measures for suspected TB patients (Jensen et al., 2005). Since nosocomial *M. tuberculosis* transmission in HCWs has been documented by the DR Ministry of Health (Genao & Rodríguez, 2013), dual challenges will need to be addressed. First, although successful DOTS roll-out reached an estimated 94% national coverage by 2012 (Dominican Republic Ministry of Health, 2014), interrelating factors – such as personal, health service, social and structural – continue to complicate patient adherence to long-term *M. tuberculosis* pharmaceutical regimen (Munro et al., 2007). Thus, HCWs may be exposed to *M. tuberculosis* by erroneously assuming that TB patients are compliant to treatment when seeking healthcare services. Second, pre-employment or annual screening of HCWs with TST or interferon-gamma release assay (IGRA) for LTBI is not routinely conducted in the DR. Without these regular evaluations, this high-risk group may not receive the LTBI diagnosis and recommended preventive therapy to reduce the estimated five to 10 percent risk of reactivation TB over the lifetime (Zumla et al., 2013). By limiting the logistical assessment of nosocomial *M.*

tuberculosis transmission in HCWs, health institutions will be unable to prioritize the physical health of HCWs.

Although participants described that occupational exposure to *M. tuberculosis* is daily, suggesting the clinical need for airborne protection measures within institutions as essential, such as appropriate masks and isolation units, the “knowledge to action” gap was notably observed. This gap can be described as the observed inconsistent application of clinical knowledge in direct clinical practice (Graham et al., 2006; Haines et al., 2004), which can increase risk of occupational exposure to pathogens or negatively affect delivery of healthcare services (Haines et al., 2004). In low- and high-income countries, well-documented factors that enable the expansion of this “knowledge-action” gap have included time-constrained or short-staffed health settings, limited knowledge or erroneous perceptions of HCWs, lack of access to clinical research or reports, political ideologies that conflict with scientific evidence, and absence of financial resources (Farmer, 2013; Haines et al., 2004). Since this study identified five perceived barriers among HCWs that limit their ability to comply with preventive strategies that reduce risk of TB transmission, additional in-depth exploration of these barriers should be studied to build a theoretical framework for dual purposes. First, stakeholders and other leaders of health institutions can tailor interventions and develop practical recommendations, in collaboration with HCWs, which aim to promote adherence to infection control measures among HCWs. Second, this framework can serve as a baseline for the preparation of research studies, using quantitative or mixed methods approaches, which can test hypotheses and identify causal associations

between selected variables, such as effectiveness in the implementation of the recommended hierarchal strategy within institutional infection control programs.

Our study included nine HCWs from two health institutions, yet saturation was reached as defined when no new information was added to categories (Charmaz, 2000). This study intended to explore overall clinical knowledge, perspectives and infection control practices among HCWs about TB infection and disease related to transmission, diagnosis, management and prevention. Thus, in-depth exploration and review, rather than generalizability, were essential to examine the cultural processes related to delivery of healthcare services. By understanding these cultural processes, however, hypotheses can be subsequently formed and tested in a future studies that incorporate quantitative or mixed methods design. Although two researchers reviewed the data, it should be recognized that there may be additional ways to interpret the data and more variables to explore in future study designs to validate our results (Miles & Huberman, 1994).

Conclusions

Using a qualitative approach, this study identified perceived barriers related to adherence to TB infection control measures among HCWs in the DR. Our findings report that ineffective TB infection control strategies within health institutions coupled with erroneous understanding or perceptions of TB risk complicate TB management in limited-resource settings. These perceived barriers at the individual- or institutional-level may hinder how HCWs understand the actual risk of TB transmission and are able to comply with preventive strategies that reduce their risk of *M. tuberculosis* exposure. Addressing these barriers by strengthening the infrastructure of infection control

programs and implementing educational interventions within institutions may reduce risk of nosocomial *M. tuberculosis* transmission to HCWs.

Table 3-1. Demographic and administrative variables of the two selected tertiary-level health institutions in the Dominican Republic, 2014

	Hospital A	Hospital B
Demographic		
City	Santo Domingo	Santiago de los Caballeros
Population (2010)	2,374,370	963,422
General		
Hospital classification	National	Regional
Year opened	1946	1978
Annual number of admissions	11,513	24,822
Annual number of emergency visits	168,485	105,337
Annual number of consultations	117,110	175,759
Number of hospital beds*	214	425
Medical training programs		
Number of medical specialty programs	6	10
Number of medical subspecialty programs	2	13
Tuberculosis		
Number of reported cases with respiratory symptoms	1,062	524
Number of reported TB cases diagnosed at center		
Patients	139	15
Healthcare workers	4	1
Number of reported MDR-TB cases diagnosed at center		
Patients	0	0
Healthcare workers	0	0
Presence of TB isolation area		
Internal Medicine ward	No	No
Intensive Care Unit	No	No

Abbreviations: MDR = multidrug-resistant; TB = tuberculosis

*Due to hospital renovations by the Dominican Republic Ministry of Health, the number of hospital beds varied per month in 2014. Thus, we calculated the average number of hospital beds in 2014 by adding the number of hospital beds per month and dividing this total number by 12. [Data provided by the Dominican Republic Ministry of Health National Department of Statistics, National Tuberculosis Program, and Hospital B.]

Table 3-2. Demographic characteristics of the study participants of the semi-structured interviews

#	Hospital	Profession	Sex	Department	Role
1	A	Physician	Male	Emergency	Chief physician
2	A	Physician	Male	Emergency	Attending physician
3	A	Physician	Male	Internal Medicine	Attending physician
4	B	Physician	Male	Internal Medicine	Chief resident physician (4th year)
5	A	Physician	Male	Internal Medicine	Resident physician (4th year)
6	A	Physician	Female	Internal Medicine	Chief physician
7	A	Physician	Female	Internal Medicine	Attending physician
8	A	Nurse	Female	Nursing	Nursing Coordinator
9	B	Nurse	Female	Nursing	Nursing Director

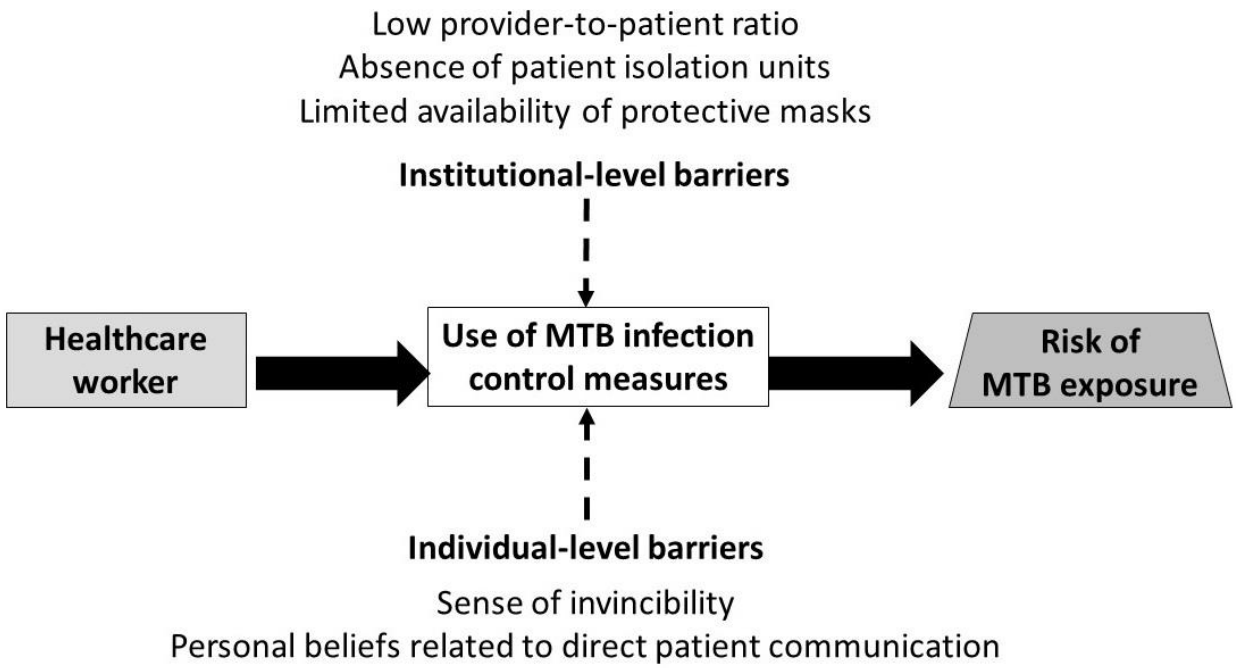

Figure 3-1. Conceptual model about perceived individual- and institutional-level barriers faced by healthcare workers that impact the risk of occupational *Mycobacterium tuberculosis* (MTB) exposure in the Dominican Republic

