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Three-year Evaluation of Pre-employment Screening for Tuberculosis (TB) and Post-exposure Compliance with Therapy for Latent TB Infection Among Healthcare Workers Working in A Tertiary Care Hospital in Saudi Arabia

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An abstract of
A thesis submitted to the Faculty of the Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of Master of Public Health in
Hubert Department of Global Health, 2012

ABSTRACT

Background: Controlling tuberculosis (TB) among occupationally exposed healthcare workers (HCWs) is challenged by limited documentation of pre-employment tuberculin skin test (TST) screening and the lack of clinical evaluation and completion of therapy for latent TB infection (LTBI) after occupational TB exposure. **Methods:** We retrospectively reviewed occupational TB exposures between 2008 and 2010 in King Abdulaziz Medical City, Riyadh, Saudi Arabia. We abstracted records and collected predictor data for documenting pre-employment TST status and subsequent TST screening and treatment for LTBI among occupationally exposed HCWs. **Results:** We found 13 occupational TB exposure events involving 298 HCWs. Exposed HCWs tend to be female (70.6%), non-Saudi (76.9%), nurse (55.7%) or respiratory therapist (19.5%), working in critical care locations (72.8%). Pre-employment TST documentation existed for only 123 out of 298 (41.3%) exposed HCWs. Among those with documented baseline TST, 63 (51.2%) were TST positive (21.1% of all 298 HCWs). After exposure, 53 (17.8%) of 298 exposed HCWs were newly diagnosed with LTBI and 49 (92.5%) of them were prescribed therapy for LTBI. Among those prescribed, 46 (93.9%) started therapy for LBTI with the majority (82.6%) did not finish the recommended course of therapy. **Conclusions:** We found low rates of pre-employment TST documentation among exposed HCWs in a large tertiary care hospital in Saudi Arabia. Compliance with starting post-

exposure isoniazid (INH) prophylaxis among HCWs was poor and only small fraction of those who started INH completed the recommended course of therapy. These findings suggest substantial opportunities to implement administrative measures to enhance LTBI management among HCWs.

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Acknowledgments

I would like to express my deepest gratitude to my thesis and practicum advisor, Dr. Scott McNabb, for his kind support, knowledge, and skills generously shared with me during my studies at Emory University. Thanks to my colleagues, Dr. Hanan Balkhy, Dr. Thaddeus L. Miller, Dr. Saira Muzaffar, and Jennifer B. Nuzzo, with whom I was working on this project during Summer–Fall period of 2011. I would also like to thank my Academic Adviser, Angela Rozo for creating supportive study environment. I am also thankful to the founders of Muskie Fellowship Program which made my stay in US and study at Emory University possible.

INTRODUCTION

Tuberculosis (TB) remains a global public health pandemic. It is one of the most dangerous communicable diseases in the world and is a serious health and social problem for many countries. It has killed more people than any other disease in human history [1]. In spite of the fact that Robert Koch discovered the pathogenic agent more than 100 years ago and an effective treatment is available, TB remains a major health and social concern all over the world.

There is a vaccine for TB: Bacille Calmette-Gurin (BCG) which was first used in humans in 1921. It is used in many countries and effective in preventing severe forms of TB in children, particularly childhood TB meningitis and miliary disease. In the United States BCG is not recommended because it has limited effectiveness for preventing pulmonary TB overall and interference with tuberculin skin test (TST) reactivity [2].

The symptoms of TB include weakness, weight loss, fever, and night sweats [3]. The symptoms of pulmonary TB include cough, chest pain, and hemoptysis [3]. Symptoms of TB disease of non-pulmonary TB depend on the area affected. Because of the non-specific symptoms, TB is often overlooked by patients and medical professional, causing delayed detection, treatment, and consequently further spread [2].

The World Health Organization (WHO) estimates that one-third of the world’s population is currently infected with TB and that two million deaths occur each year [4]. Worldwide, TB is the second largest contributor to adult mortality among infectious diseases [5]. TB disproportionately affects the most productive age groups, thus the economic cost is high [6]. In developing countries, 75% of TB cases occur in the most economically productive age group (15-54 years) [3]. On average, an adult with TB loses three to four months of work time. This often leads to the impoverishment of households [3]. Beyond biologic, socio-economic factors also contribute to the TB pandemic: poverty, poor education, and migration. One important factor is the high frequency of patients with poor adherence to prescribed treatment regimens [7].

TB incidence is increasing worldwide [8]. In 2010, there were approximately 8.8 million new cases of TB and 1.1 million deaths among HIV-negative people. Additionally 0.35 million people died from HIV-associated TB [4]. The reasons for the increasing TB burden include: poverty and the increasing gap between rich and poor in some populations, inadequate case detection and treatment, poor compliance with treatment, antibiotic misuse, and the human immunodeficiency virus (HIV) pandemic [3]. HIV infection significantly increases the risk of developing TB. Countries with a high prevalence of HIV (e.g. sub-Saharan Africa) shows a two or three times increase in the number of TB cases in the 1990s [3]. TB is the main cause of death in people with HIV/ADIS [4]. TB is a significant public health issue not only in low-income, but also high-income countries.

