Changing epidemiology of tuberculosis detected by an 8-year retrospective laboratory study in a tertiary teaching hospital in central Saudi Arabia

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ABSTRACT

الأهداف: دراسة التشخيص المختبري لمرض السل وربط النتائج بعلم الأوبئة

الطريقة: أجريت الدراسة الإستعادية في قسم الأمراض/ علم الأحياء الدقيقة في مستشفى الملك خالد الجامعي في المملكة العربية السعودية بمدينة الرياض خلال الفترة ما بين يناير 2003م إلى ديسمبر 2010م. وتم استرجاع بيانات النتائج المختبرية من نظام المعلومات التابع للمستشفى. بعد دراسة 9،405 عينة وتلوينها من قبل زيل نلسن (ZN) وصبغة اورامين رودامين تم بعد ذلك زراعتها في مستنبتات وسط باكتيك 960 السائل ووسط لونستين–جنسن الصلب .وقد تم التمييز بين مجموعات المتفطرة السليّة والمجموعات الغير متفطرة سليّة عن طريق استخدام وسائط بروبتك بي. وفي هذه الدراسة تم تحديد المتفطرة البقرية عن طريق حساسيتها لمادة (TCH) وقد تم فحص الحساسية بالمضادات الحيوية عن طريق مراسم حساسية إم. جي .أي. تي 960.

النتائج: ما مجموعه 568 أي مايساوي (6%) عينة عزلت فيها مجموعة المتفطرة السليّة من بين هذه كان هناك (87%) من مرضى السعوديين المصابون بالسل بمعدل 55.6/ لكل000، 100 شخص. وجدت في هذه الدراسة علاقة مباشرة بين زمن نمو البكتريا الايجابي في الوسط السائل وعبء لطاقة العصبيات المقاومة للحمض. في هذه الدراسة كانت الغالبية العظمى من المرضى الذين وجد فيهم النمو الايجابي في فئة من العمر18 ـ 35 عاماً وبلغت نسبة المقاومة المتعددة للعقاقير (0.7%) .

الخاتمة: تعد الغالبية العظمى من المرضى الذين عانوا من مرض السل في هذه الدراسة سعوديون بنسبة (87%) بمعدل 55.6 من بين 100,000 شخص. وكانت هناك زيادة ملحوظة في حالات السل في الفئة العمرية الأصغر من 18ـ 35 عاماً .وقد بلغت نسبة مقاومة مجموعة المتفطرة السليّة للايزونيازد 10.6% و ريفامبيسين 1% وإيثامبوتُول 8-2% ، وستربتوميسين 6%.

Objectives: To study the laboratory diagnosis of tuberculosis (TB), and relate the findings to its epidemiology in central Saudi Arabia.

Methods: This retrospective study was carried out at the Department of Pathology/Microbiology, King Khalid University Hospital, Riyadh, Kingdom of Saudi Arabia between January 2003 and December 2010. Data were retrieved from the hospital information system on laboratory findings. After adjustment, 9,405 specimens were studied. The specimens were stained by Ziehl-Neelsen (ZN), auramine-rhodamine, and cultured in Bactec alert 960, and Lowenstein-Jensen media. *Mycobacterium tuberculosis* (*M. tuberculosis*) complex and non-tuberculous mycobacteria were differentiated by ProbTec system and p-nitrobenzoate medium. The BACTEC MGIT 960 SIRE kit was used for susceptibility testing.

Results: A total of 568 (6%) specimens grew *M. tuberculosis* complex, and 87% were from Saudis with an incidence rate of 55.6/100,000 of TB. Time to positive growth in the Bactec liquid medium was directly related to the acid fast bacilli smear load. Most of the positive patients were from the 18-35 years age group. The percentage of multidrug resistance was 0.7%.

Conclusions: Most patients (87%) were Saudis showing an incident rate of 55.6/100,000. An increase of TB cases was noticed in the 18-35 age group. Resistance to isoniazid was 10.6%, 1% to rifampicin, 2-8% to ethambutol, and streptomycin was 6%.

