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Distribution and Determinants of Tuberculosis among Non-Saudi Residents, Kingdom of Saudi Arabia, 2018

By

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2015

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A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfilment of the requirements for the degree of
Master of Public Health
in Hubert Department of Global Health 2020

Abstract

Background: Tuberculosis (TB) is caused by *Mycobacterium tuberculosis*, affecting the lungs and brain. TB remains a global health problem despite medical interventions to manage its prevalence. In 2018, the World Health Organization (WHO) registered > 480,000 cases of multidrug-resistant TB (MDR-TB). Foreigners in the Kingdom of Saudi Arabia (KSA) are particularly likely to have MDR-TB. These immigrants also increase the prevalence of TB in the country. Previous studies assessed the risk factors and the prevalence of TB in KSA but had gaps.

Methods: This study examined data between January 2018 and December 2018 from the yearly statistical health report. We compared TB rates between Non-Saudi and Saudi residents. The critical variables in the data were residence, nationality, sex, and age. We established five groups based on age and used SPSS and Microsoft Excel (Version 16.30).

Results: Non-Saudis in Jazan reported the greatest TB prevalence and Saudis in Jeddah reported the highest infection rates. Comparatively, Non-Saudis were more susceptible to TB than Saudis. KSA reported the highest TB infection rates in October. Males were also more vulnerable to TB than females. A majority of patients (54.54%) with TB were between 30 and 59. The prevalence rate was the lowest (0.52%) among the citizens aged < four years old.

Discussion: We evaluated 20 regions and documented that non-Saudi residents had a higher TB prevalence than Saudi counterparts. Immigration is a significant contributor to TB in KSA, therefore efforts to eradicate TB should concentrate on non-Saudi males due to the high TB incidence.

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I would like to express my gratitude to my thesis advisor Dr. Scott McNabb for what he has done for me to complete this study.

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Chapter One

Introduction

Tuberculosis (TB) is a highly infectious disease caused by *Mycobacterium tuberculosis*. Typically affects the lungs; TB can attack other areas (e.g., brain, spine, and kidney). Spread through the air when an infected person coughs, sneezes, or speaks and those nearby inhale the air carrying the bacteria (1; 24), the common symptoms are weight loss, night sweats, fever, and general feelings of weakness and sickness. Coughing and chest pain are other signs, particularly the hepatic type (20). TB is detected through skin tests, sputum analysis, and chest X-rays. Factors increasing the risk include IV drug and alcohol abuse, close-contract situations, and chronic illnesses (e.g., diabetes, HIV, and STIs) (20; 24). TB is a dangerous disease because of not only its highly contagious nature but also its ability to kill if no effective treatment is administered promptly.

Even though TB treatment is usually highly successful, the disease remains a major global public-health challenge. Slightly fewer than 10 million new cases are reported yearly with > 1.5 million affected persons succumbing. In 2018, 1.5 of 10 million reported cases resulted in death. Of the total reported cases, 5.7, 3.2, and 1.1 million were men, women, and children respectively, indicating that males are most impacted (27). Even so, the eight million survivors are a testimony that TB treatment is effective. Normally, the disease is treated with a combination of antibiotics (e.g., isoniazid, pyrazinamide, rifampin, and ethambutol) (10; 24). The treatment lasts from six to nine months, with the exact duration dependent on the patient's general health.

Treatment and management has reduced TB incidence rate to 2%/yr; the increasing cases of multidrug-resistant TB (MDR-TB) have reduced the possibility of eradicating it in the near future. In 2018, the World Health Organization (WHO) reported 484,000 new cases of MDR-TB. Even worse, 73% of these cases were MDR-TB which is very difficult and quite costly to

manage (6; 27). Most MDR-TB cases have been successfully treated using second-line drugs; WHO reported > 56% of MDR-TB patients worldwide have been successfully treated. The treatment usually lasts for two years and involves extensive chemotherapy using expensive and toxic second-line drugs (27). Overall, the world has made a significant step in managing MDR-TB.

The Kingdom of Saudi Arabia (KSA) – like many rapidly developing nation-states – struggles with TB which is worsened by immigration. KSA receives millions of foreigners who come as pilgrims, immigrants, and tourists (17). The large number of people visiting or seeking refuge in KSA is occasioned by its rapid socio-economic development. Currently, immigrants number about 12 million/yr; they make up close to one-third of KSA's population. Despite having a huge number of refugees, KSA has managed to reduce its vulnerability to TB and other infectious diseases significantly by raising the living standards of its people and implementing effective health programs, including prevention and treatment (2; 30). Unfortunately, the intense immigration puts KSA at a high risk.

The entry of many foreign nationals into KSA increases the risk of transmission of TB. By 2018, the total population of KSA was 33.4 million people (Saudis comprise 20.8 million and non-Saudis 12.6 million) (30). Non-Saudis are composed of persons from war-torn and poverty-stricken, low-income countries seeking refuge and a better life. Yearly, KSA receives > 1.8 million Hajj pilgrims and > seven million Muslims enter KSA yearly to celebrate Umrah (19). In 2017, KSA had 12.2 million immigrants (2) and > 40 million tourists (23). The influx of foreigners, immigrants from African and Asian countries, and refugees and foreigners increase the risk of TB (28). KSA began providing tourist visas for 49 countries whose citizens can now tour and aims to attract up to 100 million annual visits in ten years (23). This puts KSA at a higher risk of TB (28). Therefore, unless KSA puts in place strict control measures, such as

compulsory TB screening before and after arrival, the cases of the infectious disease could rise significantly.

Saudi and non-Saudi TB cases differ by region, gender, and mortality rate. Overall, the rate of TB cases among non-Saudis is greater than in Saudi counterparts with the former and latter accounting for 27% and 11.5% of all cases (5). The greater TB prevalence among immigrants is attributed to their countries of origin where the disease is poorly managed due to insufficient resources. By administrative region, Riyadh and Makkah account for the greatest portion (70% of all KSA TB cases). Makkah, Jizan, Riyadh, and Northern Province have about 22, 19, 15, and 12 TB-infected cases per 100,000 inhabitants. On the other hand, Al-Madinah, Qaseem, Aseer, and Eastern Province possess 10, 11, 7.1, and 9 cases of TB for every 100,000 residents. Conversely, Najran, Al-Joof, and Tabuk have 8, 6.1, and 11.2 cases of TB per 100,000 inhabitants (5). Al-Baha and Ha'll records show 4.4 and 4 TB cases for every 100,000. About 13.4% of Saudi men and 23% of male immigrants were infected. On the other hand, infected females were 9.7% and 35% for Saudis and non-Saudis respectively (5). Non-Saudis had a mortality rate of 5.4%, while Saudi national mortality rate was 6.4% (4).