Multi-drug resistance – caused by poorly managed TB disease and the misuse of antibiotics – is a growing global problem [3]. Resistance to TB drugs can occur when patients do not complete a full course of treatment [2]. That is why compliance with TB treatment is a crucial factor for TB control. Poor compliance has repeatedly been cited as one of the major obstacles in TB control [8]. Noncompliance can lead to inadequate treatment, resulting in relapse, continued transmission, and development of drug resistance [3].

The Kingdom of Saudi Arabia (KSA) is the largest state in Western Asia with 27 million people [9]. Located in Arabian Peninsula and has an area of approximately 2,149,690 sq km, KSA has experienced considerable improvement in main health indicators. For example, life expectancy increased from 52 in 1970 to 74 in 2010. Immunization rates are high; 98% coverage of BCG, DTP1 and DTP3, polio 3, measles, HepB 3 and Hib 3 vaccines in 1-year olds. Under-5 mortality rates decreased dramatically from 45 in 1990 to 18 in 2010 [9].

Despite these advances, KSA has significant TB morbidity and mortality [10-12]. KSA reported 18 cases per 100,000 population (5,000 cumulative TB cases) in 2010 [4]. The risk of TB transmission is especially high during mass gatherings (e.g., Hajj) [13]. Overcrowding during Hajj leads to a high risk of transmission of airborne infectious diseases, including TB. Wilder-Smith, *et* al showed that 10% of 149 TB antigens-negative pilgrims who visited Mecca had a significant rise in immune response to TB antigens three month after the pilgrimage [14]. A large number of immigrant laborers also contribute to high transmission rates [13]. Of 27 million, almost nine million residents in KSA are registered foreign expatriates [15]. Gleason, *et* al. found that compared with Saudis, non-Saudis had a 2-fold greater TB incidence rate [13]. BCG vaccine is included in the National Immunization Calendar of KSA and routinely used in newborn children [16].

The ultimate goal of Latent Tuberculosis Infection (LTBI) treatment is to prevent active TB disease and spread of infection. Multiple factors contribute to LTBI detection and timely treatment in healthcare facilities (HCF). Among those influencing effective LTBI case detection are existing hiring and TB screening policies and their enforcement.

Compliance with prescribed TB treatment is a challenging issue connected with long-term treatment regimen, TB drugs toxicity, and other multiple factors. Compliance with LTBI treatment is even more problematic because of the fact that TST positive persons have no TB-related symptoms or health complaints. Besides, there is a common perception that there is an association between positive TST test results and BCG vaccination history [2]. Johansson, *et* al. (1999) found that treatment failure is not only attributable to patients' low adherence to treatment (e.g., in keeping appointments, taking medications, executing life-style changes), but also to the failure of physicians to comply with prescribed therapy [8]. Poor compliance enhances the development of chronic TB cases with resistance to TB medications. Another factor that could possibly affect TB treatment adherence is patients' gender. Gender differences in compliance with TB treatment have rarely been studied. However, it has been reported in the existing literature that in general women are more likely to comply with TB treatment than men [8]. Ogden, *et* al. (1999) emphasized that TB control programs need to address social dimensions of TB and adhere to the principles of comprehensive TB care "effective tuberculosis control cannot be achieved so long as the disease is considered in isolation from the social processes that maintain it, create the conditions facilitating its spread and act as barriers to care" [17]. A conceptual framework describing factors contributing to TB treatment compliance is presented in the Figure 1.

This study aims to analyze three years of pre-employment screening data for TB and post-exposure compliance with therapy for LTBI among healthcare workers (HCWs) working in a tertiary care hospital in KSA. Findings of this study will strengthen the hospital infection control program and foster more effective prevention of nosocomial TB transmission.

LITERATURE REVIEW

LTBI is defined as the presence of *Mycobacterium tuberculosis* in the body without symptoms, or radiographic or bacteriologic evidence of TB disease [18]. One-third of the world's population is infected with *Mycobacterium tuberculosis*. In the United States, an estimated 9–14 million people have LTBI. Approximately 5–10% of persons with LTBI will develop TB disease at some point in their lifetime if untreated [18]. That is why timely detection and adequate treatment of LTBI is crucial for TB control and dissemination prevention.