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The World Health Organization (WHO) estimates that one-third of the world population is infected with *Mycobacterium tuberculosis (M. tuberculosis*).[1] Different rates of *M. tuberculosis* disease are encountered in all countries (Executive Summary WHO Report 2013).[2] The disease results in approximately 9 million new cases, and 1.7 million deaths each year, making it the leading killer from a single infectious disease in adults.[2] The highest percent of these cases occur in 22 low income countries.[3] The problem of tuberculosis (TB) has been complicated in the last 3 decades by co-infection with human immunodeficiency virus (HIV), and the development of multidrug resistant strains of *M. tuberculosis*.[4] The epidemiology of TB has been affected by factors like HIV infection, and development of diagnostic tests that assist in the laboratory confirmation of clinical diagnosis. In spite of the profound development in the Kingdom, improvement in the standard of living and standard of public health, use of at birth Bacillus Calmette-Guérin (BCG) vaccination, and active case-finding and treatment, TB is still prevalent in the Kingdom of Saudi Arabia (KSA) with an incidence rate of 22 per 100,000 population, as reported in a study on extrapulmonary TB in the year 2009 .[5] The role of the laboratory in the diagnosis of TB, and the epidemiology of these diseases were not addressed in detail in this region of the Kingdom before. In this study, we retrospectively assess the data of TB laboratory diagnosis accumulated over 8 years (2003-2010) in our hospital, describing some of the significant findings in our institution. We report in this study how these laboratory finding reflect changes in the epidemiology of TB, and the age group of patients affected in central KSA.

Methods. We retrospectively reviewed all data on the samples submitted to the TB laboratory at King Khalid University Hospital (KKUH), Riyadh, Saudi Arabia from January 2003 to December 2010, and selected those found to be culture positive for *M. tuberculosis* complex (MTBC). This laboratory data were collected from the KKUH hospital information system and the laboratory requisitions forms, which included the date of collection, date of culture positivity, type of *Mycobacterium* isolated, and susceptibility of these isolates to first line anti-TB drugs. Demographic information and clinical features of the patients such as: clinical presentation, sample site, age, gender, and hospital units were also included. Sample collection and processing followed our laboratory policy/procedure system. All sputum and other samples were collected and transferred to the Microbiology Department on the same day (or the following day, if they were collected after 4 PM). Two to 3 specimens per patient were collected. The results obtained represent one positive culture per patient, the samples were then processed for smear microscopy by Ziehl-Neelsen (ZN) and auramine-rhodamine stains, and cultured in Mycobacterium growth indicator tube Bactec 960 liquid medium, and on Lowenstein-Jensen (LJ) solid pyruvate and glycerol media. The specimens were processed according to standard accepted methods.[6]

Quantitation of acid alcohol fast bacilli on the smear was reported as follows: no acid fast bacilli seen, if no bacilli were seen on 300 fields, 1+ for 1-9 bacilli/100 fields, 2+ for 1-9 bacilli/10 fields, 3+ for 1-9 bacilli/field, and 4+ for >9 bacilli/field. Time to detection of growth of mycobacteria was based on the date of earliest Bactec 960 instrument liquid culture positivity. The solid media were incubated at 37°C in aerobic atmosphere until colonies appeared on the medium, which showed acid alcohol fast bacilli on ZN smear, or for a maximum of 8 weeks if the culture remains negative until this time. Identification of mycobacteria was based on colony morphology on the solid medium, colony pigmentation, rate of growth on the solid medium, results of biochemical tests that included; nitrate reductase test, niacin test, and thiophene-2-carbaldehyde acid hydrazide test. Differentiation of MTBC (mainly, *M. tuberculosis, M. bovis, M. africanum, M. microti,* and BCG strain) from non-tuberculous mycobacteria was carried out by BD ProbTec system (Becton Dickinson, Franklin Lakes, NJ, USA) following the manufacturer instructions, as well as growth of the non-tuberculous mycobacteria on solid medium containing para amino benzoic acid. Biochemical tests were carried out to identify *M. bovis*. The methods included obtaining laboratory data on specimens from patients. These methods were carried out according to the updated Principles of the Helsinki Declaration. The susceptibility of MTBC isolates from these specimens to first line anti-TB drugs, streptomycin, isoniazid, rifampicin and ethambutol was performed using BACTEC MGIT 960 SIRE Kit according to the manufacturer instructions. Inclusion criteria include single results of specimens from a patient, while exclusion criteria include multiple results of a specimen, or repeated specimens from the same patient.