Laboratory testing of non-Saudis before and after arriving in KSA for purposes of diagnosing and confirming TB cases is a very important tool for reducing the country's vulnerability to the infectious disease (31). According to WHO, KSA is one country that has witnessed a reemergence of TB. Although the number has reduced from 18 cases per 100,000 in 2000s to 12 per 100,000 in 2018, this is still very high. KSA receives about 600,000 immigrants every year from Africa and Asia. Foreigners come to KSA to fill job vacancies created by a rapidly expanding economy. Besides immigrants, two million pilgrims from other countries come each year to perform the Umrah and Hajj rituals (17). Since KSA receives a high number of foreigners each year with the majority originating from the TB-prevalent nations, testing them before and after arriving is the only way to control the entry of the disease. To ensure immigrants

and visitors do not carry TB into KSA, testing should be performed before they exit their home countries. This may also help prevent the spread of the disease during travel. When they arrive, another examination should be done to re-confirm that the visitors are TB free (17; 31). In case any immigrant is diagnosed, prompt treatment and quarantine should follow to prevent them from infecting others.

Previous research on TB in KSA has been general barely examined specific risk factors, such as immigration. Past studies have also generalized TB cases without specifying the different manner in which the disease affects locals and immigrants. The study by Al-Hajoj and Varghese (2015) looked at TB in KSA in terms of the ups and downs the country has experienced when dealing with the disease (10). On the other hand, Al-Ammari *et* al. (2018) investigated MDR-TB in KSA broadly without exploring the differences between Saudi and non-Saudis (6). There is need for a new study that examines TB in KSA in a more detailed manner, including the effects of immigration.

This project examines TB in KSA with a specific perspective. We explore TB trends among the non-Saudis living in KSA from January 2018 – December 2018. We analyzed TB incidence among immigrants in KSA using records from 20 different regions. This study will provide information that KSA can use to build more cost-effective screening programs in order to evaluate TB incidence rates and trends among Non-Saudis and confirm the impact of controlling TB among Non-Saudis.

Chapter Two

Literature Review

The Global Tuberculosis Pandemic

Tuberculosis (TB) is one of the most critical public health issues of the day. The Global Tuberculosis Report released by the World Health Organization (WHO) in 2019, pointed out that TB infected approximately 10 million people in 2018, with the total number of patients worldwide between 9 million and 11.1 million (25). However, TB prevalence varies widely in different nations. In some countries, there are fewer than five new cases per 100,000 persons per year; while in others, the annual average of newly infected persons can be more than 500 per 100,000 (25). The global average incidence is 130 persons per 100,000 (25).

Apart from prevalence, TB is a top ten causes of death. In 2018, 1.5 million people died because of TB (32). HIV infection is a TB co-infection because it weakens the immune system, making the person more susceptible. An HIV-positive patient with a deficient immune system has greater risk of becoming infected with TB or reactivating it. HIV also shortens the time between exposure to TB and the development of infection. WHO classifies deaths due to TB among HIV-positive and negative persons. In 2018, the global mortality by TB among HIV-negative persons ranged from 1.1 to 1.3 million (21); a decline from 2000 when the figure was 1.7 million. Additionally, the number of TB-related deaths among HIV-positive persons ranged from 223,000 – 281,000 (60% reduction since 2000 when the figure was 620,000) (21).

TB is present worldwide, but the risk of exposure varies among locations. Geographically, the prevalence also varies from region to region. In 2018, South Asia's TB prevalence was 44%, with the greatest number of TB cases globally. Africa had a TB prevalence of 24% and the Eastern Mediterranean had a prevalence of 8% (25). Western Pacific and the Americas had a prevalence of 18% and 3%, respectively (25).

TB in the Middle East

In the Middle East – due to prolonged civil war and continuous movement of refugees – there is considerable risk of disease spread. Expatriates within TB-affected areas rarely benefit from WHO preventive measures (14). TB prevalence in the United Arab Emirates (UAE) has steadily increased since 2010. Its growing incidence, coupled with the influx of expatriates into U.A.E., has become a significant concern (3). Immigrants from TB-affected areas include workers, refugees, and tourists; they contribute to the rising TB burden.

There is much more to do to achieve elimination of TB in the Middle East. A study conducted by NCBI analyzed the mortality, incidence, and MDR-TB rates in 17 countries of the Middle East (14). Data from national surveys and surveillance revealed that to reduce the number of TB cases to fewer than one every 100, 000 persons, a dire need exists for testing and treatment of latent TB infections (LTBI). The risk of developing MDR-TB in the Middle East is high, with an alarmingly high figure of 4.5% MDR-TB cases in the Kingdom of Saudi Arabia KSA (8). In the UAE and Kuwait, the prevalence of MDR was 4%, while Yemen ranked first with a prevalence of 9.5% (8).

Tuberculosis in the Kingdom of Saudi Arabia

KSA has a moderate TB burden. This implies that KSA is not a poor performer, but not the best in combating TB. A recent report revealed the prevalence of TB in Riyadh is 8.5%; Hail is 23.1%; and Makkah 38% (10). Recent health interventions undertaken have significantly reduced the incidence. However, the prevalence TB is considerably high; thus, significant input is necessary to combat it and change the current situation. Data on TB prevalence has been available for several years now. Following the report released by the WHO in 2017, the percentage of Multi-drug Resistant TB (MDR- TB) was 0.51% among new cases (6). MDR-TB increased to 5.5% among those who had received treatment. In this report, 14% – 20% of cases reported with resistance to first-line medication (6). In the past ten years, KSA observed a

notable increase in the notifications of TB (6). Another article reported the rate of smear-positive TB to be endemic among KSA citizens was (44.9% – 50.2%) while among immigrants the rate was greater (52.1% – 62.6%) (16). These rates are greater than the global average (45.5%) (16). However smear-negative reported TB cases in KSA was doing well compared to other regions of the world. The Saudi Centers for Disease Control and Prevention (KSA CDC) reported the total TB incidence in 2017 ranged from 290 – 390 per 100,000 persons. In the same year, new cases were 2.6%, while previously treated cases were 1.7% (16). New and relapse cases were 2,963, with 22% women and 75% men; the total number of notified cases was 3,035 (16). These data show that much needs to be done to improve detection, notification, and timely treatment. However, the increased incidence and prevalence may not necessarily mean an increase in the disease burden, it may have occurred because of intensified diagnostic capabilities and health awareness.