The diagnosis of LTBI is complex, based on information from the medical history, TST or IGRA tests result, chest radiograph, physical examination, and sometimes on sputum examinations [18]. Before starting treatment for LTBI careful assessment to exclude the possibility of TB disease is necessary as not adequate treatment may bring to development of drug resistant TB [2]. There are two testing methods available for the detection of *Mycobacterium tuberculosis* infection. They are Mantoux tuberculin skin test (TST) and Interferon-gamma release assays (IGRAs) [18].

TST should be interpreted with caution in people who had recent history of BCG vaccination. BCG may cause a false-positive reaction to the TST. This fact may complicate decisions about prescribing LTBI treatment. The size of a TST reaction in a BCG-vaccinated person is not a determining factor whether the reaction is caused by LTBI or the prior BCG vaccination. IGRA blood test, unlike the TST, is not affected by BCG vaccination and is less likely to give a false-positive result [2].

Decision on prescribing LTBI treatment based on the size of TST induration and results of TB blood test. According to Center for Diseases Control and Prevention (CDC) guidelines, the following high-risk groups should be prescribed with LTBI if their reaction to the TST induration is at least five mm or they have a positive result at TB blood test [2]:

- Recent contacts to a active TB case
- Persons with fibrotic changes on chest radiograph consistent with old TB
- Patients with organ transplants
- HIV-infected persons and persons who are immunosuppressed for other reasons

The following high-risk groups should be prescribed with LTBI if their reaction to the TST induration is at least 10 mm or they have a positive result at TB blood test [2]:

- Injection drug users
- Recent arrivals (< five years) from high-prevalence countries
- Residents and employees of high-risk congregate settings (e.g., correctional facilities, nursing homes, homeless shelters, hospitals, and other health care facilities)

- Mycobacteriological laboratory personnel
- Persons with clinical conditions that place them at high-risk for developing TB disease (e.g., diabetes)
- Children < four years of age, or children and adolescents exposed to adults in high-risk categories

Persons with no known risk factors for TB may be considered for LTBI treatment if TST test induration reaction is at least 15 mm of or they have a positive result using a TB blood test [2].

LTBI is special concern in health care settings. HCWs have an increased likelihood of exposure to active TB disease and consequently at increased risk of progression from LTBI to active TB [18]. Other risk factors that may be associated with progression from LTBI to TB disease are HIV infection, injection drug use, active TB history, low body weight, and diabetes. Also immigration from TB-endemic region and recent TST conversion (increase of 10 mm or more in the size of the TST reaction within a two-year period compared with baseline) are risk factors. The risk of progression to active disease is greatest in the first two years after infection [18].

HCF can serve as foci for TB transmission, with occupational exposure leading to active disease or LTBI among HCWs [19]. There is evidence showing high prevalence of LTBI among HCWs. A study conducted in Republic of Georgia showed 77% (203 of 265) of HCWs tested positive for LTBI [20]. The same study showed the association between increased risk of LTBI and older age or longer employment of HCW [20].

A study conducted by Abbas, *et* al. on the prevalence of LTBI among 2-year new hires of HCWs in four major tertiary care hospitals in Riyadh, Saudi Arabia showed 11% of HCWs had a positive TST test. The highest positive TST rates were found among HCWs in the age group of 50 years and older compared with younger group. No statistically significant association was found between gender and a positive TST test [21].

Pre-employment, baseline TST and a thorough evaluation of TB exposure and infection among HCWs are fundamental to infection prevention and control (IP-C) global best practices [22]. Such screening among HCWs serves a vital function not only by identifying persons with LTBI, but also in establishing a baseline vital for the identification of new infections after future exposures. Conversion from a recent, known negative TST to a positive TST is considered the most robust marker of recent infection. Such conversion can only be ascertained when baseline TST status is known.

Identification and treatment of individuals with LTBI is key to an effective and efficient TB control program [23]. Persons with LTBI are at high risk of progression to active TB disease and comprise an important reservoir for future active TB disease [23]. HCWs known to have been recently or newly infected with *Mycobacterium tuberculosis* are at highest risk to develop acute TB disease and may benefit most from treatment for LTBI [7]. Completion of therapy for

LTBI averts TB morbidity and mortality by reducing the risk of future, active disease by more than 70% [24]. The standard course of isoniazid (INH) treatment is simple and inexpensive, yet extended and carries a risk of liver toxicity [7, 25, 26].

Enhancing adherence to therapy for LTBI is essential for TB elimination [10, 27]. Adherence and completion of LTBI therapy is often limited by several factors [28]. Decline to start and poor adherence to INH prophylaxis are major limitations for treatment of latent TB. In studies done in the United States and Canada, about 15% of those who had positive TST declined treatment and almost half of those who already started treatment of LTBI completed the recommended regimen [27, 29-31]. Compliance with INH prophylaxis among HCWs was shown to be even worse than community exposure to TB cases [30]. Unfortunately, there are no such data in KSA.