Statistical analysis of all the data collected on Excel sheet was analyzed using the Statistical Package for Social Sciences version 12 (SPSS Inc., Chicago, IL, USA). Results were considered significant if $p \leq 0.05$.

Results. Out of the 9405 specimens processed, 568 (6%) grew *M. tuberculosis*. **Table 1** shows the incidence rate of TB among Saudis and non-Saudis during the study period, the incidence rate of TB in Saudis was 55.6/100,000, and the overall incidence rate during the study period in the whole population served by KKUH was 51.3/100,000. **Table 2** shows the nationality and gender of patients from whom the 568 MTBC species were isolated. Most patients (87%) were Saudi nationals, and there was no significant difference in percentage between the male and female gender. **Figure 1** and **Figure 2** shows the relationship between acid alcohol fast bacilli smear quantitation and time to positive culture results in the Mycobacterium growth indicator tube (MGIT) liquid medium of the respiratory and non-respiratory specimens that grew MTBC species. With the smear negative results the majority of isolates grew within 7-14 days, showing percentages of 59, 47 for non-respiratory and respiratory respectively. With the quantity of +1 Acid alcohol fast bacilli smear, most non-respiratory specimens (74%), and 57% of the respiratory specimens grew within this period (7-14 days). As for the 2+ acid alcohol fast bacilli smears quantity the percentage of growth within 7-14 days was 100% for the non-respiratory, and 71% for respiratory. For the 3+ smear quantity 78% of the respiratory specimens showed growth within less than 7 days. However, in the 4+ acid alcohol fast bacilli smear quantity 90% of the respiratory, and 83% of the non-respiratory showed growth within 7 days. In the total specimens, most growth occurs during 7-14 days for smear quantity from negative to 2+, however, the highest percentage of growth occurred within 7days showing percentages of 78% for the 3+ and 90% for the 4+. **Figure 3** shows the age distribution of the patients whose specimens grew the MTBC isolates during the 8 years of the study period. Most patients from whom the MTBC were isolated in the years 2006, 2008, and 2010 were in the age range of 18-35. This age range group had the second highest percent of patients whose specimen grow MTBC in the years 2004, 2005, and 2007, and third highest in the years 2003, and 2009.

Table 1 - The incidence rate of tuberculosis in Saudis and non-Saudi during the study period (*p<0.0001).

Variables	Number of positive/ population	Incidence rate during the study period per 100,000
Saudi*	494 (888,576)	55.6
Non-Saudi*	74 (218,383)	33.9
Overall	568 (1,106,959)	51.3

Table 2 - Nationality and gender of patients in which the *Mycobacterium tuberculosis* complex were isolated (N=568).

Variables	Specimens n (%)		*P*-value	Total
	Respiratory n=264	Non-respiratory n=304		n (%)
Nationality				
Saudi	233 (88.3)	260 (85.5)	0.3903	493 (86.8)
Non-Saudi	31 (11.8)	44 (14.5)	0.4107	75 (13.2)
Gender				
Male	134 (50.8)	148 (48.7)	0.6780	282 (49.7)
Female	130 (49.3)	156 (51.3)	0.7679	286 (50.8)
Respiratory: Saudi versus non-Saudi (p<0.0001), non-respiratory: Saudi versus non-Saudi (p<0.0001)				