CHAPTER 4
UNDERSTANDING THE "KNOWLEDGE-ACTION" GAP IN HEALTHCARE WORKERS TO REDUCE OCCUPATIONAL EXPOSURE TO *Mycobacterium tuberculosis*: A GROUNDED THEORY APPROACH

Introduction

Globally, healthcare workers (HCWs) are recognized to have an increased risk of infection with *Mycobacterium tuberculosis* in the workplace, estimated at two to three times the risk in the general population (Baussano et al., 2011). Occupational categories with clinical responsibilities related to direct patient care influence overall risk of *M. tuberculosis* infection or disease (Institute of Medicine Committee on Regulating Occupational Exposure to Tuberculosis, 2001; Menzies et al., 2007). The threat of nosocomial *M. tuberculosis* transmission has been linked to the number of active tuberculosis (TB) patients and the application of infection control measures in the health institution (Menzies et al., 2007). Infection control measures, including administrative, environmental and personal respiratory protection, however, may not be consistently implemented in health institutions of low- and middle-income countries (Jones-López & Ellner, 2005; Pai et al., 2006).

As a middle-income country in the Caribbean region, the Dominican Republic (DR) has reported a decline in TB incidence from 100 (per 100,000 people) in 2000 to 60 (per 100,000 people) in 2015 (World Health Organization, 2015, 2016c). High drug resistance levels have been reported, with 3% and 12% in new and previously treated TB cases, respectively (World Health Organization, 2016c). Rates of nosocomial *M. tuberculosis* transmission in HCWs are unknown. Only one national DR study documented that 116 HCWs, who were employed at 49 specialized health institutions between 2005 and 2012, developed TB disease, representing nurses (27%), janitorial

staff (11%), and physicians (11%) (Genao & Rodríguez, 2013). With the large TB burden in the general population, no current research or active surveillance programs evaluate adherence to *M. tuberculosis* infection control measures or measure HCWs' risk of exposure or disease.

HCWs encounter daily challenges in order to remain up-to-date with evidence-based clinical practices and translate educational information into actions in clinical practice (Graham et al., 2006). The "knowledge-action" gap, also called the "know-do" or "do-know" gap, describes the discrepancies observed when applying clinical knowledge to practice (Haines et al., 2004; Thamlikitkul, 2006). Observed gaps in practice may reflect barriers at the individual- or systems-level (Kitson & Straus, 2010), thus influencing healthcare service delivery to patients. Once these barriers are identified and analyzed, authorities can engage stakeholders or policy makers, leading subsequent action where research findings will influence adherence of clinical practices from "paper" to "practice".

We address the "knowledge-action" gap by examining the decision-making process by which HCWs understand their occupational risk and use preventive strategies to reduce nosocomial *M. tuberculosis* transmission in clinical practice. Our purpose is two-fold. First, we aim to contribute new findings about how trained DR clinicians, who are familiar with TB disease management and World Health Organization (WHO) and Centers for Disease Control and Prevention (CDC) evidence-based guidelines, use their knowledge as a foundation when applying scientific concepts to the clinical setting. This study will provide the first step to understanding "why" these gaps exist in practice, which can subsequently be further analyzed and

presented in open dialogue with stakeholders. Second, based on the underlying challenges faced by HCWs that hinder consistent use of *M. tuberculosis* infection control strategies, we provide participants' perceived practical recommendations toward improved TB control in the health institution and country. For this reason, our research question is as follows: What is the decision-making process by which HCWs use preventive strategies to reduce nosocomial *M. tuberculosis* transmission in their clinical practice?

Methods

Study Design

Using a grounded theory approach, we aimed to better understand how HCWs perceived their ability to use TB infection control strategies in clinical practice. We used the socio-ecological framework, modified for social science and behavioral research in TB, to facilitate the research design, methodology and data analysis and interpretation (Centers for Disease Control and Prevention, 2005). Then, through grounded theory methods, we were able to explore the processes that influence the perceptions of participants regarding their ability to adhere to *M. tuberculosis* infection control practices (Charmaz, 2006).

Focus group discussions were used to facilitate an open dialogue with participants about their perspectives and experiences on the phenomenon, permitting back-and-forth exchanges of agreement or disagreement (Krueger, 1988). In particular, "Focus groups are useful when it comes to investigating *what* participants think, but they excel at uncovering *why* participants think as they do" (Morgan, 1988, p. 25). Based on the context of the research question, selected participants may share common characteristics, such as demographic variables, but should maintain adequate diversity

to promote conversation (Krueger, 1988). Participants who perceive that they have shared general interests with other group members are more likely to discuss their experiences, opinions and perspectives openly (Kidd & Parshall, 2000).

Participant Sample

A purposive sample of 40 HCWs, composed of 24 physicians and 16 nurses who had direct clinical patient care responsibilities in the emergency, internal and family medicine specialties at one of two selected tertiary-level health institutions, was invited to participate in focus group discussions. Using theoretical sampling strategies, we were able to expand our data collection from the previous chapter and elaborate on the study findings (Charmaz, 2000). To reduce any potential power imbalance or dynamics in the focus group discussions (Barbour, 2005), we organized focus groups of the same sex and occupation. Of our sample, physicians and nurses must have completed at least one year of their medical specialty or one year (technical training) of their nursing education, respectively. Any physician or nurse with part-time employment, or less than 25 hours per week, was not recruited for the study.

Data Collection

Based on the five barriers identified from the semi-structured interviews with physicians and nurses and described in the preceding chapter, a semi-structured focus group interview guide was developed. Questions were prepared in English, translated into Spanish, and verified by a bilingual Dominican physician for accuracy and clarity. Prior to the start of each focus group discussion, each participant completed a demographic survey regarding their age, educational formation, clinical responsibilities and duration of employment within the institution, regular work schedules, and frequency of on-call schedules. Then, focus group discussions were conducted by the

principal author and digitally recorded in a quiet, conference room in the hospital, lasting approximately 60 minutes. Most focus group discussions included a co-facilitator, appointed from administration, for note-taking during the session. At the end of the focus group discussion, each participant received a small gift bag of various office supplies for personal use. Field notes from jottings of informal dialogue with HCWs, diary notes about daily activities in the health institution, and daily log of the timetable of events were prepared (Bernard, 2011). Data collection continued until saturation, or no new emerging themes, was reached (Charmaz, 2000).

The focus group discussions followed three steps. First, interview questions facilitated an open dialogue about individual, institutional and socio-cultural factors that influenced the ability of HCWs to adhere to recommended *M. tuberculosis* infection control practices. Each of the previously described five barriers were presented to allow a more in-depth discussion of the specific challenge. Interview probing techniques were used to obtain more information about participants' responses (Bernard, 2011). Second, after each barrier, participants were asked about their recommendations to improve overall compliance to *M. tuberculosis* infection control measures in the institution. Finally, at the end of the focus group discussion, participants were asked about their recommendations to improve *M. tuberculosis* infection control measures and prevention in the DR. Table 2 presents the sample interview questions of the focus group discussions.

Data Analysis

Focus group interview data were digitally recorded, transcribed verbatim into Spanish, and verified by a bilingual Dominican physician to confirm accuracy of the data transcription. Co-facilitator and field notes, diary notes and daily log of the timetable

were de-identified and transcribed to maintain confidentiality of responses. QSR International's NVivo 11 qualitative data analysis software (QSR International Inc., Burlington, MA) was used to manage data transcripts and facilitate the coding process. Grounded theory and dimensional analysis techniques were used to guide the data analysis process (Charmaz, 2006; Schatzman, 1991). Two investigators, familiar with the research subject and study described in the previous chapter, developed initial codes prior to data collection. In order to improve inter-observer reliability, they coded each data transcript independently and subsequently discussed all codes and arising discrepancies. Memos were prepared throughout the three steps of analysis: 1) open coding to identify categories and sub-categories from the data; 2) axial coding to identify how categories are related; 3) selective coding to establish the primary category ("story") of the framework (Corbin & Strauss, 1990). The use of comparative analyses, or comparing how categories are similar or different, aided the process of theory development (Corbin & Strauss, 1990). Card sorting was used to examine relationships among emerging constructs of the model development (Ryan & Bernard, 2003). Audit trails documented the data collection, including field notes, diary notes and daily log of the timetable, and interpretations during the analytical process (Guba, 1981). Peer debriefing (Lincoln & Guba, 1985), with qualitative experts of the UF Qualitative Data Analysis Group, occurred throughout the preparation of the study design and analysis to ensure rigor, reliability and validity in the analytical process. An explanatory model was developed to represent the theoretical framework.

