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Cost Evaluation of Current Pulmonary MTB Diagnosis Process in a Hospital in Abu Dhabi and Proposal to Implement the World Health Organization MTB Clinical Pathway

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Abstract

Aim: Mycobacterium tuberculosis (MTB) is a leading cause of death worldwide. The World Health Organization (WHO) recommends X-pert MTB/RIF or X-pert Ultra as the initial test for pulmonary MTB diagnosis. While several studies have explored the cost-effectiveness of this technology, none have specifically looked at its use in the United Arab Emirates (UAE). To evaluate the average estimated cost and length of stay for suspected MTB patients admitted from the emergency department to the respiratory isolation rooms to rule out MTB using the MTB classic diagnosis pathway of 3 AFB smear and MTB cultures compared to the estimated cost if the WHO X-pert MTB/RIF outpatient pathway is implemented for suspected MTB.

Materials and Methods: A quality improvement project was conducted with a retrospective audit and data analysis of suspected pulmonary MTB infection at a secondary care hospital in Abu Dhabi, UAE. We report the true accrued costs of the current admission practice for management of suspected pulmonary MTB. We also report the estimated cost of working up these same patients with the WHO pathway using X-pert MTB/RIF testing.

Results: Data analysis demonstrated that 62% of the cost of working up suspected pulmonary MTB was accumulated during admissions for patients who ultimately proved to be MTB negative. Cost evaluation of study data suggests that using the WHO X-pert MTB/RIF clinical pathway would cost approximately one-tenth as much as the current practice.

Conclusion: This analysis presents evidence for cost savings associated with the use of the WHO X-pert MTB/RIF clinical pathway in a low MTB incidence area such as the UAE. Further analysis to assess how the pulmonary MTB diagnostic pathway was influenced by COVID-19 is needed.

Keywords: Pulmonary MTB, emergency department, cost evaluation, mycobacterium tuberculosis, WHO clinical pathway, X-pert MTB/RIF, AFB smear

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Introduction

Mycobacterium tuberculosis (MTB) is an infectious disease commonly affecting the lungs (pulmonary MTB), also it may involve other organs (1). Prompt diagnosis of active pulmonary MTB is a priority for TB control, both for treating the individual and for public health intervention to reduce further spread in the community (2). MTB is often a curable disease if it is detected early and effectively treated (3). In 2018, the United Arab Emirates (UAE) total population was 10 million. The World Health Organization (WHO) estimated UAE MTB incidence at 1 (0.88-1.2) per 100 000 signifying that UAE is a low MTB incidence and burden country (4).

Current practice in many hospitals in UAE involves admitting patients with suspected MTB to the respiratory isolation ward to confirm or rule out the MTB infection. Patients are subjected to multiple diagnostic tests, including chest X-ray (CXR) and acid-fast bacilli sputum smear microscopy (AFB smear). Adding to that, the gold standard MTB culture and at times additional diagnostic tests such as QuantiFERON Gold test or MTB rapid polymerase chain reaction (PCR) may be performed. This practice has an impact on the system, resulting in increasing hospital admission rates & prolonged hospital stay, and hospital overcrowding which then leads to emergency department (ED) exit block. these practices affect patients directly through increased total cost, and indirectly can impact the patient's and their family's social and mental health (5,6).

WHO recommends X-pert MTB/RIF or the X-pert Ultra, the newest version, as the initial test for MTB (7). This testing procedure is to replaces the current standard practice of the three AFB smear (8-12). X-pert MTB/RIF test has multiple advantages: it is an automated PCR test using the GeneXpert platform, it can detect both MTB complex and rifampicin resistance in a single test with high sensitivity and specificity profile on both culture positive and culture negative sputum samples, and it is a rapid test with results available in two hours with minimal hands-on technical time. The assay's sample reagent has tuberculocidal properties eliminating biosafety concerns during the test procedure (7,13-15). WHO in 2013 published a pathway utilizing X-pert MTB/RIF test to screen / work up suspected MTB as outpatient (16). To our knowledge, there is no published literature regarding the cost and hospital resource use for suspected MTB patients in the UAE. This quality improvement project evaluates the average estimated cost and length of stay for suspected MTB patients admitted from the ED to the respiratory isolation rooms using the current practice described above and estimated cost if the WHO X-pert MTB/RIF outpatient pathway is implemented for suspected MTB.