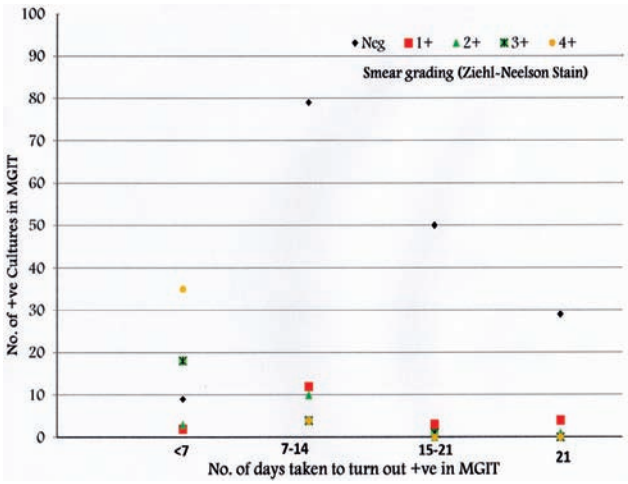

Figure 1 - Smear grading versus time frame for positivity of acid fast bacilli culture in Mycobacterium growth indicator tube (MGIT) from respiratory site specimens (N=264).

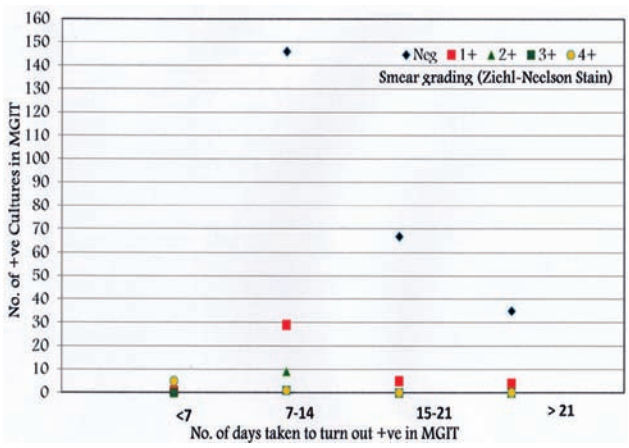

Figure 2 - Smear grading versus time frame for positivity of acid fast bacilli culture in Mycobacterium growth indicator tube (MGIT) from non-respiratory site specimens (N=304).

There was a significant increase in the percentage of patients whose specimen grew MTBC in the age group 18-35 between the year 2003 (26%), and the year 2010 (50%) (p=0049). **Table 3** shows the number and percentages of the 264 MTBC isolates from the respiratory specimen of different age groups in the years of the study. Of the total number of 264 respiratory tract MTBC isolates, 105 (40%) were isolated in patients >55-85 years, and 80 (30%) were isolated from the age group >18-35 years. However, the percentage of isolates in the last year of the study (2010) in the age group >18-35 year (55%) was significantly greater than the