Ethical Aspects

This study had the approval of the Institutional Review Boards of the University of Florida (Gainesville, Florida, USA) and O&M Medical School (O&MED) (Santo

Domingo, DR). The National Tuberculosis Program (NTP) (Santo Domingo, DR) evaluated and authorized the protocol. Finally, the Department of Academics of Hospital A (San Pedro de Macorís, DR) and the Institutional Review Board of Hospital B (Santiago de los Caballeros, DR) approved the protocol. All participants provided written informed consent for study participation.

Results

A total of 40 focus group discussions (24 physicians, 16 nurses) were conducted, ranging from 45 to 60 minutes (average of 55 minutes) in duration. Participants had direct clinical responsibilities in emergency medicine (n=26), family medicine (n=6) and internal medicine (n=8). Physicians were second- or third-year medical residents, and nurses had certificate-, associate- or bachelor-level training. The average age of participants was 34.2 years, divided between physicians (29.0 years) and nurses (42.1 years). Table 2 presents the demographic characteristics of the sample population.

From our data, we developed a theoretical model from the HCWs' perspective to describe: a) context of feeling powerless; and b) intrinsic and extrinsic conditions that influenced the use of *M. tuberculosis* infection control strategies (knowledge and perceptions, institutional policies, clinical responsibilities, institutional infrastructure). We also present HCWs' perceived recommendations, which together with future evidence-based interventions, can empower HCWs in improving adherence to *M. tuberculosis* infection control strategies in clinical practice. The first cycle describes the context of powerlessness, while the second cycle represents how empowerment through evidence-based interventions can be applied in the future. Figure 1 represents the HCWs' perceived limitations in using *M. tuberculosis* infection control measures in clinical practice, influencing the "knowledge-action" gap.

The Context of Feeling Powerless

Participants expressed that they had numerous limitations in their clinical practice, which did not allow them to consistently adhere to *M. tuberculosis* infection control measures. One male physician stated that HCWs are often unable to apply their clinical knowledge to practice: “Although we know how we should manage this type of [TB] patient, we do not have the space [isolation ward] and sometimes neither the resources, although we have the knowledge.” Participants also described specific examples of when this emotional distress was experienced. One female nurse mentioned that applying infection control measures in practice was often outside her control: “Sometimes we look for many [preventive] strategies, but sometimes we feel helpless. We want to do [more], but we cannot.” Sharing this sentiment, one female physician commented more specifically on the inability to separate patients of highly infectious or immunocompromising conditions: “We are aware that we should not have placed the [TB] patient with other [non-TB] patients, but with limited space, we have no other option. We are aware that what we are doing is wrong.”

In addition, participants described their limited voice as clinicians and observed inaction of health authorities, demonstrating evidence of power dynamics or imbalance in their clinical practice. One male physician stated that medical residents felt that they are unable to influence changes in clinical practice even if they were to report these requests to health authorities:

> These limitations in clinical practice bother us. We see these things and unfortunately we sometimes feel angered [because] as a resident we cannot complain. We express that we have justification, but they [authorities] do not take our concerns into consideration.

Many participants stated that their clinical responsibilities had minimal supervision for oversight from health authorities, expressing that they feel that no authority figure holds their presence or well-being at high esteem or priority. Finally, participants described the absence of collaborations among stakeholders in efforts to improve healthcare service delivery to patients. One male nurse questioned how HCWs could be effectively empowered in their clinical responsibilities, albeit limited resources: “What does it mean to us to want to collaborate if we do not have the [administrative] input and supply of disposable materials?” One male physician added that each stakeholder had an essential role that influenced the overall outcome of service delivery:

> If the [health] leaders do not do their job, others will not do their job… I mean, if patients do not help themselves, if healthcare workers are not actively playing a role, if the government does not provide the necessary resources, if health promotion activities do not have incentives, it [use of preventive strategies] will be difficult but not impossible. It is a matter of willingness and desire to work. Nothing more.

Intrinsic Factors

Knowledge about TB disease and management. Participants expressed that TB was a common clinical presentation in the emergency room and hospital ward of their institutions, due to the high TB burden in the DR. They described common socio-demographic characteristics of suspected TB patients, including low socio-economic status, overcrowded living conditions, drug or substance abuse, and lack of family support. In particular, participants emphasized that the undocumented immigration of Haitians, who typically reside in overcrowding and impoverished conditions of the bateys (sugarcane plantations), remains a significant challenge in TB prevention and control in the DR. One male physician expressed that this recognized social disease of poverty would be difficult to control: “Many foreign nationals from our neighboring

country [of Haiti] come here. This would be another challenge for us to eradicate the pathology because they bring TB here from their country." In addition to immigration or language barriers that exist in their institutions, they also mentioned that many TB patients hide their diagnosis and do not follow recommended treatment or prevention measures, often leading to disease transmission, advanced disease progression or death. One female physician noted how TB patients will often fail to disclose their health condition: "Many times, patients belong to the TB program and remain quiet. You have to ask them again and again, and then they will respond. Sometimes they abandon treatment and remain quiet, saying nothing to their health provider."

Participants shared empathy for TB patients, as they must endure the extensive recovery period on directly observed treatment, short-course (DOTS), including facing medication side effects and risk for treatment abandonment, fluctuation in emotional and psychological health, and stigma influencing family dynamics and social support. They expressed that health promotion tools are key to empower TB patients to better understand their disease process, recognize the importance to complete DOTS, and use prevention measures to protect further disease transmission to family and friends. One female physician stated that health and human rights could be protected through patient education: "Patients who are empowered by their pathology can better defend their rights and protect themselves as well as others." In addition, one male nurse expressed that the cured TB patient could serve as a community role model: "All patients can be spokespersons for [TB] prevention because they have already lived and recovered from the disease. Who better than to say 'TB can be cured'?"

Perception about occupational risk. Participants expressed that HCWs serve on the frontline to direct patient care in the emergency room and hospital wards, assuming an occupational risk of nosocomial transmission of multiple pathogens. One female physician recognized this daily occupational exposure: “Each day, we are exposed to all types of hospital-acquired infections.” One male physician added that HCWs are aware of their occupational risk: “We know that we are susceptible, we know what we should to do reduce transmission risk, but we still continue our clinical work without consistently using [prevention strategies] to reduce risk.” Irrespectively, they confirmed that they knew at least one other HCW who had developed TB disease while employed at their institution. Moreover, they expressed deep concern about the increased risk of disease transmission in non-clinician HCWs, such as employees working in the cafeteria, human resources, janitorial services or patient transport, who are not formally trained in clinical disease knowledge.

On the other hand, participants expressed the importance of the HCW’s vocation and ethical role in direct patient care. One male nurse expressed that as HCWs they understand their occupational risk in clinical practice, demonstrating commitment to health promotion in direct patient care: “When you study this lengthy career, you know the risks that you will be exposed to. If I dedicate myself to study nursing, it was because I want to promote health, but I also must protect myself too.” One female physician mentioned that HCWs may knowingly not comply with prevention measures in clinical practice: “Many times we do not even think about the disease [and] we do not protect ourselves because we want to help another person. It all depends on the vocation of each person.”

Participants expressed a general sense of invincibility, although conscious of their increased risk of occupational exposure to TB or other pathogen. One female physician stated that their occupational exposure over time has served as a protective factor: “We live in an [TB] endemic country, where we develop the latent infection. We are ‘auto-vaccinated’ and do not develop the disease.” In fact, one male physician described this TB exposure in relation to the hypothetical screening measures using the tuberculin skin test (TST): “We have been exposed [to TB]. We all have a latent tuberculosis infection, whether due to the vaccine or continued exposure, and we will have a positive [TB] screening test.” Finally, participants expressed a general assurance that their direct patient care with TB patients has not resulted in the development of active TB disease. One male physician expressed this erroneous confidence related to the risk of TB transmission: “Many physicians do not take [TB risk] into consideration and are confident that since they have worked for five or six years [with TB patients], they will not develop TB disease. They fall in this trap. But, in reality, we have a high occupational risk.”