Materials and Methods

This was a quality improvement project where we conducted a retrospective audit and data analysis for suspected MTB patients admitted through our ED over a 1-year period. The hospital where the analysis was performed is a secondary care hospital in Abu-Dhabi with 380 beds. In 2017, the hospital had a bed occupancy rate of 84% with an average length of stay (LoS) of 6.2 days.

All patients admitted through the ED for suspicion of pulmonary MTB over the calendar year 2017 were included in this analysis, and there were no patients excluded for any reason. The primary goal of the audit was to evaluate the cost and LoS of patients who tested negative for pulmonary MTB. Secondary analysis included the cost and LoS of patients who tested positive for pulmonary MTB. We collected data from health information management, and cost data was requested and obtained from the revenue development management with the assistance of the patient service accountant. All data storage and an analysis were performed in Microsoft Excel.

Ethics committee approval was not required for quality improvement projects at our hospital when this project was planned. Clinical data can be used for research under the general consent that all patients sign on admission to the ED. Appropriate methods were used for the storage, security, and destruction of the excel data collection sheet.

Results

In 2017, 200 patients with suspected MTB were admitted from the ED, of which 123 were male and 77 were female. Thirteen patients were below 18 years of age and 31 patients were above 65 years of age. Thirty-one patients were UAE nationals and 169 patients were expatriates. 33% (66/200 patients) were diagnosed with pulmonary MTB and 67% (134/200 patients) did not have pulmonary MTB (Table 1).

One hundred thirty-four patients (67%) who did not have pulmonary MTB had an average LoS of 13 days. 62% of the total hospital cost was for these patients (around $1,216,119.88 USD) and the average cost per MTB negative patient was around $9,075.52 USD.

Sixty-six patients (33%) were diagnosed with pulmonary MTB with an average LoS 27 days. This accounted for 38% of the total cost. The overall cost for the pulmonary MTB-positive patients was $735,235.00 USD, and the average cost per person was $11,140.42 USD (Tables 2, 3).

Statistical Analysis

Cost Analysis

The total cost for evaluating 200 patients with suspected MTB as inpatients was $1,951,387.31 USD. Detailed analysis showed per night average cost of a respiratory isolation room at $375.71 USD, single AFB smear at $14.16 USD, QuantiFeRON test at $157.91 USD, MTB culture at $27.50 USD, and Gene X-pert MTB average per-test costs is $82.20 USD per test. The estimated cost of evaluating suspected MTB patient as out patient who presents to the ED and tests negative inclusive of a repeat Gene X-pert test when MTB is highly suspected or if first test is not conclusive in addition to a follow-up appointment in the Respiratory Clinic was calculated to be $996.31 USD (16). Figure 1 outlines the WHO X-pert MTB/RIF clinical pathway and Table 4 details the cost analysis and minimum cost per patient for MTB likely negative patients if managed as inpatients versus outpatients. On the other hand, the estimated minimum cost saving per patient applying the WHO X-pert MTB/RIF outpatient screening clinical pathway is estimated to be $3923.91 USD (see Table 5 for details).

Table 1. Baseline characteristics of study participants (n=200)

Age range	**2-91 year**
Male	123 (61.5%)
Female	77 (38.5%)
Pediatric ≤18 years	13 (6.5%)
Elderly >65	31 (15.5%)
UAE National	31 (15.5%)
MTB positive (TB culture)	66 (33%)
MTB negative (TB culture)	134 (67%)
Total cost	$1,951,387.31

MTB: Mycobacterial tuberculosis, TB: Tuberculosis, UAE: United Arab Emirates

Table 2. LoS for Suspected MTB patients

	MTB positive=66/200	**MTB negative=134/200**
Average LoS	27 days	13 days
Median LoS	13 days	10 days

MTB: Mycobacterial tuberculosis, LoS: Length of stay

Table 3. Cost review for suspected MTB patients as inpatients

	MTB positive=66/200	**MTB negative=134/200**
Cost	$735,235.00 (38% of total cost)	$1,216,119.88 (62% of the total cost)
Average cost per patient	$11,140.42	$9,075.52
Median cost per patient	$4,869.91	$4,212.36

MTB: Mycobacterial tuberculosis

Discussion

In 2010, WHO endorsed X-pert MTB/RIF as an initial diagnostic test for people thought to have MDR-TB or HIV-associated tuberculosis (15,17). In 2013, WHO extended its proposal that X-pert MTB/RIF can replace AFB smear as the initial diagnostic test for all adults and children patients with suspected MTB (10,15,18). Data showed that 67% of suspected pulmonary MTB tested negative and their average LoS was 13 days, which has a high impact on hospital admission rate, bed occupancy rate, and ED exist block. The average cost was $9,075.52 USD per patient, which includes the cost of diagnostics (about 10-20%) and admission and hospital stay expenses, which highlights multiple opportunities for cost saving. These patients also stay in a respiratory isolation room for days, which creates anxiety for the patients and their families (5).