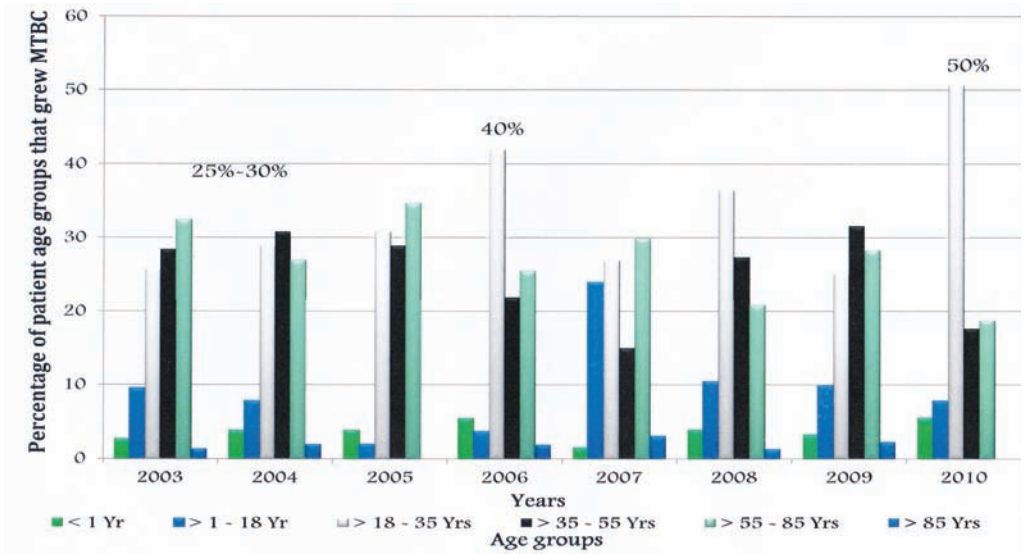

Figure 3 - Percentage distribution of age groups of patients whose specimens grew the 568 *Mycobacterium tuberculosis* complex (MTBC) during the study years.

Table 3 - The numbers and percentages of *Mycobacterium tuberculosis* complex isolated from respiratory specimens of different age groups during the years of the study (N=264).

Age group	Year, n (%)								
	2003	2004	2005	2006	2007	2008	2009	2010	Total
≤18	2 (6.0)	0	0	2 (6.0)	4 (13.0)	5 (16.0)	3 (7.0)	5 (11.0)	**21 (8.0)**
>18 - 35	8 (22.0)	5 (21.0)	5 (21.0)	14 (42.0)	6 (19.0)	8 (26.0)	8 (20.0)	26 (55.0)	**80 (30.0)**
>35 - 55	10 (28.0)	8 (35.0)	6 (25.0)	4 (12.0)	5 (16.0)	7 (23.0)	12 (31.0)	6 (13.0)	**58 (22.0)**
>55 - 85	16 (44.0)	10 (43.0)	13 (54.0)	13 (39.0)	16 (52.0)	11 (35.0)	16 (41.0)	10 (21.0)	**105 (40.0)**
Total	**36 (14.0)**	**23 (9.0)**	**24 (9.0)**	**33 (13.0)**	**31 (12.0)**	**31 (12.0)**	**39 (15.0)**	47 (18.0)	**264 (100)**

No significant difference observed between the years and among different age groups. The percentage of *Mycobacterium tuberculosis* complex isolated from respiratory specimens in age group >55-85 was significantly higher than the age group >35-55 (p=0.0311). Similarly, the number of patients in the age group <18 was significantly lower when compared with the age group >55-85 (p=0.0104).

Table 4 - Numbers and percentages of *Mycobacterium tuberculosis* complex isolated from different age group from non-respiratory specimens (N=304).

Age group	Year, n (%)								
	2003	2004	2005	2006	2007	2008	2009	2010	Total
≤18	7 (18.0)	6 (20.0)	3 (10.0)	4 (16.0)	13 (36.0)	6 (13.0)	10 (18.0)	9 (19.0)	**58 (19.0)**
>18 - 35	11 (29.0)	10 (34.0)	11 (38.0)	10 (42.0)	12 (33.0)	20 (43.0)	15 (27.0)	21 (45.0)	**110 (36.0)**
>35 - 55	11 (29.0)	8 (28.0)	9 (31.0)	8 (33.0)	5 (14.0)	14 (30.0)	18 (33.0)	10 (21.0)	**83 (27.0)**
>55 - 85	9 (29.0)	5 (17.0)	6 (21.0)	2 (8.0)	6 (16.0)	6 (13.0)	12 (22.0)	7 (15.0)	**53 (17.0)**
Total	**38 (13.0)**	**29 (10.0)**	**29 (10.0)**	**24 (8.0)**	**36 (12.0)**	**46 (5.0)**	**55 (18.0)**	47 (15.0)	**304 (100)**

There is no significant difference observed between the years and among different age groups. The percentage of *Mycobacterium tuberculosis* complex isolated from non-respiratory specimens in the age group <18 was significantly lower than the age group >18-35 (p=0.0352), however, the number of patients in the age group >18-35 was significantly higher when compared with the age group >55-85 (p=0.0214).