Extrinsic Factors

Institutional policies. Participants described the absence of institutional programs that regularly evaluate the physical health of HCWs, including *M. tuberculosis* exposure. One female physician believed that economic factors may hinder the comprehensive implementation to practice: “There are no prevention programs for healthcare workers or other personnel. I think that these programs may exist only on paper and are not implemented due to lack of institutional resources.” Other participants, however, claimed that they had never received any health evaluation while employed at their health institution. One female nurse, however, described that health authorities

appeared to act only when there was a national call to action: “The health authorities of our center do not provide monthly, biannual or annual health evaluations. When there is an outbreak, then they worry about the employees.” Likewise, another female nurse mentioned that the institutional priorities do not include protecting the health of HCWs: “By the time they [authorities] take action, we [healthcare workers] are all exposed. The health institution is more concerned about training physicians than providing care to patients and health providers. We are totally neglected. They do not protect us.” One male physician, however, challenged this sentiment: “It [prevention] is important to the country and the Ministry of Health, but they do not invest the necessary resources to protect healthcare workers who care for these [TB] patients so that they can provide high-quality healthcare services.”

Participants mentioned that health educational programs for HCWs could serve as the foundation for effective TB control in health institutions. Most participants shared that they were unaware of and had not attended any regular continuing education programs related to TB or other general health threats while employed at their health institution. One male nurse stated that some general trainings were provided randomly to a select group of nurses: “There needs to be [continuing] education for nurses who provide direct medical attention. Last year, there were several trainings only for bachelor-level nurses, but certificate- and associate-level nurses have not received any type of training for years.” However, one female nurse added that their health institution had appointed a health educator to conduct health seminars and case study presentations and educate nursing personnel about different infectious diseases. At the same time, they mentioned that the DR Ministry of Health conducted irregular TB

educational campaigns as well as the annual World TB Day promotion, which aim to educate communities about TB disease. One female nurse asserted that HCWs were responsible for their continued education throughout their career: “There are many educational outlets. We [healthcare workers] do not actively educate ourselves. We are disobedient to education because these programs constantly inform us about TB and other infections.”

Finally, participants described the challenge in sustainable and consistent communication between the TB program and their clinical department related to TB patient management. One female physician stated the typical scenario in the emergency department:

> We receive patients, we diagnose them by their clinical symptoms, and then after you find the [diagnostic] results, you send them to the [TB] program. There, they record the patient and manage the disease. From there onward, we do not have further contact with the patient, only with those patients who do not follow treatment and later return to the emergency room [with complications] and we identify them and admit them to the hospital.

Participants added that the Ministry of Health appeared to prioritize the maternal-infant health indicators, rather than TB incidence rates, although both are critical aspects of the Millennium Development Goals. One male physician said that reducing TB incidence should be an institutional priority: “It all depends on how the hospital administration understands this responsibility, where they are conscious about disease control.”

HCW responsibilities. Whether participants had daily clinical responsibilities in the emergency room or hospital ward, they described their demanding schedule to manage patient clinical evaluations, admissions, discharges and referrals. In particular, they described that there is a low patient-provider ratio, or an inadequate number of

HCWs to provide high-quality healthcare services to patients. One male nurse emphasized the context of this busy clinical setting with patient overcrowding: “Sometimes the clinical area is very swamped with patients, and sometimes there are two nurses to manage 70 patients.” Another male nurse used one example to describe the challenge to meet all recommended prevention measures: “I have a protocol with guidelines and I have 70 patients. In any given time, the protocol will be disrupted because myself alone with 70 patients, how can I comply with the protocol?” In addition, participants emphasized that the presence of few HCWs in the clinical area negatively impacted the quality of healthcare service delivery to patients. Many participants recognized that suspected TB cases may even be missed in their patient evaluations due to this hectic clinical environment. One female physician described the consequence of limited and insufficient time to conduct a comprehensive patient evaluation in the emergency room:

> The lack of health providers influences the rapid patient evaluation and sometimes fails to provide the best diagnosis of the patient. It influences the fact that if we had more health providers, since we have a high patient flow… we would improve case finding and how to follow the process for patient treatment and management.

Participants mentioned that the excess workload, where they managed daily work schedules and on-call services, increased physical and mental exhaustion and stress. One male physician focused on the impact of the workplace stress:

> I believe that the stress does not allow us to think about TB infection, to have so much work and stress… It is not because of lack of knowledge, but rather job stress, that we are unable to think about transmission, but simply do our job.

Likewise, another male physician echoed this perspective, emphasizing that HCWs understand TB transmission and prevention measures: “Although we know that

we should [use prevention strategies], we overlook them." Describing the overwhelming clinical responsibilities that greatly impact their own analysis of their occupational risk, one female physician stated: "We complete our duties, and we do not even think about the possibilities of [occupational] risk for one second of the day. We simply work with each patient and continue forward to the next patient." One male nurse added that despite their rapid actions in the clinical setting, HCWs can lower their guard on risk perception: "Although we have the knowledge, sometimes our work overwhelms us and we lose the equilibrium of this order. We may enter with a mask first, but then trusting our patients, sometimes we enter again without a mask." Finally, participants described that the protective masks or gloves, if not available in the clinical area, would require completion and submission of a hospital form to the supply room outside of the clinical area. One female physician described the "no-win" scenario, where leaving the clinical area to obtain protective equipment for herself and her patient would result in visible resentment or anger of accompanying family members: "Sometimes, we have to act without using prevention strategies because I cannot leave the patient alone [to look for a mask], as the family will observe and ask me, "Why is the patient alone?"

Institutional infrastructure. All participants expressed that the absence of an isolation ward for TB patients facilitated the spread of *M. tuberculosis* to HCWs and other patients in the health institution. Two participants referenced that HCWs served as the "host" and "vehicle" of pathogen propagation, since TB and non-TB patients were placed in the same clinical area in lieu of an isolation ward. One male nurse described the high risk of nosocomial *M. tuberculosis* transmission in the hospital ward: "If we are in an environment where [TB] bacilli are in the air, and we have patients with other

pathologies [in the area], when we are beside the [TB] patient, we are exposing the neighboring patient to possible disease transmission of the [TB] patient." Participants mentioned that hospital overcrowding is a daily and constant challenge, expressing that patients cannot chose their disease pathology or management, trusting their HCWs. One male physician stated, "Patients do not know the diagnosis of the patient who is beside them. They cannot protect themselves. This is what worries me. You can only take precautions for what you know." Participants described the challenge of providing healthcare services in clinical areas without adequate ventilation. One male physician stated, "The current hospital structure does not have [proper] ventilation in the emergency room, so if patient with active tuberculosis disease arrives, everyone can be exposed." Finally, one female nurse expressed her concern that she does not feel protected by the infrastructure of her institution: "In reality, what the institution provides us does not eliminate the direct transmission of Koch's bacillus of [TB] patients to healthcare workers."

Participants mentioned that their health institutions only dispersed surgical masks for HCW and patient use. One female nurse stated that HCWs understood that their use of surgical masks in clinical practice did not provide full protection to HCWs: "We use masks because at least it is something, but we are not 'protected, protected'." One female physician noted that she often observed an exhausted supply of masks: "Sometimes we spend one month, and we do not have any type of protective masks. This is what promotes [disease] transmission." Participants also identified that the N95 type respiratory masks were ideal for TB control, and they questioned the relative cost of these masks and why health institutions were unable to purchase them. They

mentioned that although surgical masks were frequently limited in supply, they would confirm that at least the patient wore the surgical mask. One female physician, however, expressed that the absence of masks was not a barrier in service delivery: “Whether we have a mask or not, the patient receives medical attention. This does not affect our duties.”

Perceived Recommendations for Empowerment in Infection Control

Participants discussed recommendations that they believed could empower HCWs to adhere to *M. tuberculosis* infection control measures within health institutions and the country. They reported four common categories between institutional and national recommendations, including: a) education and training to increase awareness to patients, HCWs and community members about TB disease and preventive measures, while dispelling myths and reducing social stigma or discrimination; b) policy to prioritize HCW health and well-being and TB surveillance, diagnosis and prevention strategies; c) infrastructure to reinforce strategies that reduce hospital overcrowding and risk of nosocomial *M. tuberculosis* transmission; and d) economic considerations to identify available funding sources to maintain adequate supplies of disposable materials and equipment and overall health expenditure for TB control. They also reported two additional categories for national recommendations, such as: a) research to assess basic health indicators, identify barriers in service delivery and examine the influence of stigma and social determinants of health; and f) political considerations to identify any modifications in local or national political leadership that can strengthen TB control and prevention. Table 4 presents these six categories of proposed recommendations by HCWs.