TB incidence, prevalence, and mortality varies widely among the 13 KSA regions; not all have similar TB burden profiles. Some have high incidence, others are not threatened. A study conducted by NCBI in 2014 divided the country into five regions (central KSA, Eastern, Northern, Southern, Northern, and Al-Qurayyat) and investigated severity of TB in these areas (15). The southern region included Najran, Asir Al-Baha, Al-Qunfudah, and Bisha provinces. Makkah and Gizan were also separated since they depicted different results. Makkah and Gizan had high incidences (25.13 and 17.1 per 100,000 respectively) (15). For the past 20 years, TB incidence rates have risen in Makkah. The central region had a notable rise of 6.4% (15). While Jazan had an incidence of 16.5 – 18/100,000; the Southern, Eastern, and Southeastern regions stood at 4 – 9.5/100,000 (15). From these data, the distribution of TB in the featured areas was not uniform (15) because of differences in environmental conditions, population distribution, and demographic variations (i.e., nationality, population size, and population variations).

TB in KSA affects both men and women, and the rate of infection is greater among young males, especially those with TB history. In a recent study, the total number of TB cases from 2014 through 2015 was 6,753 (9). Another study found the mean age of reported cases was 36.6 (±15.9) (6). Males represented 69.1% of the total number of reported cases (6). High prevalence among males is the probable due to the lack of adherence to medication. Females have a greater likelihood of developing RR-TB and MDR TB (6). Females are 2.21 times more likely to have MDR-TB and 1.78 times greater susceptible to RR-TB (6). This implies that, upon poor drug adherence, women are more likely to develop MDR-TB compared to men.

Nationality affects the rate of TB infection and prevalence in KSA. The KSA Central Department of Statistics approximated one-third of the KSA population represented immigrant workers from TB-endemic countries. From 2000 to 2009, the annual TB incidence rate ranged from 11/100,000 – 16/100,000 (21). In a study conducted in 2014 in the KSA among 524 samples analyzed from immigrants, 75% showed positive TB results (9).

In 2014, an increased TB incidence among children and the elderly was presented (7). Children < 15 years of age had an incidence of 1.8 – 2.8/100,000 (7). The low-incidence rate was associated with 97% BCG coverage (7). The elderly had a high TB incidence (27 –37 per 100,000). This higher rate was associated with activation of latent TB (11). In a national TB survey done with the tuberculin skin test, 45% of adults aged 25 – 35 reported positive (18). For the people above 45 years, the rate was 60% (18). The large pool of latent TB is the suspected cause of active TB among adults, which, in turn, explains the high incidence among adults as compared to children (11).

TB is a significant health problem for community health workers (CHWs) (32). Both healthcare providers and practitioners are at risk since they come into direct contact with TB patients (17). A study conducted in collaboration with different universities in KSA investigated the prevalence of latent TB among healthcare workers in the four largest tertiary-care institutions

in Riyadh (3). It studied 2,650 recently employed healthcare workers (14.9% were physicians and 12.9% were nurses) (3). Of the total, 291 (11%) tested positive (3). This implied that there was no difference between male healthcare workers and their female counterparts (15).

Examining trends of TB morbidity is an essential part of program monitoring and evaluating and guides policymakers to implement effective programs (12). Annually three million people die because of TB; among these, one thousand are citizens or residents of KSA (4). Even though WHO has a target of 85% elimination of TB, KSA has yet to meet it. In a recent (2018) study published by NCBI – among 291 patients who had different types of TB – 85.9% successfully recovered and discharged (13). The remaining 14% succumbed after staying in the hospital for 1.87 months (13). In this study, the TB mortality rate was lower than that in the past. In 2018, WHO found out that the fatality ratio (estimated mortality/estimated incidence) of TB in KSA was 23% (26). This included a mortality ratio of 2.3 in HIV-negative TB patients and 0.02 in HIV-positive counterparts (26). Over the years, the mortality rate due to TB has diminished, but not yet achieved global targets.

HIV is one risk factor that affects TB. Due to compromised immunity, people living with HIV are more likely to contract TB compared to those with normal immunity (32). In a 10-year study conducted by King Faisal Specialist Hospital and Research Centre in Riyadh, the TB incidence rate among people infected with HIV was 1354/100 000 (32). These data show that an individual living with HIV is more likely to contract TB. In another study, the authors concluded that due to the incomplete TB reporting in KSA; TB prevalence was at least thirty times in people living with HIV compared to the rest of the population (29).

The KSA National TB Control Program (NTP) directs TB surveillance, diagnosis, and treatment. Dedicated to eradicating TB, the two main chest-specialization hospitals are in Riyadh and Taif (4). They manage and treat all chest-related diseases and work as referral facilities for chest-related problems. Although any healthcare facility can identify TB patients, chest

specialists perform diagnosis and give drug prescriptions (5). While patients are treated in specialized hospitals, their follow-up treatment is entrusted to general practitioners in the primary health centers (PHCs). PHCs also undertake surveillance and refer patients for diagnostic purposes (5). TB surveillance, diagnosis, and treatment should be intensified in KSA. Bearing in mind that it receives millions of pilgrims and tourists from different parts of the globe, control of TB is of utmost importance, as the world strives to combat this menace.

TB drug resistance (MDR-TB) is the ability of the bacterium to resist rifampicin and isoniazid, which are the most effective anti-TB pharmacologics. In KSA, there have been reports of strains of TB that have resisted these drugs (6). A cohort study on the cases reported to NTCP during 2014 – 2015 investigated 2,098 TB confirmed cases; among these, 4.4 % of the patients had MDR-TB (32). In general, KSA's national data on MDR-TB incidence corresponds to data released by the WHO.

In KSA, the incidence, distribution, and control of TB are influenced by immigration and mass gatherings. The other most common risk factor is HIV infection (29). A 10-year study conducted by King Faisal Specialist Hospital and Research Centre in Riyadh discovered that the TB incidence rate among those co-infected with HIV was 1354/100 000 (32). The influx of foreigners to KSA is another factor leading to its spread. There are many legal and illegal immigrants (e.g., from Pakistan, Africa, Kazakhstan) (7). Finally, the risk of contracting tuberculosis increases with age (22).

