Original Article

Cost Analysis for Patients with Presumed Pulmonary Tuberculosis Attended in the Public Health System of Rio de Janeiro, Brazil

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Abstract

Background: In last years, few attention has given to the patient's prediagnostic costs when evaluating the introduction of new technologies for tuberculosis (TB) and in this context, this study evaluated patient's costs and cost-effectiveness incurred with TB diagnosis comparing Bactec™MGIT™960 system (MGIT) to the Löwestein–Jensen (LJ) culture in a health center and in a university hospital, in Rio de Janeiro City, Brazil. **Methods:** Patient's mean costs were evaluated during the diagnosis process and cost-effectiveness based on mean time in days for the adoption of appropriate clinical anti-TB treatment in two health units comparing culture by means LJ and MGIT. **Results:** The mean cost of LJ and MGIT in the health center was U. S. dollars (US$) 26.6 and US$ 45.13, respectively, and in university hospital was US$ 206.87 and US$ 285.48, respectively. Comparing the two approaches for TB diagnosis incurred by the patients, the incremental cost-effectiveness of MGIT compared to LJ was US$ 0.88 and US$ 4.03 per patient, respectively, to reduce the average time to adopt appropriate treatment. **Conclusions:** The culture method directly impacts patient costs while waiting for the correct diagnosis and contributing to aggravating costs with patients with TB.

Keywords: Clinical study, diagnosis, mean cost, public health system, tuberculosis

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Introduction

Since 2006, the Global Plan Stop tuberculosis (TB) of the World Health Organization included TB research as an essential tool to evaluate the incorporation of new diagnostic technologies for TB, TB and human immunodeficiency virus (HIV) and multidrug-resistant TB cases.[1] Despite the smear sputum microscopy having low sensitivity (30%–80%), this test remained as one of the most used tests for the TB diagnosis routine in low and middle resource countries.[2]

To improve the diagnostic performance of smear-negative pulmonary TB cases, chest X-ray and culture of *Mycobacterium* TB have been recommended,[3] and more recently, the molecular tests.[4]

The culture is the current reference standard of the laboratory diagnostic and despite the increasing use of rapid molecular tests in many countries, culture remains necessary for treatment monitoring and detection of nontuberculous mycobacteria.[5]

In Brazil, many advances in TB control in the past 10 years have been described, but serious obstacles need to be overcome, as TB ranks fourth as a cause of death from infectious disease, which is the leading cause of mortality among HIV-infected

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persons, partially related to the low rate of TB detection among smear-negative TB cases, as in 2019, culture was performed only in 30.4% of TB cases reported.[5]

Interestingly, few attention has given to the patient's prediagnostic costs when evaluating the introduction of new technologies for TB, which are usually the costs incurred in care seeking for presumed pulmonary TB patients.[6-10]

In Brazil's unified health-care system (SUS), the diagnosis and treatment cascade for TB is carried out without any expenses with health services for patient, as well as with the purchase of medicines,[11] but there are scarce data on the cost-centered studies of patient spending while awaiting TB diagnosis and initiation of appropriate treatment such as transportation, feeding, or additional testing.

In this context, this study evaluated patient's costs and cost-effectiveness incurred with TB diagnosis comparing Bactec™MGIT™960 system (MGIT) to the Löwestein–Jensen (LJ) culture in a health center and in a university hospital, in Rio de Janeiro City, Brazil.

Methods

Place and study population

Presumed TB subjects were evaluated at two health units of Rio de Janeiro: health center (HC) Polyclinic Augusto Amaral Peixoto of the Municipality Health Secretariat of Rio de Janeiro and the University Hospital (UH) Clementino Fraga Filho of Federal University of Rio de Janeiro (UFRJ) during the period from April 2008 to October 2010.

Patients who had collected samples for culture were included. Culture was evaluated in a solid medium of LJ and in MGIT, and to avoid bias selection, patients were randomly selected from those included in pragmatic clinical trial that evaluated the clinical performance and cost-effectiveness of MGIT compared to LJ.[12]

In both the study sites, the main criterion for inclusion was the bacteriological diagnosis of TB on subjects with over 16 years of age; those who were already being treated for TB were excluded.

For the hospital site, patients admitted in the wards who had clinical and laboratory findings suggestive of active TB were included. In the HC, patients were recruited at the pulmonology sector with a history of cough for 2 weeks or more, and/or hemoptysis, and/or abnormal chest radiograph consistent with pulmonary TB.

Data collect

The patients were interviewed at the time they received the diagnosis of TB. Information was collected by trained health professional using a standardized questionnaire.

For patients evaluated at HC, the aim was to obtain important informations of the costs they had during the diagnosis period, highlighting: (1) number of visits made to other health units; (2) how much they spent on transportation and food during these visits; (3) the time it took on average to spend according to their health status until they get the TB diagnosis (defined as loss of income); and (4) job opportunities and income generation that were lost, together with the period when the diagnosis was not defined and the patient had symptoms.

For patients admitted to the hospital, in addition to the above-described activities, the aim was also to measure how long hospitalization for TB and what the costs incurred to the patient associated within the TB diagnosis period.

Cost and economic analysis

For transportation cost calculations, it was considered the value of the ticket equal to U. S. dollars (US$) 1.17 (price of a bus ticket in Rio de Janeiro in September 2010) and regarding income, the reference value was US$ 255.00 for the minimum wage (MW), according to the amount defined by State Law (Lei 12.255/2010, DOU June 16, 2010). Regarding the expenses for transportation and loss of earnings, at HC, the calculation was performed based on the number of times the patient had to go to the unit to gain access to TB test results. The transport cost for HC unit considered two distinct moments. The first refers to how much the patient has spent to go to the station to be attended for the first time and perform sputum collection. The second moment refers to how much was spent for transport until he could have access to test results and at transport, "Return/Output" was considered the chain of visits the patient had to receive the test result.