Discussion

This is the first known study in the DR to explore how HCWs' perceive their ability to use preventive strategies for *M. tuberculosis* control in the workplace, and more specifically, illustrate how the intrinsic and extrinsic factors influenced their decision-making process to adhere to these infection control practices. The observed "knowledge-action" gap emerged, influenced primarily by HCWs' feelings of powerlessness to prevent nosocomial *M. tuberculosis* transmission in their clinical practice. The DR Ministry of Health has regularly updated and widely disseminated guidelines to improve hospital and community TB control (Dominican Republic Ministry of Health, 2010, 2014), based on evidence-based guidelines by the CDC and WHO (Jensen et al., 2005; World Health Organization, 1999). Supervision of the application of these infection control strategies, however, has not been universally prioritized across the public and private health sectors, thus leaving the existing threat of nosocomial *M. tuberculosis* transmission for HCWs and patients.

The feeling of powerlessness in the clinical setting, as evidenced in this study, has been reported as a barrier when physicians or nurses independently coordinate work schedules (Gask, 2004), complete assigned clinical tasks (Kuokkanen & Leino-Kilpi, 2001; Norrish & Rundall, 2001), or use evidence-based guidelines (Lipman, 2000). The concept of power, defined as a combination of authority and influence over others, has been described historically in nursing practice (Prescott & Dennis, 1985). One review documented that the ideal contribution to nurses' practice depended on their control over competence, content of practice, and context of practice (Manojlovich, 2007). Thus, although the academic formation of physicians and nurses differ by philosophical model, length of academic and clinical training, depth of clinical skills, and

projected clinical responsibilities, HCWs collectively were unable to attain full levels of empowerment and consistently adhere to *M. tuberculosis* infection control measures.

Competence or expertise in the scientific discipline is key to provide high-quality healthcare service delivery and optimal patient outcomes. Participants were knowledgeable about their increased occupational risk of nosocomial *M. tuberculosis* transmission, including the high TB burden that exists in the DR (60/100,000 in 2015) and the neighboring country of Haiti (194/100,000 in 2015) (World Health Organization, 2016c, 2016d). Their knowledge and perceptions about TB infection and disease, however, limited their ability to protect themselves and their colleagues in three distinct ways. First, HCWs expressed that they had previous *M. tuberculosis* exposure due to "auto-vaccination" from habitual occupational exposure and previous history of the Bacillus Calmette-Guérin (BCG) vaccine. These combined discrepancies in the immunological protection of the BCG vaccine and risk associated with continued occupational exposure resulted in feelings of invincibility, which may hinder their use of infection control strategies in clinical practice. Second, HCWs expressed their strong sense of vocation to maximize service delivery to patients, regardless whether they were able to adhere to infection control measures. Although this altruistic view to provide personalized care to all patients is admirable, their failure to consistently adhere to infection control strategies increases their risk of nosocomial *M. tuberculosis* transmission to HCWs and patients. Third, scientific and skill-based expertise do not equal experience or duration of employment, which is important to recognize in a country, like the DR, where license re-certification and continuing education programs are not currently mandatory (Iglesias et al., 2015).

The content of clinical practice, which emphasizes professional autonomy, or appropriate decision-making and independent action based on professional expertise (Skår, 2010), plays an essential role in practitioner control in clinical practice. In this study, HCWs were limited in full expression of their professional autonomy in two ways. First, physicians and nurses have different academic and clinical training, where nurses, in particular, select one of three specialty levels: professional (e.g., bachelor-level), technical (e.g., associate-level) and auxiliary (e.g., certificate-level) (Siantz & Malvárez, 2008). However, with limited continuing education programs offered to physicians and nurses, they may only count on their previously acquired knowledge as they serve as independent practitioners. Second, absence of isolation wards for suspected TB patients coupled with excess workload and hospital overcrowding, HCWs were inevitably forced to place patients of different pathologies in one hospital room, ultimately feeling helpless in their clinical decision making. To combat this limitation, the DR government has financed the national reconstruction and renovation of more than 50 hospitals since 2013, where many health institutions will be designed with an isolation ward to improve infection control.

The context of clinical practice, which can motivate HCWs to maximize their leadership potential and serve as key stakeholders in health decision making, can foster a positive workplace environment as well as job satisfaction (Manojlovich, 2007; Weston, 2010). In this study, HCWs expressed dissatisfaction and disillusion that institutional health leaders and stakeholders failed to identify and prioritize clear deficiencies in healthcare service delivery. This presents two challenges. First, HCWs who feel devalued or unimportant to the institution's mission may be psychologically

affected in their completion of daily clinical responsibilities as well as their reflections on their selected vocation, including motivation to adhere to infection control strategies. Second, with weak communication links between the hospital TB program, emergency room and hospital ward for TB management, HCWs may be perceive that they have an insignificant role in strengthening TB diagnosis, management or infection control.

Finally, by understanding the limitations that foster feelings of powerlessness, key evidence-based interventions can be implemented to empower HCWs to incorporate and implement their knowledge and skills into infection control practices. The concept of individual empowerment incorporates three main components (Manojlovich, 2007). First, opportunities to pursue professional development within the workplace, combined with adequate institutional support and available resources, can motivate employees to apply their leadership across organizational levels. Second, psychological motivation to maximize self-confidence and self-efficacy is an active process that incorporates workplace environment as well as personality characteristics of employees. Third, by building relationships to promote compassionate and empathetic care, employees can feel confident to apply their leadership skills in practice. These three components may help to empower HCWs intrinsically in their daily clinical practice; however, the extrinsic or systems-level limitations within health institutions persist and should be promptly addressed. As a national “call to action” campaign, the DR Ministry of Health can motivate all health institutions to understand the TB burden and mandate that they become familiarized with reported limitations in physical infrastructure and policies, influencing how HCWs adhere to *M. tuberculosis* infection control measures in clinical practice. Consequently, health institutions can take

appropriate and prompt action to adapt and repair the presence of these structural limitations. In this study, we also examined how HCWs believe that *M. tuberculosis* infection control measures can be strengthened at institutional and national levels, by emphasizing six main categories. Future steps may synthesize the HCWs' proposed recommendations with evidence-based strategies in *M. tuberculosis* infection control, paving the way for interventions at specific target areas that reduce the "knowledge-action" gap by empowering HCWs in their application of *M. tuberculosis* infection control measures in practice.

Our study was comprised of 40 HCWs who were employed in emergency, family or internal medicine specialties from two health institutions. Two additional focus groups, each with four physicians, were added to the total sample, to compensate for one health institution where family medicine residents were primarily female. Due to the excessive workload, not all focus group discussions could obtain a co-facilitator for note-taking during the session, which would have provided additional field notes to analyze. Using theoretical sampling, participants could elaborate on their experiences and perceptions related to the five barriers identified from the previous chapter; however, no new emerging themes were apparent in these discussions (Charmaz, 2000). Although the primary researcher conducted all 10 focus groups, as an external member of the health institution, she gained rapport and trust with participants since she received academic and research support (e.g., "buy-in") from hospital administration. Two researchers conducted in-depth analysis of the data transcripts, and two additional researchers assisted in the development of the model, confirming the influence of cultural or social processes evident in various constructs; however, we recognize that

the data may be uniquely analyzed and interpreted in multiple ways (Miles & Huberman, 1994).

Conclusions

This study identified how the intrinsic and extrinsic factors influenced the decision-making process among HCWs to adhere to *M. tuberculosis* infection control practices in two DR health institutions. The “knowledge-action” gap was observed, influenced primarily by HCWs’ feelings of powerlessness to prevent occupational *M. tuberculosis* transmission. HCWs proposed six categories of institutional and national recommendations, such as education and training; policy; infrastructure; economic considerations; research; and political considerations. By identifying reasons behind the “knowledge-action” gap, future evidence-based strategies can be combined with HCWs’ perceived recommendations to empower HCWs to strengthen *M. tuberculosis* infection control strategies, employing interventions to reduce nosocomial *M. tuberculosis* transmission in DR health institutions.