TB spreads quickly during mass gatherings since it is airborne. Each year, millions gather in Makkah and Medina to celebrate Hajj and Umrah (10). Hajj is the most revered pilgrimage to Makkah, and the visit to Medina, which is considered a holy city by the Islamic communities, gathers approximately three million Muslims from different parts of the globe. Muslims perform Umrah as a ritual at any time of the year by making a trip to the holy cities, which gathers close to seven million foreigners annually (10). These celebrations and rituals with the influx of people

from different parts of the globe cause congestion that translates to a higher risk of infection. Most pilgrims are from the countries where TB is endemic (e.g., Asia and Africa) cause an increase in new TB infections (7). This translates to a rise in the TB disease burden in KSA as well as the whole world since those infected are locals and foreigners. Therefore, these celebrations have become among the paramount factors that affect the spread of TB in KSA.

Movement of people from one place to another is a significant contributor to the increase in the burden of disease not only in KSA but also globally. Once restrictions were on foreigners visiting KSA and only pilgrims had permission to enter the nation (10). However, KSA has opened up for tourism and began issuing visas to tourists from all over the world. Due to the tourism, there is a likelihood that foreigners will rapidly increase. The impact of this influx and a growing movement to and from KSA may increase the risk of infectious illnesses (10). As a result, KSA should initiate and intensify TB screening in all the entry points, such as airports and border posts (5).

The government of KSA has a significant responsibility to ensure that it meets the WHO targets of eradicating TB. However, it must take several steps to achieve that objective. Ensuring that all the children obtain a BCG immunization is among the most effective ways to eradicate the disease. This strategy has been effective in areas of the world where TB is endemic (5). Early detection and treatment of new cases enables a reduction in the spread of the disease (27). Continuous public health education and sensitization are other means so that the public will have essential details concerning modes of transmission, drug adherence, and ways to prevent TB (25). Continued surveillance is also necessary for detecting new cases, which will enable the ministry of health to introduce strategies targeting constantly affected regions. All the public places need to be well aerated to ensure that there is freely moving air. Moreover, treatment should be available to everyone. Moreover, TB testing services should be accessible at any time of the day, and the health department should immediately enroll any citizen diagnosed with TB.

Chapter Three: Manuscript

Abstract

Background: Tuberculosis (TB) is caused by *Mycobacterium tuberculosis*, affecting the lungs and brain. TB remains a global health problem despite medical interventions to manage its prevalence. In 2018, the World Health Organization (WHO) registered > 480,000 cases of multidrug-resistant TB (MDR-TB). Foreigners in the Kingdom of Saudi Arabia (KSA) are particularly likely to have MDR-TB. These immigrants also increase the prevalence of TB in the country. Previous studies assessed the risk factors and the prevalence of TB in KSA but had gaps.

Methods: This study examined data between January 2018 and December 2018 from the yearly statistical health report. We compared TB rates between Non-Saudi and Saudi residents. The critical variables in the data were residence, nationality, sex, and age. We established five groups based on age and used SPSS and Microsoft Excel (Version 16.30).

Results: Non-Saudis in Jazan reported the greatest TB prevalence and Saudis in Jeddah reported the highest infection rates. Comparatively, Non-Saudis were more susceptible to TB than Saudis. KSA reported the highest TB infection rates in October. Males were also more vulnerable to TB than females. A majority of patients (54.54%) with TB were between 30 and 59. The prevalence rate was the lowest (0.52%) among the citizens aged < four years old.

Discussion: We evaluated 20 regions and documented that non-Saudi residents had a higher TB prevalence than Saudi counterparts. Immigration is a significant contributor to TB in KSA, therefore efforts to eradicate TB should concentrate on non-Saudi males due to the high TB incidence.

Methods

TB is one infectious diseases in the Kingdom of Saudi Arabia (KSA) that requires mandatory notification. Every new TB case in primary health centers or hospitals are reported to the National TB Control Program (NTP) in the Ministry of Health from all regions. Gathered data are sorted, organized, and distributed inside the yearly statistical health report. In this study, we focused on TB data for the period from January 2018 to December 2018. We started this study by comparing the TB incidence rates of Saudis with Non-Saudis to confirm the importance and impact of controlling the TB among Non-Saudis. TB information included age, sex, nationality, and area. TB frequency was determined dependent on Non-Saudis' information from the Branch of Statistics and Information, Ministry of Economy and Planning. The Non-Saudi residents' information was analyzed for different regions. For this study, we focused only on Non-Saudis who lived in twenty regions: Riyadh, Makkah, Jeddah, Taif, Madinah, Qasim, Eastern, Alahsa, Hafr albatin, Aseer, Bishah, Tabouk, Hail, Northen, Jazan, Najran, Al-bahah, Al-jouf, Qurayyat, and Qunfudah. TB trends were analyzed for five different age groups of Non-Saudis. When analyzing the TB incidence trends by age groups, we divided them into five categories (from zero to four years, from five to fourteen, from fifteen to twenty-nine, from thirty to fifty-nine, and from sixty and above). All analysis and calculations were done by using Excel (Version 16.30) and SPSS for t-test.

Ethical Considerations

This study was based on secondary data analysis without personal identifiers. Therefore, it did not meet the category of human subject research and was reviewed by Emory‘s IRB.

Results

The study examined the incidence of TB by region. Analysis among non-Saudis revealed that Jazan had the highest incidence rate, with nearly double the incidence rate of second-placed Qurayyat region. The Madinah and Al-Jouf regions had the two lowest incidence rates (Figure 1). Among Saudis, Jeddah had the highest incidence rate, followed by Jazan. Tabouk and Hail regions had the lowest TB incidence rates among Saudis (Figure 2).