22% in the first year of the study (2003) (p=0.0049). **Table** 4 shows the number and percentages of the 304 MTBC isolates from non-respiratory specimens of different age groups. In total, the highest percentages of isolates (36%) were from the age groups >18-35. **Table** 5 shows the numbers of the *M. tuberculosis* and (*M. bovis*/ BCG) isolated from different age groups. Out of the total 568 MTBC isolates, 27 were *M. bovis*/BCG strain with a percentage of 5%. The *M. bovis* and BCG were not biochemically differentiated. However, most of these were from children and infants who presented with lymphadenopathy, and were clinically compatible with BCG strain infection (BCGitis). Out of the 22 MTBC isolated in the age group less than one year, 14 (64%) were *M. bovis*/BCG strain. In the age group >1-18, the number of *M. bovis*/BCG was 6 out of 57 *M. tuberculosis* complex isolates (11%). No HIV infection was reported in all these patient and their mothers. **Figure** 4 shows the percentage of antibiotic resistance to the first line anti TB drugs during the 8 years of the study period. Isoniazid resistance predominates (average 11%) during all the years of the study, except the year 2005, where ethambutol resistance was the highest. The average resistance rate of the other first line drugs was 7% for streptomycin, and 2% each for rifampicin and ethambutol. The resistance to both isoniazid and rifampicin indicating multidrug resistance was 0.7%.

Table 5 - Number of *Mycobacteria tuberculosis* (MTB) and *Mycobacterium bovis (M. bovis)*/Bacillus Calmette-Guérin (BCG) isolates from different age groups.

Age range	MTBC identification n (%)		*P*-value	Total no. of MTBC
	M. bovis/BCG	MTB		
≤one year	14 (64.0)	8 (36.0)	0.4107	22
>1 - ≤18	6 (11.0)	51 (89.0)	<0.0001	57
<18 - ≤35	2 (1.0)	188 (99.0)	<0.0001	190
>35 - ≤55	1 (0.7)	140 (100.0)	<0.0001	141
>55 - ≤85	4 (3.0)	146 (97.0)	<0.0001	150
>85	0	8 (100.0)	0.0005	8
Total	**27 (5.0)**	**541 (95.0)**	**<0.0001**	**568**

MTBC - *Mycobacteria tuberculosis* complex

Discussion. Out of 9,405 specimens tested for TB in this study, 568 specimens grew MTBC species with a percentage of positivity of 6%. This result is less than the positivity reported by authors in other studies.[7-9] A study comparing Bactec MGIT 960 with LJ medium for mycobacterial growth from specimens showed superiority of MGIT to LJ.[10] In our study, most patients, in which the MTBC species were isolated were Saudi nationals (87%), showing an incidence rate of 55.6/100,000 in Saudis, 33.9/100,000 fo non-Saudis, and 51.3/100,000 in total patients. In another study from KSA, the percentage of Saudi nationals is lower (36%).[11] The likely reason is that the previous study[11] was from the city of Jeddah, whose population is affected by pilgrims coming to perform Umrah and Hajj. Our hospital is open only to Saudi nationals and expatriates employed by King Saud University.

In a general study in KSA, the ratio of non-Saudis to Saudis was 2:1.[12] That study reflected the status