Studies in patients with suspected MTB reported X-pert MTB/RIF sensitivity of 85% and a specificity of 98%. In a smear-positive with culture-positive, X-pert MTB/RIF sensitivity is about 98%, while in a smear-negative with culture-positive MTB, the sensitivity is 67% (19,20). when compared to X-pert MTB/RIF, X-pert Ultra yielded a sensitivity of 88% and a specificity of 96% (14). X-pert Ultra, when compared to X-pert MTB/RIF, for detection of smear-negative culture-positive MTB, yielded a higher sensitivity of 63% than X-pert MTB/RIF of 46%, and lower specificity of 96% than X-pert MTB/RIF 98% (14). In contrast, AFB smear is a low-cost test but with low sensitivity of between 50 and 60%, which can result in a large number of MTB cases that can go undiagnosed until culture results are obtained (21-28). Around 5000 to 10,000 CFU/mL must be present in the specimen for MTB bacteria to be visible by AFB smear by contrast, X-pert MTB/RIF can detect as low as 112.6 CFU/mL, and X-pert Ultra can detect as low as 15.6 CFU/mL (14,21-23).

Fifteen studies analyzed X-pert MTB/RIF cost-effectiveness, with most studies are taking place in sub-Saharan Africa. Twelve studies found that X-pert MTB/RIF is cost-effective in their setting and 3 studies (in India, Malawi, and South Africa) showed a neutral cost profile (24). One study quoted that X-pert MTB/RIF saved $2,278 USD per admission and $533,520 USD per year, and most cost savings arose from reductions in LoS in respiratory isolation (18).

Millman et al. (19) reported that X-pert MTB/RIF decreased isolation bed utilization from an average of 2.7 to 1.4 days per suspected MTB patient. Likewise, they showed a reduction in total annual isolation bed usage from 632 to 328 bed-days, directly bringing down bed occupancy rates, and potentially reducing ED exit block (19).

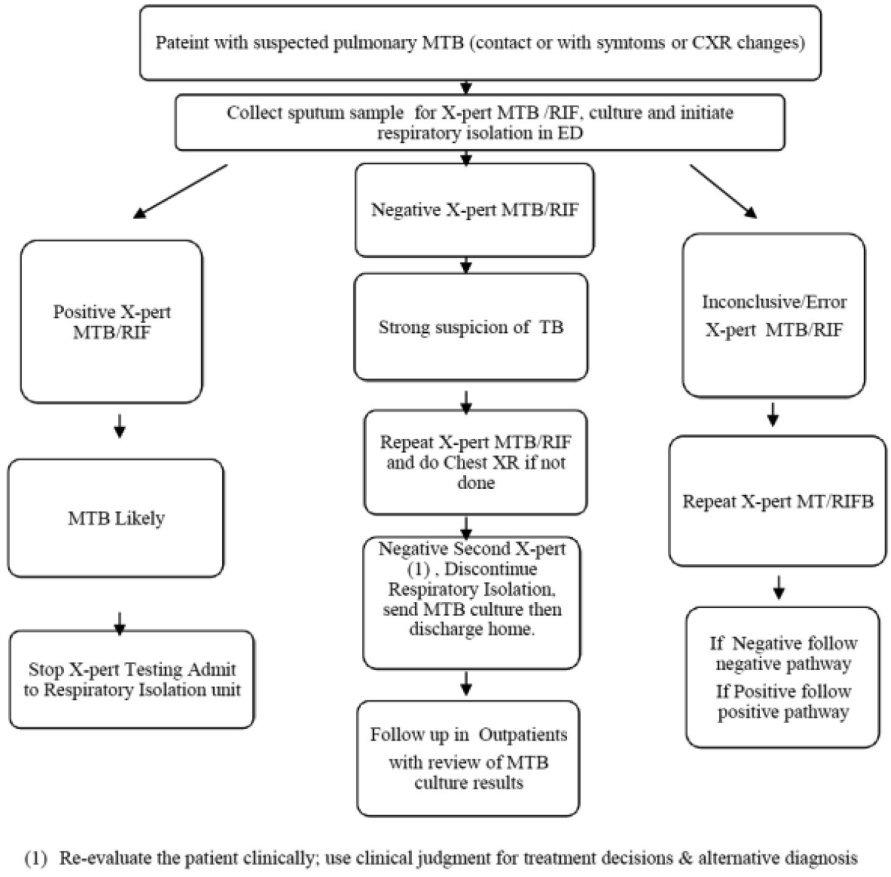

Figure 1. WHO X-pert MTB/RIF outpatient screening clinical pathway
WHO: World Health Organization, MTB: Mycobacterial tuberculosis, CXR: Chest X-ray