Incidence by Region and Nationality

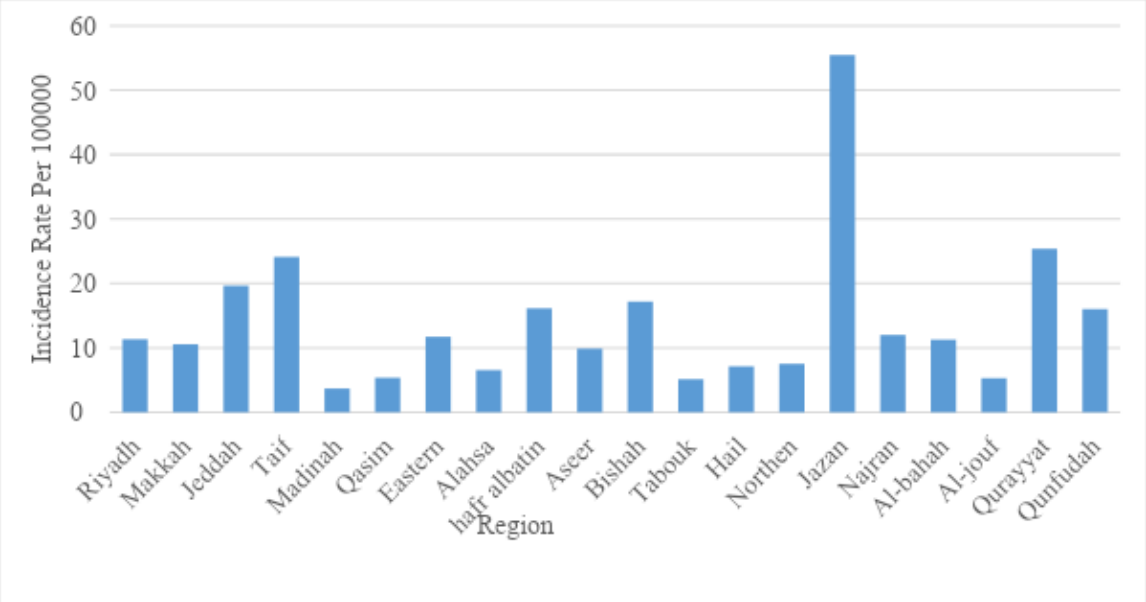

Figure 1: Incidence Rate of Reported Tuberculosis Cases among Non-Saudis, by Region, 2018

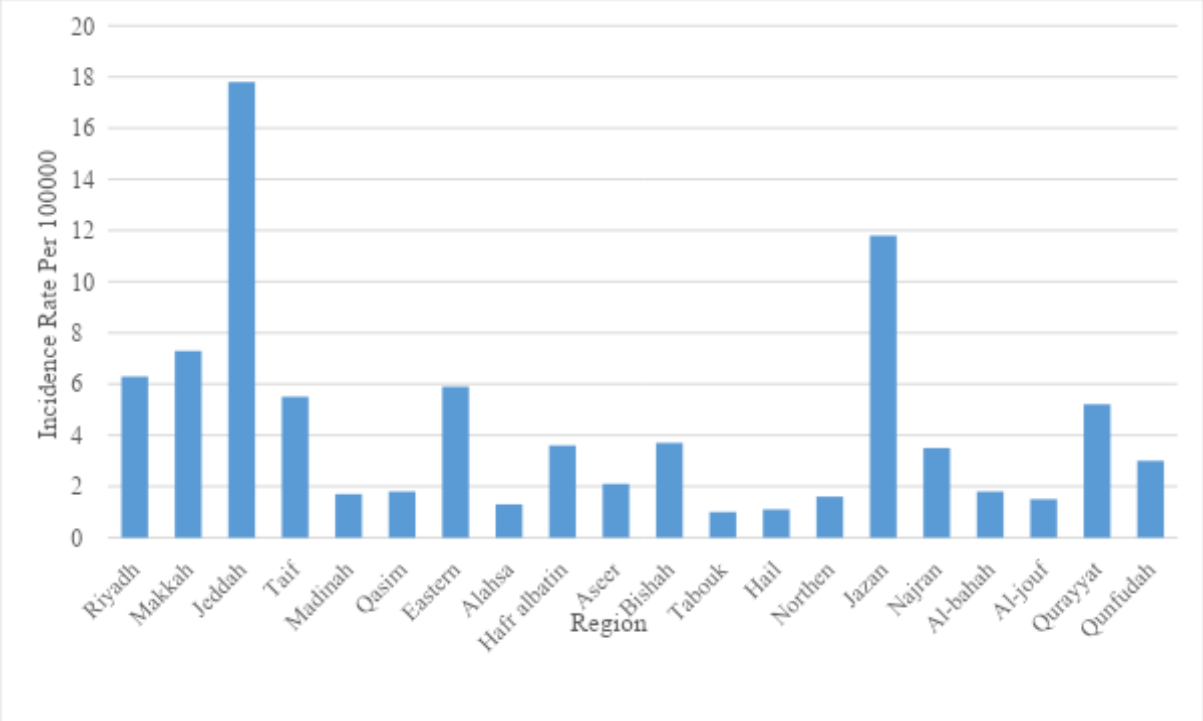

Figure 2: Incidence Rate of Reported Tuberculosis Cases among Saudis, by Region, 2018

The incidence rate between Saudis and non-Saudis were compared across the twenty regions. There are definite variations in the incidence of TB across the regions for both Saudis and non-Saudis. In all regions, the prevalence of TB among non-Saudis is higher than that for Saudis (Figure 3). The patterns of the incidence across the twenty regions states follow almost similar patterns. In areas where the TB prevalence for Saudis is low, the TB prevalence of non-Saudis is also low. The trend is repeated in regions that have a high incidence of TB. Jazan, Taif, and Jeddah stand out as the areas with the highest overall prevalence of TB.