Table 4-1. Demographic and administrative variables of the two selected tertiary-level health institutions in the Dominican Republic, 2015

	Hospital A	Hospital B
Demographic		
City	San Pedro de Macorís	Santiago de los Caballeros
Population (2010)	290,458	963,422
General		
Hospital classification	Regional	Regional
Year opened	1999	1978
Annual number of admissions	10,422	17,648
Annual number of emergency visits	86,145	84,529
Annual number of consultations	96,469	128,999
Number of hospital beds	190	418
Medical training programs		
Number of medical specialty programs	3	10
Number of medical subspecialty programs	0	13
Tuberculosis		
Number of reported cases with respiratory symptoms	1,299	389
Number of reported TB cases diagnosed at center		
Patients	30	15
Healthcare workers	1	2
Number of reported MDR-TB cases diagnosed at center		
Patients	2	0
Healthcare workers	0	0
Presence of TB isolation area		
Internal Medicine ward	No	No
Intensive Care Unit	No	No

Abbreviations: MDR = multidrug-resistant; TB = tuberculosis
[Data provided by the Dominican Republic Ministry of Health National Department of Statistics, National Tuberculosis Program, and Hospitals A and B]

Table 4-2. Demographic characteristics of the study participants of the focus group discussions

#	Hospital	Sex	Age	Length of Institutional Employment (yrs)	Profession	Department	Role
1	A	F	27	3	Physician	Emergency	Third-year resident
2	A	F	26	3	Physician	Emergency	Third-year resident
3	A	F	26	2	Physician	Emergency	Second-year resident
4	A	F	30	2	Physician	Emergency	Second-year resident
5	A	F	28	3	Physician	Family Medicine	Third-year resident
6	A	F	29	3	Physician	Family Medicine	Third-year resident
7	A	F	28	3	Physician	Family Medicine	Third-year resident
8	A	F	26	3	Physician	Family Medicine	Third-year resident
9	A	F	24	5	Nurse	Emergency	Associate-level nurse
10	A	F	59	30	Nurse	Emergency	Bachelor-level nurse
11	A	F	49	16	Nurse	Emergency	Bachelor-level nurse
12	A	F	49	22	Nurse	Emergency	Bachelor-level nurse
13	A	F	47	8	Nurse	Emergency	Bachelor-level nurse
14	A	F	40	16	Nurse	Emergency	Associate-level nurse
15	A	M	28	3	Physician	Emergency	Third-year resident
16	A	M	28	3	Physician	Emergency	Third-year resident
17	A	M	26	3	Physician	Family Medicine	Third-year resident
18	A	M	26	3	Physician	Family Medicine	Third-year resident
19	A	M	33	3	Nurse	Internal Medicine	Certificate-level nurse
20	A	M	25	7	Nurse	Emergency	Bachelor-level nurse
21	B	F	29	2	Physician	Emergency	Second-year resident
22	B	F	31	2	Physician	Emergency	Second-year resident
23	B	F	32	2	Physician	Emergency	Second-year resident
24	B	F	29	3	Physician	Emergency	Third-year resident
25	B	F	58	28	Nurse	Internal Medicine	Bachelor-level nurse
26	B	F	52	27	Nurse	Internal Medicine	Bachelor-level nurse
27	B	F	48	6	Nurse	Internal Medicine	Bachelor-level nurse

Table 4-2. Continued

#	Hospital	Sex	Age	Length of Institutional Employment (yrs)	Profession	Department	Role
28	B	F	28	1	Nurse	Emergency	Bachelor-level nurse
29	B	M	51	19	Nurse	Emergency	Certificate-level nurse
30	B	M	28	10	Nurse	Emergency	Certificate-level nurse
31	B	M	47	22	Nurse	Emergency	Certificate-level nurse
32	B	M	35	5	Nurse	Emergency	Bachelor-level nurse
33	B	M	30	2	Physician	Emergency	Second-year resident
34	B	M	30	2	Physician	Emergency	Second-year resident
35	B	M	35	3	Physician	Emergency	Third-year resident
36	B	M	34	3	Physician	Emergency	Third-year resident
37	B	M	27	3	Physician	Internal Medicine	Third-year resident
38	B	M	30	2	Physician	Internal Medicine	Second-year resident
39	B	M	26	3	Physician	Internal Medicine	Third-year resident
40	B	M	35	3	Physician	Internal Medicine	Third-year resident

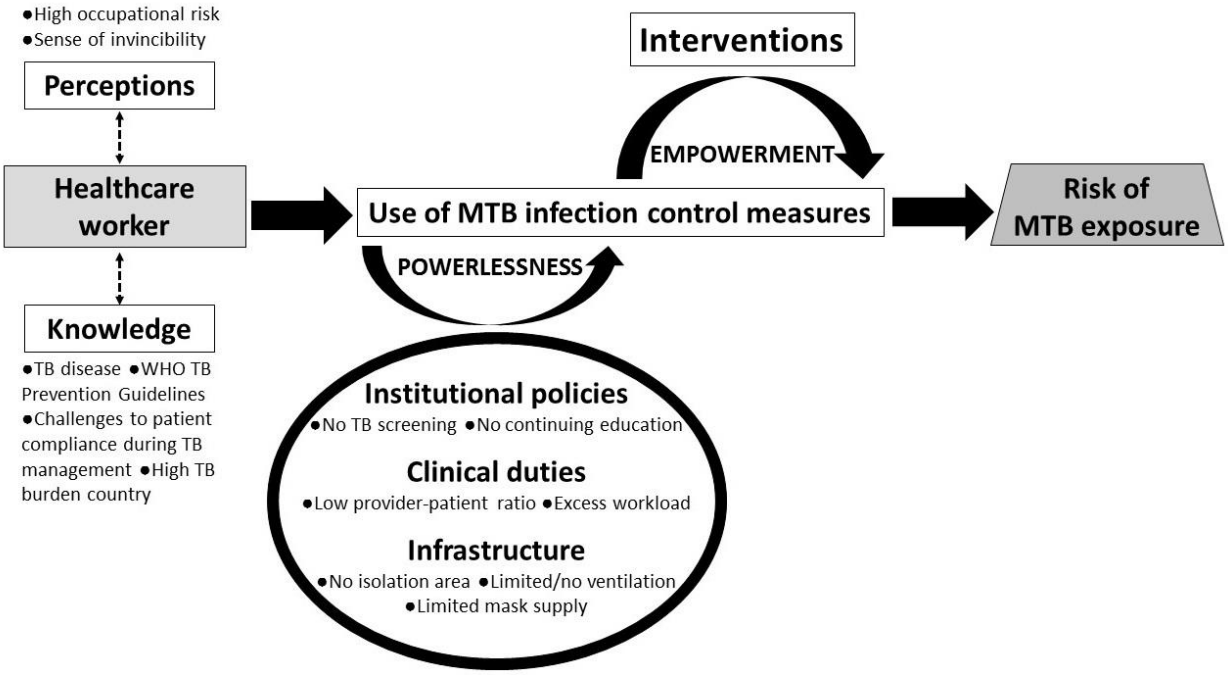

Figure 4-1. Conceptual model that presents the healthcare workers' decision-making process in the application of *Mycobacterium tuberculosis* (MTB) infection control measures in clinical practice, influencing the "knowledge-action" gap

Abbreviations: TB=tuberculosis; WHO=World Health Organization

Table 4-3. Healthcare workers' proposed recommendations to improve *Mycobacterium tuberculosis* infection control measures at institutional and national levels

Recommendation	Institutional level	National level
Education and Training	1. Develop orientation training seminars for new employees and hospitalized patients: a) TB disease, diagnosis and management b) Importance for treatment adherence c) Factors about TB as social disease and associated stigma 2. Implement daily health campaigns to educate patients and families about TB disease and importance for treatment adherence 3. Initiate regular and active training programs and workshops for non-clinical and clinical HCWs to critically analyze and reflect on current TB health burden	1. Verify that all HCWs receive regular continuing education programs 2. Promote national TB educational campaigns for the public through daily programming on media sources (e.g., television, radio, social media) and transportation services (e.g., bus, public cars, taxi) 3. Develop a health education television or radio channel or require channels to promote one-hour of health education topics (e.g., educational announcements on commercial breaks) 4. Implement monthly community education campaigns (e.g., seminars, activities) in primary, secondary and postsecondary institutions 5. Form relationships with community centers (e.g., Junta de Vecino) and local industries for participation in TB health promotion activities 6. Prioritize the role of family physicians at primary health centers to improve TB diagnosis and management in communities