Therefore, we analyzed TB occupational exposure events for a 3-year period (2008 – 2010) in King Abdulaziz Medical City, Riyadh, Saudi Arabia (KAMC-R). Our goal was to evaluate the current practices of TB prevention and control among HCWs and identify opportunities for policy and program improvements.

METHODS

Setting:

Riyadh is the capital of KSA, with an urban population of 4.725 million among a total national population of 26,132,000 [32]. The World Health Organization reports KSA with a moderate TB incidence rate of 18/100,000 in 2009 [12]. The study was conducted in KAMC-R, a large, urban hospital of 847 total beds and accredited by the Joint Commission's International arm. KAMC-R is the largest of four tertiary care hospitals serving more than a million Saudi National Guard (SANG) soldiers, employees and their families. The care provided range from primary and preventive care to tertiary care. Administrative hospital statistics showed that at least 6,369 HCWs (1,357 medical, 3,327 nursing, and 1,685 allied health and clinical) were serving at the KAMC-Riyadh during 2010. Assessment of TB exposures, as well as record keeping and follow-up, is executed under the authority of the Infection Prevention & Control Department (IP&C) at KAMC-Riyadh.

Study Design:

We conducted a retrospective chart review using de-identified administrative and clinical records of HCWs working at KAMC-R who had occupational exposure to TB between January 1, 2008 and December 31, 2010.

Data Collection:

We identified and abstracted potential risk factors of having LTB among occupationally exposed HCWs before exposure (baseline, pre-employment) and after exposure, in addition to data on post-exposure therapy for LTBI. These data included age, gender, citizenship, country of origin, work location, LTBI, TST screening results, post-exposure pulmonary TB status, diagnostic methodology and results, and the prescription, acceptance, and compliance with post-exposure therapy for those diagnosed with LTBI. We measured three outcome measures among occupationally exposed HCWs during the 13 TB exposure events: baseline, pre-employment TST status; diagnosed pre-employment LTBI infection; and post-exposure compliance with therapy for LTBI.

Human Subjects Protections:

Internal Review Board approval was obtained by KAIMRC, at King Saud University, Riyadh, KSA.

Statistical Analyses:

The frequency of LTBI was calculated as the percentage of those who had TST positive out of total exposed HCWs. The frequency of starting INH prophylaxis was calculated out of those with LTBI who were prescribed INH. The frequency of adherence to INH prophylaxis was calculated out of those with LTBI who were already started INH prophylaxis. Chi-square test was used to detect significant differences between categorical groups. SAS™ (SAS Institute Inc, Cary, NC, USA) was used to perform all analyses. All P-values were two-tailed. P-value <0.05 was considered significant

RESULTS

Two hundred and ninety-eight HCWs were involved in one of 13 events during the 3-year time period resulting in occupational exposure to TB (Table 1). The average reported age of TB-exposed HCWs was 37 years; 176 (62.9%) of 298 were female and most (76.9%) were non-Saudis. The majority of exposed HCWs were assigned to high-risk patient units in the hospital (e.g., critical care and emergency care). Two hundred and twenty-eight (76.5%) of 298 TB-exposed HCWs were contract employees while only 44 (14.8%) of 298 were members of the SANG health administration.

Baseline, pre-employment TST status was known for 123 (41.3%) of 298 occupationally exposed HCWs (Figure 2). Where baseline, pre-employment TST status was known, 63 (51%) HCWs were TST positive. Those HCWs with known baseline TST positive results represented 21% of all 298 occupationally exposed HCWs. Foreign contract employees were 2.12 times more likely to have a positive pre-employment TST baseline than domestic employees (PR = 2.12, 95% CI=0.63 – 7.13) (Table 2). Chi-square test of this relationship showed statistical significance at the 90% level (Mantel–Haenszel Chi-square = 2.34, MH p-value = 0.06). Thirteen of 60 (21.7%) occupationally exposed HCWs with negative baseline, pre-employment TST results converted to a positive TST result when tested following exposure. Among these 13 HCWs, the average time between negative pre-employment TST to positive follow-up TST was 2.8 years (range: 1.2 to 3.2; SD: 2.3).

Post-exposure TST evaluation was recorded for 174 (58%) of 298 exposed HCWs (Figure 1). Among those with documented post-exposure TST (N=174), 112 (37.6%) were TST positive and 62 (20.8%) were TST negative. There were 124 (41.6%) of 298 occupationally exposed HCWs who did not have a recorded post-exposure TST result.

Fifty-three (17.8%) of 298 exposed HCWs were diagnosed with LTBI. A standard 9-month course of therapy for LTBI was prescribed to 49 (92.5%) of 53 HCWs diagnosed with LTBI. Forty-six (93.9%) of these 49 HCWs began therapy for LTBI (Figure 3). Among the 46 HCWs who began therapy for LBTI, eight (17.4%) completed the 9-month course within 12 months. Twenty-two (57.9%) of 46 HCWs beginning treatment for LTBI were lost to follow-up or became non-adherent, including 7 HCWs whose treatment was stopped by the physician. HCWs who were Saudi citizens were 4.9 times more likely to complete therapy for LTBI than non-citizens (p-value = 0.02).