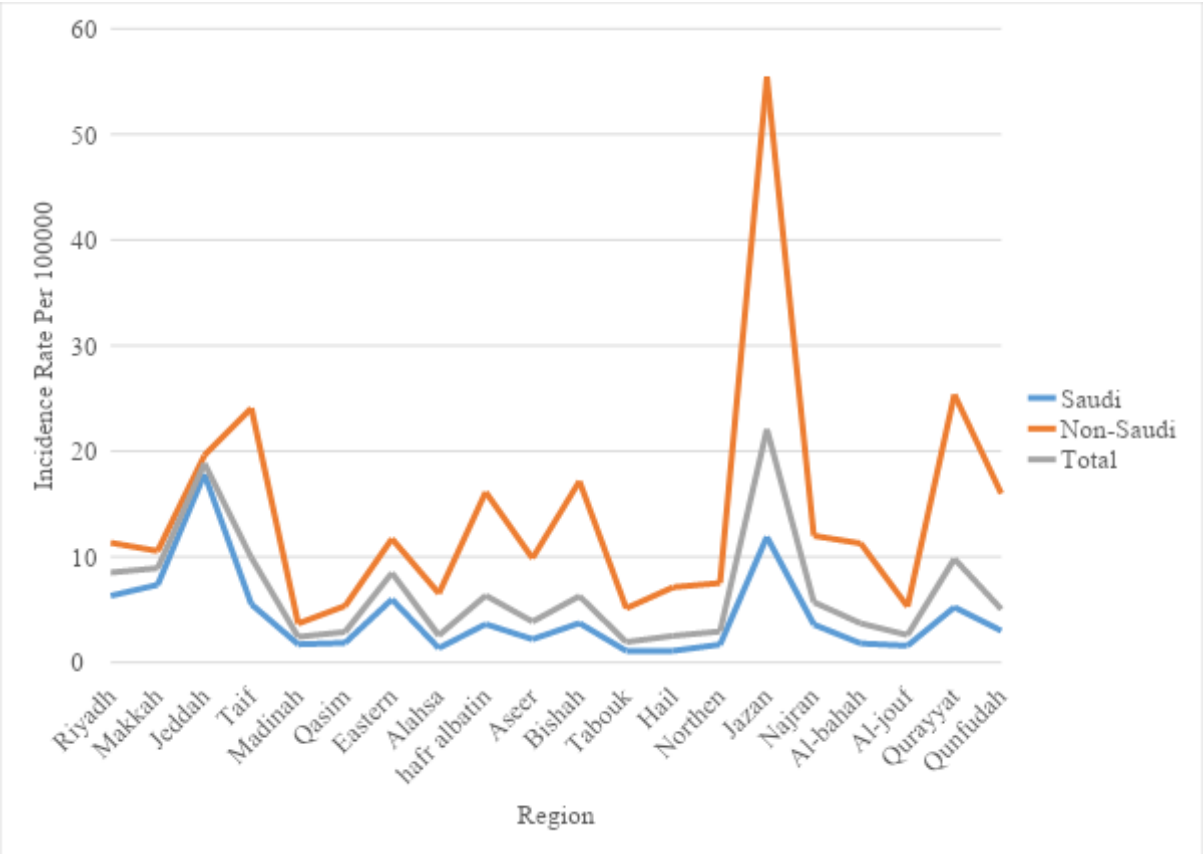

Figure 3: Incidence Rates of Reported Tuberculosis Cases between Saudi and Non-Saudi Residents, by Region, 2018

A paired sample t-test with alpha set to 0.05 was used to compare the mean incidence rates for Saudis and non-Saudis across the twenty regions. The mean incidence rate for Saudis (M= 4.36, SD=4.15) was lower than the mean incidence rate for non-Saudis (M=14.01, SD=14.01). Hypothesis testing revealed that the corresponding p-value (2-tailed) was less than 0.05. Thus, the difference in the mean incidence rate between Saudis and non-Saudis is significant, t (19) =-4.52, p<.05 (Table 1).

Table 1: Comparison of Mean Tuberculosis Incidence Rates between Saudis and non-Saudis, 2018

	Saudis	Non-Saudis
Mean	4.375	14.01
Variance	17.30197	133.282
Observations	20	20
Pearson Correlation	0.619895	
Hypothesized Mean Difference	0	
Degree of Freedom	19	
t Stat	-4.51578	
P(T<=t) one-tail	0.000118	
t Critical one-tail	1.729133	
P(T<=t) two-tail	0.000237	
t Critical two-tail	2.093024	

Monthly Trends

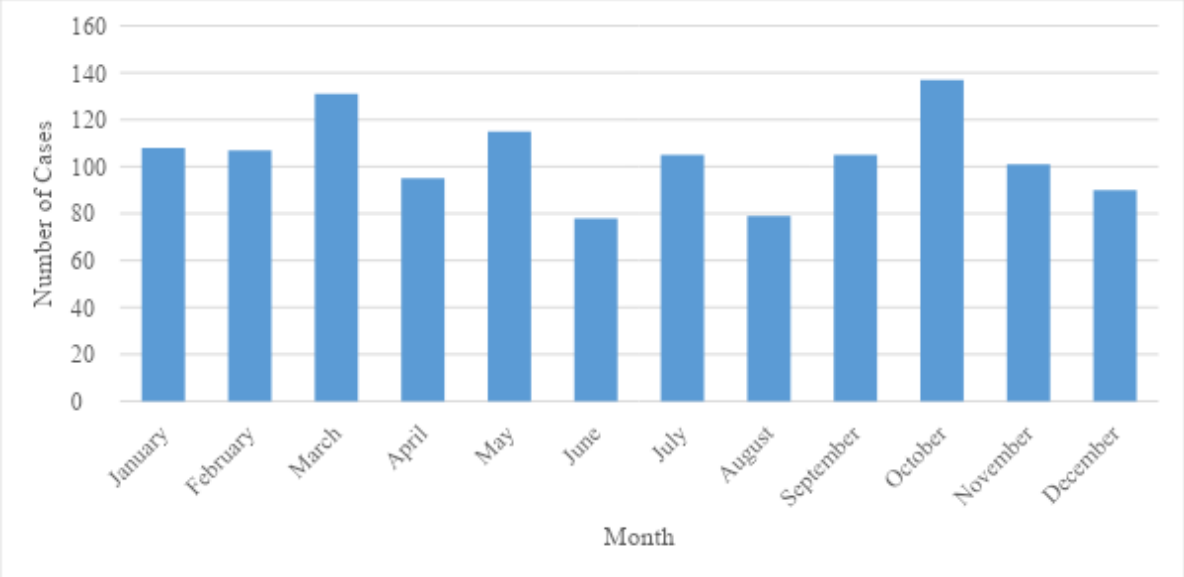

Figure 4: Monthly Number of Reported Tuberculosis Cases among Saudis, 2018

In each month, at least 78 cases of TB were reported among Saudis. At least 100 TB cases were reported in seven months among Saudis. March and October had the highest

incidents of TB among Saudis. The least number of TB cases was reported in June and August (Figure 4).