Table 4-3. Continued

Recommendation	Institutional level	National level
Policy	1. Continue surveillance program with patients who have respiratory symptoms > 2 weeks 2. Complete appropriate diagnostic work-up (e.g., smears, cultures) for suspected TB patients in an adequate time frame without time lapse 3. Strengthen psychological support for patients and families during TB management 4. Require orientation and annual periodic health evaluations for HCWs 5. Assign one HCW to each specific clinical area to supervise HCWs and patients, observe compliance with TB infection control measures, and verify sufficient supply of disposable materials 6. Designate one HCW to maintain hygiene and disinfection in emergency and hospital wards 7. Increase number of HCWS in clinical areas and reduce cumulative work hours 8. Implement disciplinary acts in the form of sanctions, salary discount, or firing for HCWs who fail to adhere to TB infection control measures	1. Require orientation and annual medical evaluations for HCWs and employees of high-risk industries 2. Form national supervisory teams to observe HCW adherence to TB infection control measures across all health institutions 3. Strengthen links between primary health centers and hospitals in order to improve TB case finding, refer patients as needed, or manage DOTS
Infrastructure	1. Build TB isolation ward to meet capacity 2. Confirm that clinical areas have adequate ventilation 3. Evaluate the quality of disposable resources (e.g., type of mask, gloves) for infection control 4. Require monthly reports from each department to identify necessary provisions of disposable materials and equipment for TB management	1. Develop TB isolation wards at select hospitals to manage suspected TB patients 2. Build various regional centers to specifically care for patients with respiratory diseases

Table 4-3. Continued

Recommendation	Institutional level	National level
Economic considerations	1. Assign an administrative personnel or team to develop fundraising campaigns for disposable materials and equipment (e.g., telethons, medical outreach) 2. Request sponsorship from private companies	1. Request that the Ministry of Health increases the annual health budget for tertiary-level health institutions 2. Educate national health authorities about high national TB burden and need to meet MDGs 3. Increase Gross Domestic Product allocated for health expenditure
Research		1. Develop epidemiologic studies in private and public sectors to examine TB incidence in health institutions and geographic regions 2. Design baseline studies that can provide a framework for future TB research: a) Identify barriers in continued healthcare service delivery b) Influence of stigma and discrimination c) Impact of social determinants of health
Political considerations		1. Decentralize politics from the health system where no politician (e.g., physician or non-physician) should direct the health system

Abbreviations: DOTS=directly observed treatment, short-course; HCW=healthcare worker; MDG=Millennium Development Goals; TB=tuberculosis

CHAPTER 5
CONCLUSIONS, IMPLICATIONS AND FUTURE RESEARCH

Contributions of the Dissertation

Globally, nosocomial *M. tuberculosis* transmission has been recognized as a major challenge for healthcare workers (HCWs) in health institutions in low- and high-resource settings. However, since *M. tuberculosis* infection control measures are not universally implemented in health institutions, the occupational exposure of HCWs continues to be overlooked. In the Dominican Republic (DR), health leaders recognize the high national tuberculosis (TB) burden and have focused public health efforts on TB diagnosis, treatment and prevention in the general community as well as high-risk groups such as immunocompromised, marginalized and incarcerated populations. However, in order to continue TB control efforts toward TB elimination, more action is obligatory. This paradigm shift in TB control will need to prioritize measures that maximize the adherence to *M. tuberculosis* infection control measures and ultimately reduce nosocomial transmission in health institutions.

This thesis provides a comprehensive overview of intrinsic and extrinsic factors that limit the application of *M. tuberculosis* infection control strategies in clinical practice, and thus influencing the “knowledge-action” gap among HCWs. We provide evidence that HCWs expressed feelings of powerlessness to prevent nosocomial *M. tuberculosis* transmission in clinical practice. Notably, we identify that intrinsic and extrinsic factors strongly influence how HCWs decide to apply these infection control measures in the clinical setting. Since HCWs represent a high-risk group for increased risk of *M. tuberculosis* infection in their daily workplace, TB elimination will not be complete without reducing risk of nosocomial transmission among HCWs and patients in health

institutions. We describe the implications of our results for TB infection control efforts in DR health institutions. We also discuss future directions that implement specific initiatives to inform health authorities and motivate them to take appropriate and prompt action to reduce risk of nosocomial *M. tuberculosis* transmission in the DR.

Implications of Nosocomial Tuberculosis Transmission in Healthcare Workers

Nosocomial *M. tuberculosis* transmission in HCWs has and will continue to challenge health institutions in their implementation and monitoring of infection control practices. Although transmission of the *M. tuberculosis* Beijing strain has been infrequently reported in Latin America (Institut Pasteur de la Guadeloupe, 2011; Ritacco et al., 2008), the attention to pathogen infectiousness and drug resistance takes precedence in nosocomial transmission in health institutions. Although our first study reported that pulmonary cavitation was not significantly associated with infection with the *M. tuberculosis* Beijing strain in a low incidence area like the United States, it is imperative to understand the clinical and epidemiologic characteristics of drug-susceptible and drug-resistant *M. tuberculosis* strains. With no active national surveillance system to robustly seek HCWs who have *M. tuberculosis* infection or disease in real-time measure (Nsubuga et al., 2006), DR health authorities rely on passive surveillance strategies that monitor TB diagnoses, treatment regimens and deaths by institutional reports. As such, by investing in an active national surveillance system with electronic database that links each health institution to the National TB Program (NTP), TB cases can be documented rapidly and timely, and thus provide insight into institutional health priorities as well as motivate health leaders to take clinical action toward effective TB control.

Historically, it is recognized that HCWs have had a positive image to serve others in need, promoting selfless and altruistic actions in clinical practice (Rhodes, Morris, & Lazenby, 2011; White, 2002). In addition, patient advocacy can be an essential element to preserve patients' right as well as empower their physical and emotional health during their short- or long-term recuperation (Gaylord & Grace, 1995; Negarandeh, Oskouie, Ahmadi, Nikravesh, & Hallberg, 2006). This dissertation provides evidence that HCWs identified strongly with their vocation and desire to deliver high-quality healthcare services to patients, regardless of their ability to apply *M. tuberculosis* infection control measures. However, combined with their feelings of powerlessness in clinical practice, whether due to intrinsic factors such as erroneous perceptions about their risk of *M. tuberculosis* transmission due to their previous history of Bacillus Calmette-Guérin (BCG) vaccine or habitual occupational exposure or extrinsic factors such as absence of isolation wards, health authorities will be unable to markedly reduce *M. tuberculosis* transmission in health institutions. For this reason, by addressing the factors that lead to HCWs' feelings of powerlessness, employee health programs can educate HCWs about the important links between patient advocacy to care for their physical and emotional health and well-being and use of *M. tuberculosis* infection control measures in clinical practice.

Future Directions

This study has the potential to serve as a framework for future studies that focus on implementing surveillance systems for TB infection control measures, addressing powerlessness and limits of education programs for HCWs, and applying interventions that empower HCWs in their clinical duties. Furthermore, it is imperative to note that these three focus areas must accompany and complement the structural modifications

and repair of the described extrinsic limitations such as physical infrastructure and institutional policies.

Implementing Surveillance Systems for Tuberculosis Infection Control Measures

In our study, we documented that no active national surveillance system existed for the timely report of HCWs who develop TB infection or disease or who adhere to *M. tuberculosis* infection control measures. The only national evidence that identified the risk of this occupational health threat reported that 116 HCWs employed at selected tertiary-level health institutions developed TB disease between 2005 and 2012 (Genao & Rodríguez, 2013). However, passive national surveillance systems will not be enough to promptly identify TB cases. At the same time, the deficiency of process surveillance systems (Baker, 1997; Friedman, Richter, Skylis, & Brown, 1984) to observe and monitor HCWs' adherence to infection control measures will not identify inadequate clinical practices that increase occupational risk of *M. tuberculosis* exposure. By investing in an electronic database that connects each local health institution with the NTP, data from active surveillance systems can be reviewed immediately to identify local and national statistics of TB incidence and process surveillance systems can monitor HCWs' adherence to infection control measures. In effect, HCWs may be empowered in their professional autonomy and clinical decision-making and use of *M. tuberculosis* infection control practices.

Addressing Powerlessness and Limits of Education Programs

Although no regular continuing education programs about TB are provided to HCWs in the DR, our study showed that the concept of powerlessness was the central theme that hindered how HCWs were able to use available resources and adhere to *M. tuberculosis* infection control measures. One traditional approach, which can be

inaccurately perceived as all-encompassing for long-term behavioral changes, includes the sole implementation of continuing education programs. Short-term educational interventions for physicians have been shown to be beneficial by improving physicians' knowledge about inappropriate antibiotic prescribing practices (Iglesias et al., 2015) and dengue fever (Doblecki-Lewis et al., 2016); however, these short-term studies did not follow the participants to assess the long-lasting effects of the educational intervention on clinical practices. Nonetheless, since the health sciences represent a dynamic field, clinicians who do not remain up-to-date on revisions in clinical practice guidelines will be at a disadvantage, placing themselves at risk of nosocomial disease transmission and failing to provide high-quality healthcare services to their patients. This is the current scenario in the DR, where clinicians are not required to maintain license re-certifications or complete additional education program credits (Iglesias et al., 2015).