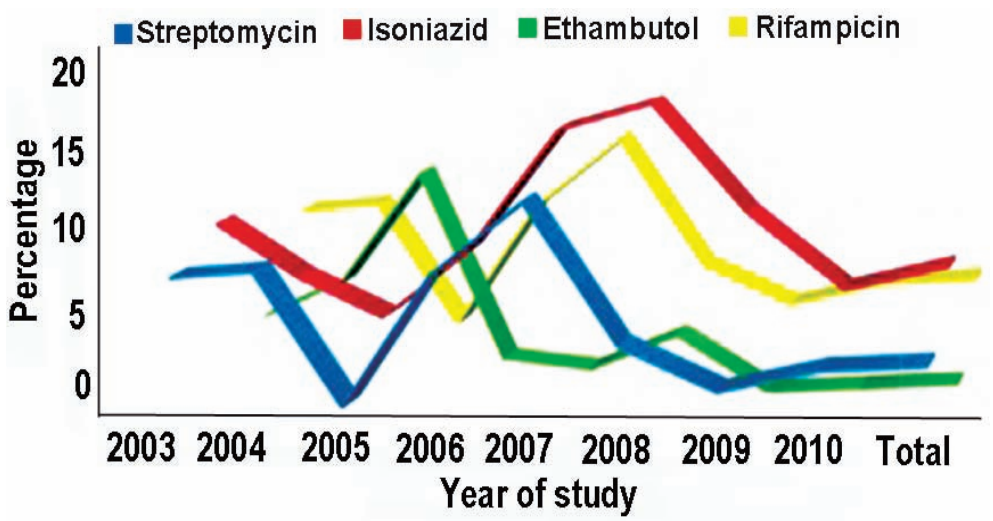

Figure 4 - Percentage of resistant strains of the *Mycobacteria tuberculosis* (n=541) isolates to the first line anti-tuberculosis drugs during the 8 years of the study.

of TB in many other hospitals, which are open for both Saudi and non-Saudi nationals, and that study was affected by a lack of proper reporting, as well as different diagnostic methods.[12] It is also important to note that study[12] reported an increase of TB in Saudis from Riyadh province similar to our study. Differences in the incident rate of results shown between that study 20.9/100,000[12] and our study 55.6/100,000 is due to the fact that the study by Abouzeid et al [12] was from hospitals all over the Kingdom, whereas ours was from a single hospital, which is a teaching hospital with active units of pulmonary, infectious disease, and microbiology, open mostly to Saudi nationals.

The male to female ratio in our study resembles that in other studies.[11,12] The MTBC isolates in our study as in other studies[11,12] involved all age groups from less than one year to >85 years. However in our study, the age group 18-35 comprised the most frequent age group, from which most of the MTBC species were isolated. This was different from a study on general trends of TB in KSA, where the highest rates were from the age group >65 years.[12] It is interesting to note that in the study of Abouzeid et al[12] there was a trend to an increase of TB cases in the young age group of 15-24 years, and a trend to decrease in the older age group (55-64) despite the fact that most isolates were from this age group (55-64). Our study showed an increase of TB cases in the age group of 18-35 years old.

In our study, there was steady increase over time in the number of MTBC isolates from different age groups from respiratory and non-respiratory specimens. This increase was prominent in the age groups >18-35 and >35-55 years. This increase in the total number of MTBC isolates was statistically significant between the number of MTBC isolates in the year 2003 (the beginning of the study, and the year 2010 (the end of the study) (p=0.0049) in the age group >18-35. The trend in the increase of TB in this age group had been indicated in another study from Saudi Arabia,[12] in which the incidence of TB in the age group 14-29 year increased from 15.7/100,000 in the year 2000 to 20.9/100,000 in the year 2009 (p<0.05).

The impact of TB was also addressed by another study.[13] In another study from our institution,[14] the high incidence rate of TB indicated by a high number of MTBC isolates in this age distribution is reflected.[14] In our study, the time to detect MTBC growth in liquid culture medium was inversely correlated with the bacilli load in the specimens as evaluated by the quantitation of ZN smear bacilli load into the following categories: negative; 1+; 2+; 3+; and 4+. We found that with 4+ (90%), and 3+ (78%) acid alcohol fast bacilli smear load of growth happened within 7 days of inoculation. However, for other categories of smear load, growth happened within 7-14 days. A previous study[15] showed time to detect growth in liquid medium from negative smear specimen to be 2 weeks, while that for smear positive was one week. A study showed the MIGT system to be faster in detecting growth than the Bio-FM system.[16] However, unlike our study, the study of Essawy et al[16] did not address the relationship of smear load to time to detect growth in detail. Such a relationship is important as in some specimens with heavy smear load of MTBC, growth can be detected in less than 7 days. This result may lead to misdiagnosing MTBC isolates to be rapidly growing non-TB Mycobacterium if the rate of growth was considered as a means for identification of mycobacterial isolates in non-well equipped laboratories for identification.