DISCUSSION

We conducted this evaluation study to examine the current practices at KAMC-R as a part of a larger quality improvement initiative. Our study found low rates of pre-employment baseline TST results documented for 298 occupationally exposed HCWs. We also found low rates of starting and poor rates of completion of therapy for LTBI among those exposed HCWs whose therapy was prescribed. Interventions to each of these areas may enhance institutional quality and protect the public's health.

Accurate and complete baseline, pre-employment TST screening of HCWs for LTBI is important to reduce the risk of TB transmission in healthcare settings. A majority of the HCWs in this study were short-term, contract employees from countries the WHO identifies as having a "high TB burden." This emphasizes the importance of a robust baseline, pre-employment TST screening program. TB risk management in the hospital setting can be challenging. Previous studies have identified many challenges that hospitals face to limit nosocomial TB transmission [33]. Confident diagnosis and adequate therapy for LTBI identified in HCWs is regarded as a key challenge [34]. In the United States and Canada, about 15% of those who had positive TST declined treatment and only about half of those who already started treatment for LTBI completed the recommended 6-month or 9-month INH regimen [27, 29-31]. However, compliance with INH prophylaxis among HCWs was shown to be even worse than non-HCWs exposed to TB in other settings [34].

There is evidence in our study of significant lack of compliance with therapy for LTBI. Though most (92.5%) HCWs that were diagnosed with LTBI were prescribed INH treatment; only 16% of them actually completed a full treatment course. We cannot explain reasons for non-adherence to INH in all cases, but information contained in medical records suggests that loss to follow-up was a problem for assessing the effectiveness of post-exposure treatment efforts. Low LTBI treatment rates observed here are consistent with findings reported elsewhere, which indicate that only 18 – 65% of patients, who accept treatment, complete the minimum effective regimen duration of six months [30]. However, in other environments, much lower rates of non-adherence to LTBI treatment have been reported. In a study conducted in the United States of those offered treatment, only 9% declined [27].

It is likely that many HCWs in this study received BCG vaccination as a routine part of their health care; however these data were not available to us [35, 36]. Establishing BCG status can be important for HCW screening efforts and is especially important to diagnostic confidence for both the patient and physician. BCG vaccination may increase the likelihood of false-positive TST results for up to 15 years after vaccination, making it difficult to assess true risk of LTBI based on TST results alone [36]. Nonetheless, some guidelines recommend ignoring the effect of BCG on TST, and in the United States, official guidelines do not include BCG vaccination history in TST interpretation [23].

Despite the proved effectiveness of therapy for LTBI, infected contacts or others diagnosed with LTBI often decline treatment and many who begin treatment do not complete it. Many reasons for poor treatment acceptance and adherence exist. Appropriate use of preventive treatment is highly dependent on the confidence of patients and treating physicians on risk assessment subsequent to TB exposure [37]. Another important factor in LTBI treatment acceptance and adherence is its prolonged course and potential side effects (e.g., hepatotoxicity). LTBI is asymptomatic, its diagnosis is uncertain, and even when diagnosed, LTBI cases may never develop into TB [38, 39]. So, treatment decisions must be weigh potential benefits against possible medication side effects.

Though we did attempt to assess concordance between TST and IGRA testing, this analysis was limited by the fact that IGRA was given as a routine test starting in 2010 for all HCWs in NGHA. However, the absence of BCG status makes it difficult to interpret these results. Still, the preliminary finding that at least 20% of employees who reported having a positive TST test that tested negative on IGRA raises a question that may easily go both ways on relying on either the TST test or the IGRA as the primary means of screening HCWs. Finally, the evaluation of risk and diagnosis of LTBI in the current study appears to have been largely clinical. Only three HCWs with known exposure had a chest x-ray result recorded, a measure that is often routine where a positive TST is noted after TB exposure. Inconsistent use of diagnostics such as labs and imaging may indicate subjectivity on the part of physicians and others in determining diagnosis and recommendations for appropriate follow-up.

Our study is considered unique in bridging the knowledge lack about TB exposure in healthcare setting and adherence to healthcare guidelines in KSA.

Nevertheless, we acknowledge some limitations. They include a large amount of missing data plus a small sample size. These limitations made it difficult to assess trends and to conduct multivariate and stratified analyses. However, while these limitations hinder data analysis and limit the generalizability of the results to other healthcare systems, documenting these data quality challenges are instructive for efforts to improve infection control at KAMC-Riyadh and for other institutions that may experience similar infection control challenges.