Table 4. Cost analysis of likely negative MTB when managed as in patient versus out patient

	Test	Cost per unit	Amount needed	Total cost
In patient track total **minimum** cost per patient: $5,112.12 USD	Per night average cost of a respiratory isolation room	$375.71 USD	Average loss 13 days	$4884.23 USD
	Single AFB smear	$14.16 USD	Average 3 AFB smear	$42.48 USD
	QuantiFeRON test	$157.91 USD	1	$157.91 USD
	MTB culture	$27.50 USD	1	$27.50 USD
Outpatient track **minimum** cost if negative $1,188.21 USD	Gene X-pert MTB average per-test costs	$82.20 USD	2	$164.4 USD
	MTB culture	$27.50 USD	1	$27.50 USD
	Follow-up appointment in the respiratory clinic	$996.31 USD	1	$996.31 USD

Note that we did not factor in other care variables such as symptomatic treatment or imaging such as CXR as both tracks will need to do CXR our comparison is focused on the microbiological testing being done as inpatient versus outpatient.
CXR: Chest X-ray, MTB: Mycobacterial tuberculosis

Table 5. Cost saving if applying WHO X-pert MTB/RIF outpatient screening clinical pathway

Hospital beds occupancy nights saved	**13x134=**	**1742 nights**
Care cost mimunum saved per patient	In patient track Total **minimum** cost per patient: $5,112.12 USD - Outpatient track **minimum** cost if negative $1188.21 USD=	$3,923.91 USD

WHO: World Health Organization, MTB: Mycobacterial tuberculosis

In 2015, the Food and Drug Administration approved the X-pert MTB/RIF test for pulmonary MTB detection as an initial diagnostic test replacing AFB smear, and this test has been widely implemented in 18 countries (17,19,25). Implementing the X-pert MTB/RIF in UAE and other low MTB incidence and burden countries will be cost-saving and cost-effective compared with the traditional admission for 3 AFP smears and culture. Data analysis showed that changing this practice could reduce the cost of MTB workup by about 90% while providing for safe practice. WHO pathway suggest that suspected MTB patients based on symptoms or abnormal CXR, or close contact with pulmonary MTB patients, should undergo X-pert MTB/RIF as an initial diagnostic test (Figure 1) (15,26,27).

To our knowledge, this is the first study evaluating the cost of the current pulmonary MTB diagnostic process in the UAE. It describes the effect of this diagnostic process on LoS and costs for patients with suspected pulmonary MTB. The current average cost of an inpatient-based MTB is almost 10 times higher at $9,075.52 USD versus the proposed outpatient X-pert MTB/RIF - based evaluation, which will cost about $996.31 USD.

Study Limitations

This is a single-center retrospective one-year audit in a low-incidence TB country, resulting in a small number of MTB-infected patients. In addition this study analysed 2017 data and was ready for publication before the Coronavirus disease-2019 (COVID-19) pandemic, which resulted in delayed submission; hence, there may be practice changes already due to COVID-19 and the demand on airborne isolation rooms in any system. A new audit to address the changes in the MTB diagnostic pathway and how it was influcned by COVID-19 in UAE will be needed.

Conclusion

Working up a patient with pulmonary MTB as an inpatient is costly and unjustified in the presence of an alternative cost-effective diagnostic pathway using X-pert MTB/RIF as an initial test to rule in/out pulmonary MTB within 2 hrs in an outpatient setting without the need for inpatient admission. Further analysis to assess how the pulmonary MTB diagnostic pathway was influenced by COVID-19 is needed.

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Ethics

Ethics Committee Approval: Ethics committee approval was not required for quality improvement projects at our hospital when this project was planned.

Informed Consent: Retrospective study.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Concept: W.G., Y.A., A.A., Design: W.G., Y.A., A.A., Data Collection or Processing: W.G., A.A., Analysis or Interpretation: W.G., Y.A., S.A., A.A., Literature Search: W.G., A.A., Writing: W.G., Y.A., S.A., A.A.

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