Another important finding in our study is the high percentage (64%) of *M. bovis*/BCG strain isolates among the MTBC isolates in the age group less than one year, and 11% in the age group more than one to 18 years. Most *M. bovis*/ BCG isolates was consistent with BCG lymphadenitis and disseminated BCG infection. Previous studies from KSA showed the presence of BCG lymphadenitis and infected cases,[17,18] and disseminated BCG in children was also documented.[19] It is also known that the type of BCG used for vaccination can be a cause for such infections.[20]

In KSA, BCG vaccination is given on the first day of life, before knowing whether any immunodeficiency is present in those who obtained the vaccine. The type of vaccine used and administering BCG before checking for immunodeficiencies may lead to the increase of BCG infection in KSA. This increase of BCG infections is leading to a consideration of revising BCG vaccination policies in KSA.[21] It is important to note that none of these neonates, nor their mothers had HIV infection.

In our study, the highest resistance of MTBC isolates was to isoniazid (11%) followed by rifampicin (7%), and ethambutol (2%) during the years of the study. Multidrug resistance indicated by resistance to both isoniazid and rifampicin was less than 1%, similar results were reported from another study from all over the Kingdom.[22] However, another study from Qassim University in the central region showed different results.[23] This difference may be due to the fact that in this study by Alorainy,[23] the patients were of multinational origin. Our results fall within the resistance range reported in another study,[24] carried out on isolates from a hospital like ours in the central region of KSA. The increase in the rate of resistance to isoniazid and rifampicin could

be explained by the transmission of resistant strain(s) to these drugs. Genotyping could confirm or refute this hypothesis.

The limitation of our study is that it is a retrospective study depending on laboratory data. Accordingly, it does not include TB types that are diagnosed mainly clinically. Future follow-up of this study can concentrate on the epidemiology factor, such as the area of living of different patients in the central region social statistic. This might give more insight on the predominance of TB in the specified age groups. In the central region of KSA, there is a change in the epidemiology of TB to affect young age groups of 18-35.

Most TB patients were Saudis (87%) with an incidence rate of 55.6/100,000, however, this is different from the proportion of TB patients that were Saudi nationals reported from different regions of KSA (Jeddah and Makkah),[25] where the ratio of non-Saudi patients to Saudi patient is high, as there is year round gathering of multinational Muslim, especially during Muslim occasions, such as, Hajj and Umrah, and the presence of immigrant workers in the other regions of the Kingdom like southern region, where there is variability in the yearly trend of TB among Saudis and non-Saudis.[25]

The resistance rate in our study to isoniazid (10.6%), rifampin (1%), ethambutol (2.8%), and streptomycin (6%) concurs with previous reports from KSA with regard to mono drug resistance, but slightly lower with regards to multidrug resistance (0.7 versus 1.8).[26] The increase in the number of cases of pulmonary TB in young active adults may enhance the transmission of TB. Rapid, sensitive, and specific molecular testing methods are needed to manage these cases, and prevent further transmission of TB disease in the community.[27]

The rate of multidrug resistance in our study was 0.7%, which is less than that reported before in the Kingdom.[23] Consolidation of the diagnostic mycobacteriology laboratory is crucial for any program for TB control. Implementation of new molecular testing and genotyping of *M. tuberculosis* are needed for both management of the patient, and epidemiology and prevention of transmission of TB in KSA.[27] Limitations of the study are that it is a retrospective study with no follow-up of patients.

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