RECOMMENDATIONS

To prevent nosocomial transmission of TB at KAMC-Riyadh we recommend complying with the CDC "hierarchy of controls" strategy. This includes administrative controls, engendering controls, and respiratory protection [40]. Most essential, administrative controls are directed to minimize the risk of TB transmission includes mandating pre-employment TB screening for all employees, enforcing evaluation of all HCWs following exposure to active TB case, encouraging the start and completion of therapy for diagnosed LTBI among HCWs, and finally improving documentation and means of follow-up with exposed HCWs. It also includes isolation and treatment of persons with active TB [41].

To improve rates of pre-employment screening for TB, plus to improve the beginning and completion of therapy for LTBI among exposed HCWs at KAMC-Riyadh, we recommend the following steps: establish BCG status of newly-hired HCWs to ensure diagnostic confidence for both the patient and physician and medical records should contain complete information on BCG history, treatment compliance, and reasons for treatment drop-outs. We also recommend raising awareness among patients and physicians on TB exposure risk and the importance of preventive treatment to ensure high compliance with prescribed treatment.

Engineering or environmental controls involve airborne infection isolation, negative pressure rooms, and air filtration. Individual protection measures should include respiratory protection equipment use (N-95 respirators) for HCWs working with TB patients, and general precautions (frequent hand washing) [41]. It is essential to comply with evidence-based guidelines and regulatory requirements and continue research to ensure effective infection control and prevention of TB transmission in healthcare settings [41].

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Table 1; Demographic Characteristics of Healthcare Workers (N=298) Occupationally Exposed to Infectious Tuberculosis Patients at King Abdulaziz Medical City, Riyadh, Saudi Arabia, 2008 – 2010

Age	Mean	Range (years)
Female	38.5	19 – 58
Male	34.2	20 – 56
Overall	37	19 – 58
Gender	**Number**	**%**
Female	176	62.9
Male	104	37.1
Unknown	18	6
Religion	**Number**	**%**
Other	192	70.6
Muslim	79	29
Unknown	1	0.4
WHO Region (Country of Origin)	**Number**	**%**
Western Pacific (WPR)	166	55.7
Eastern Mediterranean (EMR)	71	23.8

Africa (AFR)	18	6
Europe (EUR)	8	2.7
Southeast Asia (SEAR)	7	2.3
Americas (AMR)	2	0.7
Unknown	26	8.8
Citizenship	**Number**	**%**
Non-Saudi	229	76.9
Saudi	44	14.8
Unknown	25	8.3
Occupation	**Number**	**%**
Staff nurse	166	55.7
Respiratory therapist	58	19.5
Physician	15	5
Rehabilitation	1	0.3
Administrative	2	0.7
Unknown	56	18.8
Work Station	**Number**	**%**
Critical care	217	72.8
Non-critical care	44	14.8

Semi-critical care	37	12.4
Employment Type	**Number**	**%**
Contract	228	76.5
SANG/military	44	14.8
Unknown	26	8.7

Table 2: Demographic Characteristics of Healthcare Workers Occupationally Exposed to Infectious Tuberculosis Patients by Pre-Employment Tuberculin Skin Test (TST) Status, King Abdulaziz Medical City, Riyadh, Saudi Arabia, 2008 – 2010

Predictor	Baseline, Pre-employment TST status		
	Negative	Positive	Total
Gender			
Female	42 (49.4)	43 (50.6)	85
Male	18 (47.4)	20 (52.6)	38
WHO Region (Country of Origin)			
Western Pacific (WPR)	41 (46)	48 (54)	89
Eastern Mediterranean (EMR)	8 (88.9)	1 (11.1)	9
Saudi Arabia	6 (75)	2 (25)	8
Africa (AFR)	2 (20)	8 (80)	10
Europe (EUR)	1 (33.3)	2 (66.7)	3
South-East Asia (SEAR)	1 (50)	1 (50)	2
Americas (AMR)	1 (50)	1 (50)	2

Citizenship			
Non-Saudi	54 (47)	61 (53)	115
Saudi	4 (66.7)	2 (33.3)	6
Total	58*	63	121
Employment Status			
Contract	54 (47)	61 (53)□	115
SANG/military	6 (75)	2 (25)	8
Total	60	63	123