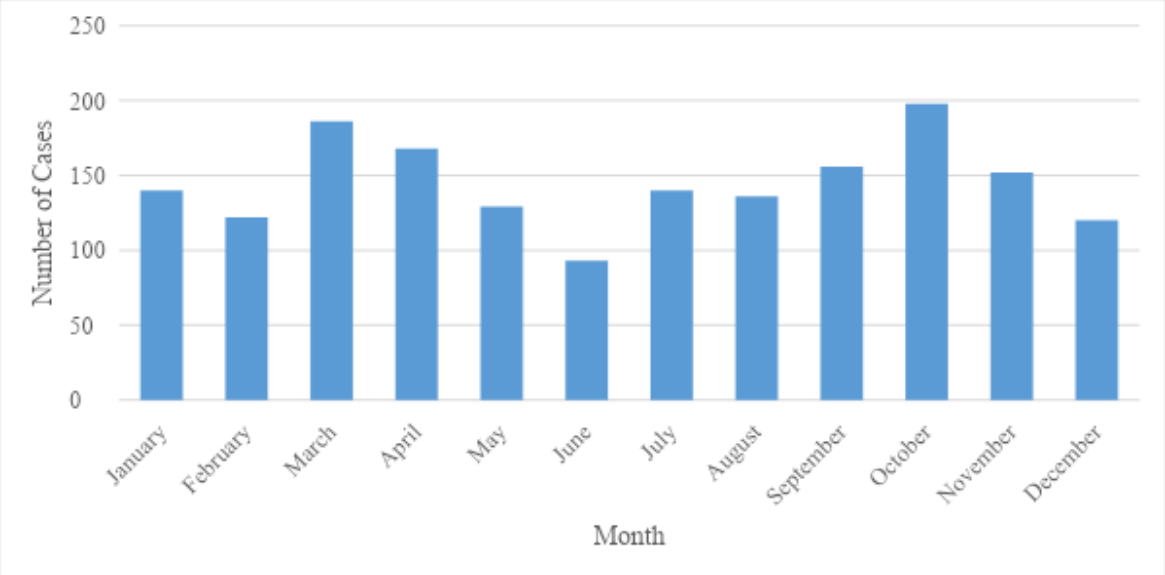

Figure 5: Monthly Number of Reported Tuberculosis Cases among non-Saudis, 2018

All but one month had more than 100 cases of TB among non-Saudis. October and March had the highest number of TB cases among non-Saudis. June had the least TB cases (Figure 5).

The monthly trends in TB cases between Saudis and non-Saudis are presented in Figure 6. October and March are associated with the highest reported cases for both Saudis and non-Saudis. June had the lowest number of TB cases.

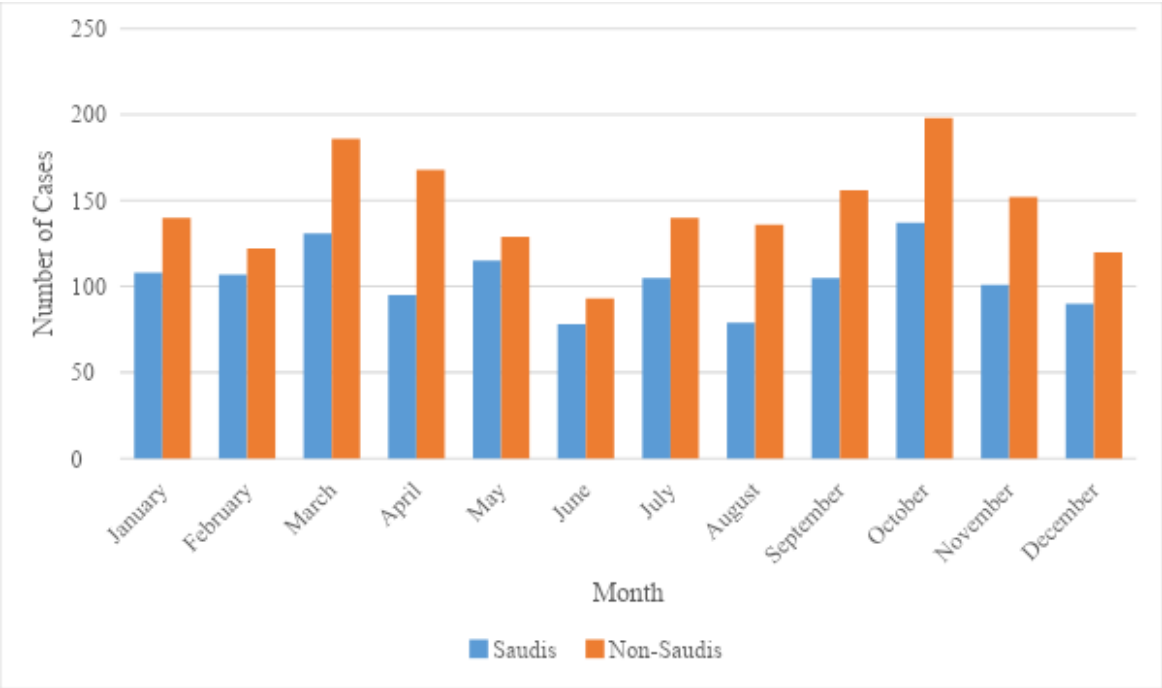

Figure 6: Comparison of Monthly Number of Reported Tuberculosis Cases between Saudis and Non-Saudis, 2018

Gender

A monthly breakdown of the TB cases among non-Saudis revealed the existence of considerable gender differences. In all 12 months, the number of TB cases was higher among males compared to female non-Saudis (Figure 7). However, the trends in TB cases among male and female non-Saudis appear to be following the same pattern with two peaks around March and October.

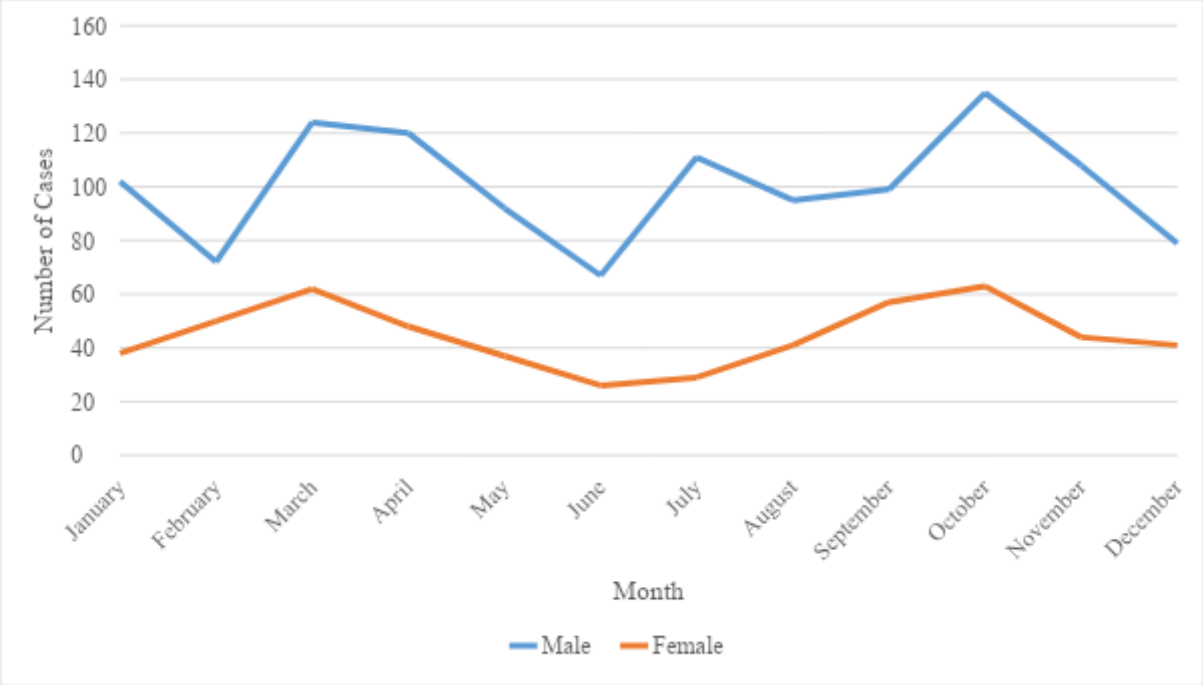

Figure 7: Monthly Trends in Reported Tuberculosis Cases between Male and Female Non-Saudis, 2018