Nevertheless, regular continuing education programs in health institutions, where programmed topics are relative to the institutional health priorities in service delivery, such as TB, only influence intrinsic factors (e.g., knowledge) related to HCWs' ability to adhere to recommended *M. tuberculosis* infection control measures. Inevitably, they do not guarantee short- or long-term behavioral changes and ultimately fail to completely address the overall context of powerlessness expressed by HCWs. Therefore, future steps should address the interplay between intrinsic and extrinsic factors and empower HCWs in their adherence to *M. tuberculosis* infection control measures.

Applying Interventions to Empower Healthcare Workers in Clinical Duties

Our results described that HCWs feel powerless in their ability to use recommended *M. tuberculosis* infection control measures in their clinical duties. They shared feelings of being devalued as HCWs, noting that health authorities did not

appear to prioritize their physical and mental health by implementing regular medical evaluations for HCWs. Previous studies have recognized this concept of powerlessness as a significant barrier in clinical practice (Gask, 2004; Kuokkanen & Leino-Kilpi, 2001; Lipman, 2000; Norrish & Rundall, 2001); however, to our knowledge, we have not identified studies that examine the concept of powerlessness as a barrier to the application of clinical knowledge to infection control practices. With the antithesis of powerlessness as empowerment, we can develop interventions that target the three components of empowerment – workplace environment, psychological well-being and social relationships (Manojlovich, 2007). Even empowering patient-provider relationships as well as individual autonomy can improve communication and overall confidence in the decision-making process (Entwistle, Carter, Cribb, & McCaffery, 2010).

Since HCWs observed key deficiencies in *M. tuberculosis* infection control practices in their workplace environment and proposed recommendations for improved TB control at institutional and national levels, it is imperative to consider their real-world clinical experiences and observations. Thus, by synthesizing their proposed recommendations with established evidence-based practices noted to increase adherence to *M. tuberculosis* infection control measures, new interventions can target one or more of the specific intrinsic and extrinsic factors that limit adherence. In effect, HCWs can regain the feeling of empowerment to apply *M. tuberculosis* infection control measures to clinical practice, while playing an active role in reducing nosocomial *M. tuberculosis* transmission in their health institutions.

Finally, the concept of powerlessness emerged during the data collection and analysis phases of this study, describing HCWs' ability to adhere to *M. tuberculosis* infection control measures in this theoretical framework. Since our study sample included physicians and nurses who were employed at three tertiary-level health institutions in three DR cities, future studies can validate this framework among HCWs who are employed in health institutions in other environments (e.g., rural geographies, low or intermediate TB burden countries, primary- or secondary-level health institutions). Further evaluation can confirm if the described intrinsic and extrinsic factors related to the concept of powerlessness are consistent with this study and thus can be generalized across multiple locations.

Conclusion

This dissertation contributes to the understanding of the impact of *M. tuberculosis* infectiousness and application of TB infection control measures to reduce HCWs' occupational *M. tuberculosis* exposure in health institutions. We provide evidence that HCWs' perceive powerlessness, driven by significant limitations at the individual and institutional levels, which hinder their adherence to *M. tuberculosis* infection control practices, and thus influences the "knowledge-action" gap in infection control practices.

APPENDIX A
INTERVIEW GUIDE FOR SEMI-STRUCTURED INTERVIEWS

1) Please describe your experiences with TB disease at your health center.
2) Please describe your experiences with TB infection at your health center.
3) How would you describe the communicability of TB?
4) What preventive practices do you use for patients with suspected TB?
5) What clinical management strategies do you use when caring for patients with suspected TB?
6) How would you describe the effectiveness of DOTS?
7) How do believe that patients cope with the TB treatment via DOTS?
8) If a healthcare worker was diagnosed with TB infection, how would he or she cope during the isoniazid preventive therapy via DOTS?
9) If you were diagnosed with TB infection, how would you cope during the isoniazid preventive therapy via DOTS?

Abbreviations: DOTS = directly observed treatment, short-course; TB = tuberculosis

APPENDIX B
INTERVIEW GUIDE FOR FOCUS GROUP DISCUSSIONS

Barrier 1: Sense of invincibility of HCWs

1) Why do you think that HCWs perceive that they had a low susceptibility to TB exposure?
2) How does this affect your adherence to use TB infection control measures in clinical practice?
   a) What is your understanding of how your previous history of BCG vaccination has protected you?
   b) How has the duration of your employment at this health center affected your susceptibility to develop TB disease or infection?
   c) Some HCWs state that they do not want to transmit TB to their families, but report that they do not consistently adhere to TB infection control measures. Why do you believe that this disconnect exists in their adherence to TB infection control measures?
3) Related to these described perceptions of low susceptibility to TB exposure, what do you believe can be done to improve adherence to TB prevention and control measures in this health center?

Barrier 2: Personal beliefs of HCWs related to direct patient communication

4) How do you believe that the personal beliefs of HCWs at this health center affect their ability to adhere to TB infection control measures?
   a) *Probe:* Why do you believe that HCWs would express that their spiritual faith may play a role in adherence to TB infection control measures?
   b) Why do you believe that HCWs preferred to avoid close contact with patients as a protective measure, rather than using a protective mask?
   c) Why do you believe that HCWs believed that patient education in disease management is the main strategy for personal protection from TB exposure?
5) Related to these described personal beliefs related to direct patient communication, what do you believe can be done to improve adherence to TB prevention and control measures in this health center?

Barrier 3: Low provider-to-patient ratio at health centers

6) How do you believe that your provider-to-patient ratio impacts your ability to adhere to TB infection control measures at this health center?
   a) Do you feel challenged in your ability to follow TB infection control measures?
7) Please describe the characteristics of patients that may influence your adherence to TB infection control measures.
   a) *Probe:* Which types of patients do you believe may influence your ability to adhere to TB infection control measures?
8) Related to the challenges encountered with a low provider-to-patient ratio at this health center, what do you believe can be done to improve adherence to TB prevention and control measures in this health center?

Barrier 4: Absence of TB isolation units for patients within health centers

9) Please describe how the absence of patient isolation units impacts your ability to adhere to TB infection control measures?
   a) *Probe:* How do you believe that your limited ability to separate patients with suspected TB from other pathologies impacts your ability to adhere to TB infection control measures?
10) Related to the absence of TB isolation units for patients at this health center, what do you believe can be done to improve adherence to TB prevention and control measures in this health center?

Barrier 5: Limited availability of protective masks for HCWs

11) Please describe how the availability and type of protective mask impact your ability to adhere to TB infection control measures?
   a) *Probe:* Do you believe that your perceived level or protection with protective masks impacts your ability to adhere to TB infection control measures?
12) Related to this limited availability of protective masks, what do you believe can be done to improve adherence to TB prevention and control measures in this health center?

Conclusions

13) What do you believe can be done to improve adherence to TB prevention and control measures in the Dominican Republic?
14) Is there anything else that you would like to add?

Abbreviations: BCG = Bacillus Calmette-Guérin; HCW = healthcare worker; TB = tuberculosis

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BIOGRAPHICAL SKETCH

Helena Jeanne Chapman graduated from the Department of Environmental and Global Health in the College of Public Health and Health Professions at the University of Florida. She served as a graduate research assistant at the Southeastern National Tuberculosis Center in the Division of Infectious Diseases and Global Medicine in the College of Medicine at the University of Florida. Helena earned her Doctor of Medicine from the Iberoamerican University in Santo Domingo Dominican Republic, and Master of Public Health in Epidemiology and Bachelor of Science in Biology from the University of Florida. She also completed a three-week cross-cultural training in tuberculosis surveillance and control at the “Pedro Kourí” Tropical Medicine Institute in Havana, Cuba. Prior to her doctoral studies in public health, she completed a one-year post-graduate internship at the Centers for Diagnosis, Advanced Medicine and Telemedicine (CEDIMAT) in Santo Domingo, Dominican Republic. She also served as adjunct professor at the Iberoamerican University School of Medicine and taught courses in Evidence-based Medicine and Preventive Medicine and Public Health. She also was founding member and first President of the first national (non-governmental) medical student organization (Organización Dominicana de Estudiantes de Medicina, ODEM) in the Dominican Republic. Her leadership in medicine and community health has been recognized through awards, presentations, and peer- and non-peer reviewed publications at the local, national and international levels. Helena’s research interests include the use of qualitative research methods to evaluate public health practices of clinical and community programs in the prevention and control of infectious diseases.