**2 missing values*

□PR = 2.12, 95% CI=0.63 – 7.13

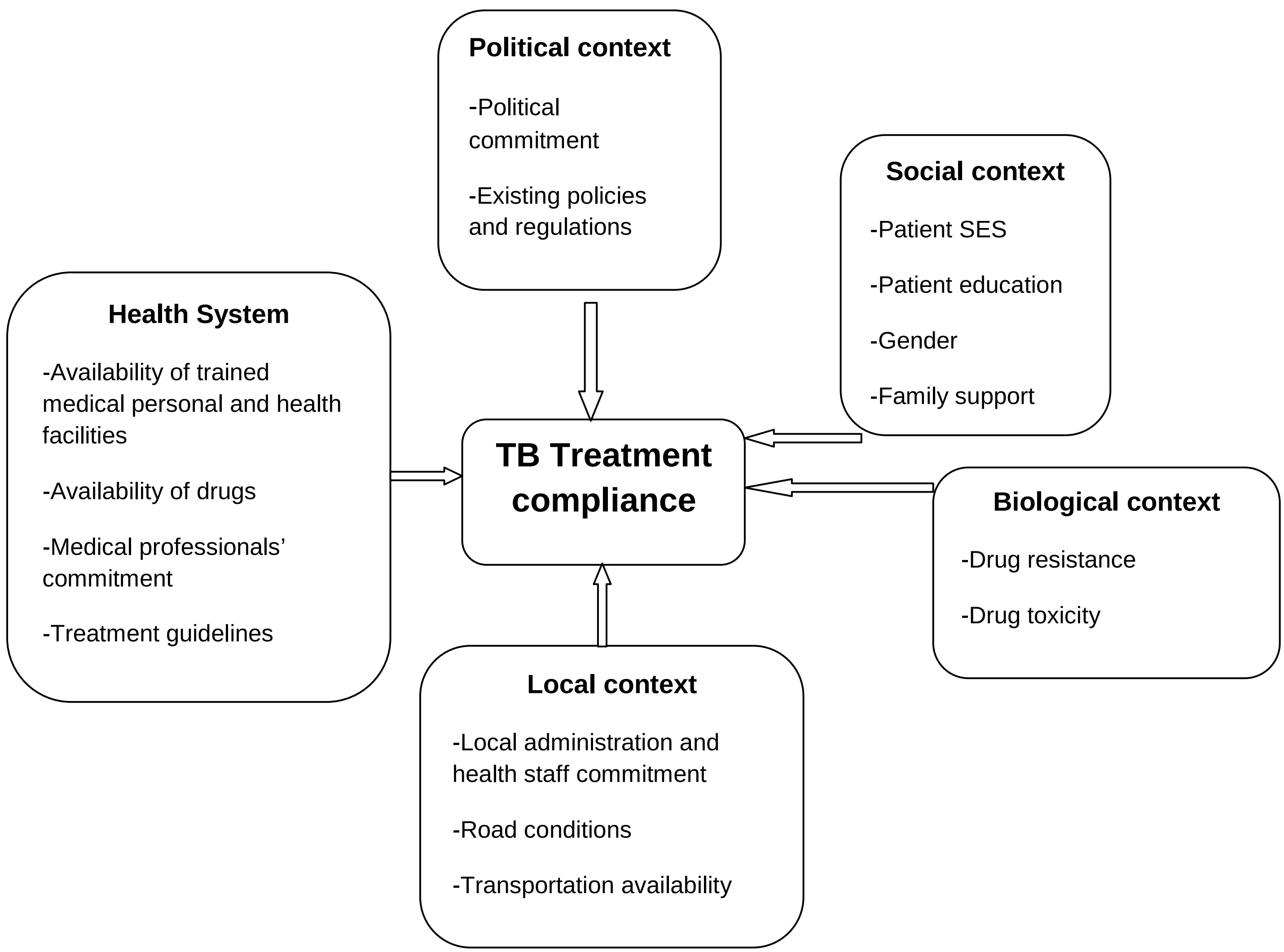

Figure 1: Conceptual framework describing factors contributing to TB treatment compliance