Paired sample-test was used to test the mean gender difference in the number of TB cases reported in a month among non-Saudis (Table 2). The results revealed that there was an average of 100 TB cases among men and 45 TB cases among women per month. Hypothesis testing revealed that the difference in the mean of TB cases between women and men was significant, $t(11) = 11.21$, $p < .05$. Thus, the findings show that there are significant gender differences in the number of TB cases.

Table 2: T-test for Gender Differences among Reported Tuberculosis Cases, 2018

	Male	Female
Mean	100.3333	44.66667
Variance	435.697	141.1515
Observations	12	12
Pearson Correlation	0.566126	
Hypothesized Mean Difference	0	
Degrees of Freedom	11	
t Stat	11.20716	
P(T<=t) one-tail	1.17E-07	
t Critical one-tail	1.795885	
P(T<=t) two-tail	2.34E-07	
t Critical two-tail	2.200985	

Age

Table 3: Breakdown of Reported Tuberculosis Cases, by Age Group, 2018

Age group	Total	Percentage
0-4	32	1.84%
5-14	9	0.52%
15-29	642	36.90%
30-59	949	54.54%
60 and above	108	6.21%

Table 3 shows the distribution of TB cases across four age groups. The incidence of TB cases was highest in the 30 – 59 year age group. The group had 949 cases, which represented more than half (54.54%) of all TB cases. It was followed by the 15-29 years age group, which contributed 36.9% of the TB cases. The age group with the least number of TB cases was the

5-14 years age group. It was responsible for less than 1% of the TB cases. The bulk of the TB cases (more than 90%) affect people between the ages of 15 year and 59 years. Hypothesis testing was not conducted to determine the relationship between age group and the number of cases due to the lack of enough data points.

Discussion

There was a difference in the incidence of TB among Saudi and non-Saudi residents. By conducting the tests in 20 regions, we established that in all areas, non-Saudis exhibited a higher TB prevalence than their Saudi counterparts. The regions of Jazan, Taif, and Jeddah had the highest prevalence of such cases. A paired t-test with an alpha of 0.05 places the mean incidence rate for Saudis at M = 4.36, SD = 4.15, while for non-Saudis it is M = 14.01, SD = 14.01. The rate of TB incidence among non-Saudis is at least three times higher compared to local citizens.

In addition, such factors as gender, age, and time of the year impact results. For instance, there is a significant difference in the incidence reports depending on gender. More males are recorded to develop TB as compared to females. Also, the yearly trend of incidence indicates peaks in March and October for both locals and non-Saudis. Finally, the TB cases varied with age; it was recorded the highest incidence of the disease among the patients aged between 30 to 59 years.

The regions that recorded a high number of incidences among non-Saudis had an equally high frequency of the disease among the Saudis. Similarly, areas with fewer TB cases exhibited the same trend. The results can be justified by the fact that it is a contagious disease. Therefore, measures set to control the prevalence of TB among non-Nationals will come in handy in reducing the overall rates in KSA. Additionally, all actions should be targeted at males more since the number of occurrences is significantly higher among men. Besides, the authorities implement the policies throughout the entire year, but more attention should be put on March and October as these months record in the highest incidence of the disease.

Similar studies came to the conclusion that the prevalence is higher among non-Saudi residents (16). Also, the influx of people from other countries to the Kingdom is a significant contributor to the rising number of cases (10). Therefore, the government should enforce stringent screening measures to curb further increase in incidences. With the recent opening of

the borders to not only pilgrims but also tourists and expatriates, the country needs to implement more preventive measures than before. The study contributes to the existing pool of knowledge by dissecting the cross-section of both the locals and non-Saudis in terms of gender, region, and age. The results will help direct government initiatives to the right people and in the proper amount. The regional gender cross-section of non-Saudi TB incidence is an improvement which past studies lacked. Authorities should investigate the reasons for the high incidences in Jazan, Taif, and Jeddah and suggest appropriate measures.

The study relied on the data that was already collected. However, the trends have changed over the past two years. Such factor as diversification of the Saudi economy to accommodate more foreign interactions may contribute to the gap. The study was also limited by the inability to trace the data on rates of foreigner-local interactions. It would help to draw a direct correlation.

Chapter Four

Conclusion and Recommendations

The Jazan region had the highest TB incidence rate among non-Saudis and the second highest among Saudis. Jeddah had the highest TB incidence rate among the Saudis. Tabouk and Hail regions had the lowest incidence rates among Saudis, whereas Madinah and Al-Jouf regions had the lowest rates among non-Saudis. In all regions, the prevalence of TB among non-Saudis is higher than that for Saudis. Jazan, Taif, and Jeddah stand out at the regions with the highest overall prevalence of TB. The mean TB incidence rate for Saudis (M= 4.36, SD=4.15) was significantly different from the mean TB incidence rate for non-Saudis (M=14.01, SD=14.01), $t(19) = -4.52$, $p<.05$. Whereas Saudis record at least 78 cases of TB monthly, non-Saudis record at least 100 cases in all but one month. March and October have the highest TB incidence among both Saudis and non-Saudis. June has the lowest number of TB cases. In all 12 months, the number of TB cases was higher among males than female non-Saudis. The difference in the mean monthly TB cases between women (M=44.67) and men (M=100.33) was significant, $t(11) = 11.21$, $p<.05$. There were also considerable differences in the number of TB cases by age group with the 30-59 years age group having 54.54% of all the cases.

The findings with specific emphasis on their convergence or divergence with the knowledge on TB trend and their implications for the control of TB. The finding suggests that age group, season, nationality, and gender may be influential on the incidence of TB.

Therefore, future studies can focus on researching various activities in different regions, such as exhibitions and pilgrimages, where more direct interaction occurs. In such way, a direct correlation between the disease's incidence among foreigners and locals can be deduced, which

can help with policy development. The government should focus more on researching the activities that expose citizens to the disease and prevent their spreading by enforcing strict policies.

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