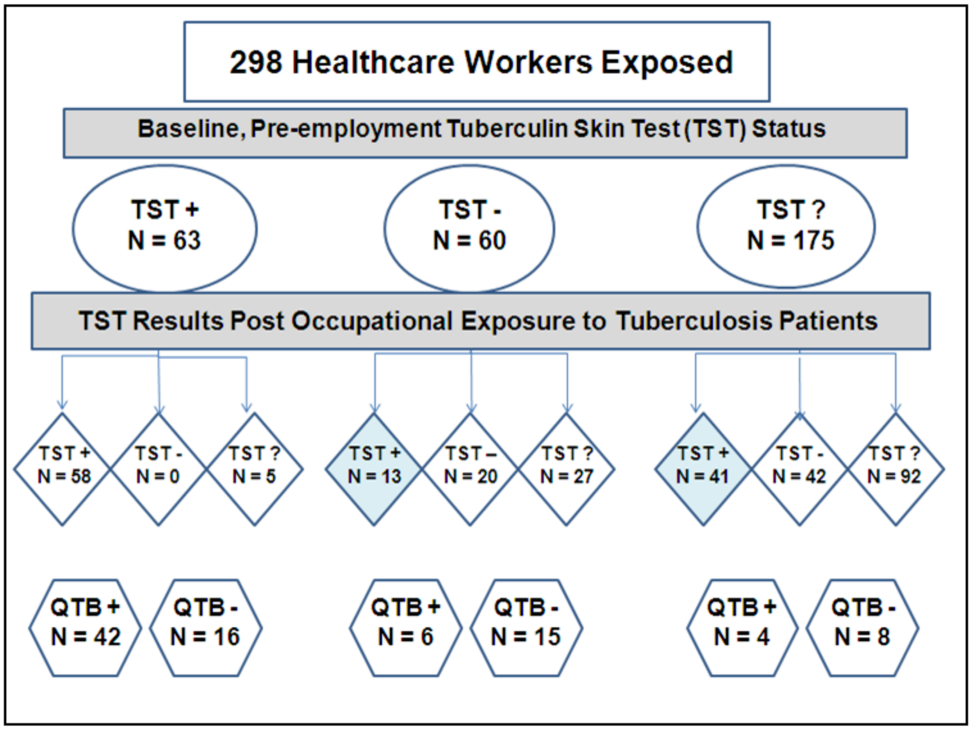

Figure 2: Baseline, Pre-employment Tuberculin Skin Test (TST) Status and Post Occupational Exposure Status of TST and IGRA among among Healthcare Workers (N=298) at King Abdulaziz Medical City, Riyadh, Saudi Arabia, 2008 – 2010

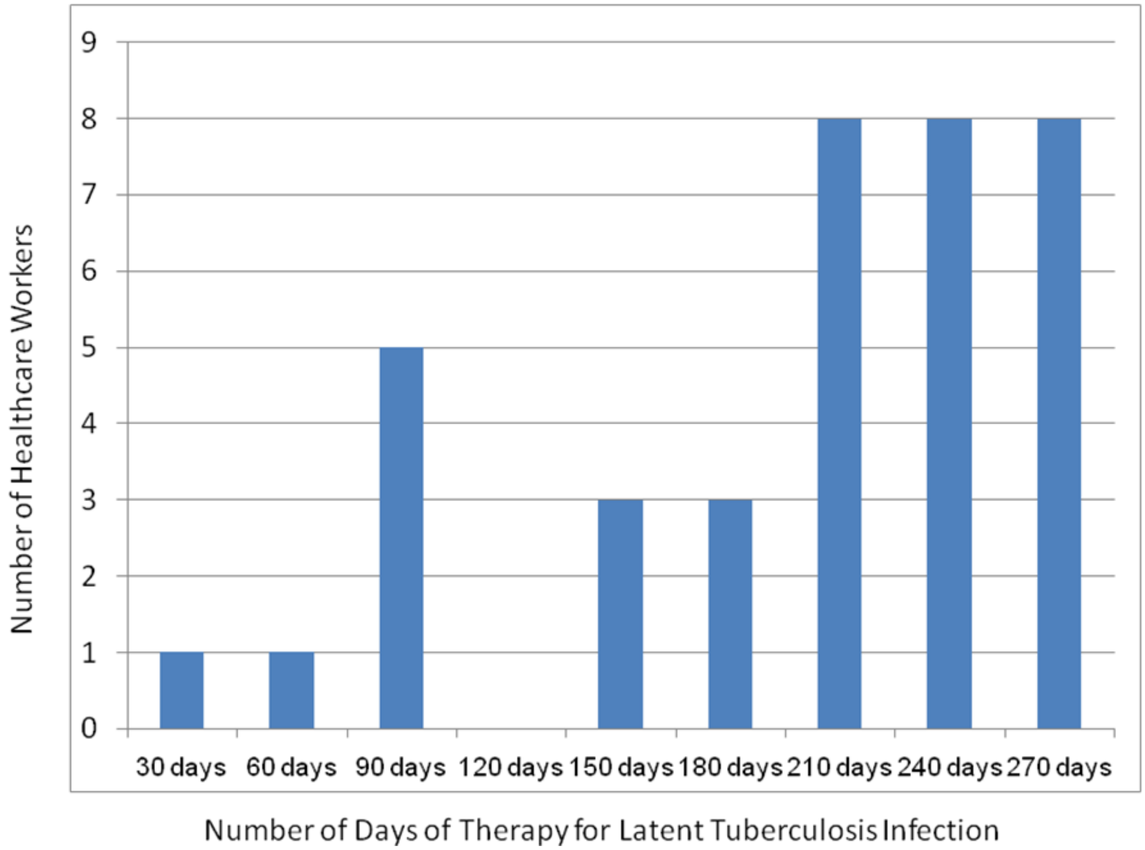

Figure 3: Duration of Therapy for Latent Tuberculosis Infection Among 37 Occupationally Exposed Healthcare Workers, at King Abdulaziz Medical City, Riyadh, Saudi Arabia, 2008 – 2010