Regarding the UH unit, the transportation cost refers to how much was spent on this item until the patient was hospitalized. This cost was calculated as the sum of two parts: the first is how the patient spent on transportation going to other units before being admitted and the second is the patient spent on transportation going to the unit where he was admitted. The income loss is the sum of both the values calculated from two parts: the first used the average daily individual income from the amount of MW earnings times the average number of days left to work in function symptoms before being admitted and the second used the average daily individual income from the amount of MW earnings times the average number of days hospitalized.

For the effectiveness, we used the mean time in days to adopt appropriate clinical treatment. In the case of HC, loss of income was related to how much money the patient lost visiting the clinic to have TB diagnosis. In the case of UH, this loss refers to how many days left to work because of symptoms. In both the cases, these values in unit time were converted into monetary values from multiplying the daily average individual income reported by the patient.

Cost-effectiveness analysis

The ratio of incremental cost-effectiveness (ICER) was calculated by the relation between the cost difference between the MGIT and LJ cultures and the difference between the mean time in days for the adoption of appropriate clinical procedure among patients interviewed.

The indicator of effectiveness mean time to adopt appropriate treatment was constructed as a fixed number of subtraction to keep the meaning of increasing scale that is the larger the index value, the larger the value of effective. The incremental cost-effectiveness analysis from the perspective of the patient was performed separately for each research site.

The analysis of economic data was performed using Microsoft Excel 2010. The sensitivity analysis has been made on the cost associated with loss of income due to the time spent.

For conversion to US$, we used an exchange rate equal to Brazilian currency money R$ 2.00 (the average annual exchange rate in 2011)[13] and this rate of exchange was updated considering the quotation of R$ 5,19 (average annual exchange rate 2020).[14]

Results

Sociodemographic data

In HC, 25 patients were included and at UH, 32 patients were included with active TB. In HC and UH, the median age (in years) was 61 (interquartile range [IQR] 43–64) and 54 (IQR 47–63) years, respectively, and the proportion of male participants was 32% and 56%, respectively.

The distribution of family income ranged from 1 to 4 MW, being the average in HC less than of inpatients at UH. Among the TB cases included in the study at HC, only 8% had a family income equal to or greater than the 4 MW, while 31.6% of patients at UH were in this income range.

Those who reported being formally employed with the employment and social security accounted for 16% of respondents in HC and 34.4% in UH and the occupation was distributed mainly among employees with homeworkers and own account. Referred persons under their own responsibility were 52% of respondents at HC, while only 9% at UH. On average, at HC, patients shared home with two people and at UH with three people.

The research project was approved by the Ethics Committee in Research of UFRJ, under number 020/07 and the Clinical Trial Registry: ISRCTN79888843.

Costs analysis

The mean cost of patient income was US$ 277.2 in HC, while in UH, it was US$ 373.4 in 2011, and this update values from 2020 are US$ 106.8 and US$ 143.8, respectively.

Of the patients interviewed in HC, 40% returned two or more times and 41% of UH patients were at other health units by two or more units before the admission at hospital.

The transport cost for HC unit considered two distinct moments: first time to perform sputum collection and second time to return or output, the income loss due to the time spent in the unit refers to how much the patient left to win because had to go to the clinic to have the TB diagnosis done converted into monetary values [Table 1].

Table 2 shows that the mean cost imposed on the patient, for each separate vector of cost and patient group and type of diagnostic test performed. Despite some variations with respect to the other items, the main difference relied on the cost vector that measures the loss of income due to time spent during the diagnostic process.

The average individual income of patients of the HU was US$ 372.30, and these patients lose income due to the time of diagnostic process was US$ 380.23, which corresponds to 102.13% of the individual income, so each patient spent with TB around 2.13 more than their income. In the case of HC patients, the average individual income was US$ 277.95 and they lost US$ 41.4 which corresponds to 14.89% of the individual income.

Bactec™MGIT™960 system versus Löwestein–Jensen

1. HC analysis: Among 25 outpatients, 14 had their clinical specimens evaluated by LJ and 11 by MGIT. The mean cost was calculated using the weighted mean frequency of the number of patients. The mean cost per outpatient in the LJ arm was US$ 43.90 and in the MGIT arm, it was US$ 74.48 (US$ 16.9 LJ and US$ 28.7 MGIT by means of 2020 dollar's quotation)
2. UH analysis: Among 32 inpatients at UH, 14 had clinical specimens evaluated by LJ and 18 by MGIT. The mean cost per inpatient was US$ 341.34 for LJ and US$ 471.05 for MGIT (US$ 131.53 LJ and US$ 181, 52 by means of 2020 dollar's quotation). The calculation of these mean costs was made by removing the outliers when present.

Of the 32 patients interviewed at UH, the mean hospital stay for the time prior to receiving the diagnosis was approximately 21 days, without considering the patient spent time visiting other health units before being admitted. Added to this, the fact that a quarter of patients said they lost real job opportunities due to TB disease, and 79% of the patients reported that they would lose their current jobs after discharge.

Cost-effectiveness

Comparing the two approaches for TB diagnostics incurred by the patients, the incremental cost-effectiveness of MGIT compared to LJ, at HC and at UH, was US$ 0.88 and US$ 4.03 per patient, respectively, to reduce the average time to adopt appropriate treatment [Table 3].

The aim of this study was not to compare the two types of unit – HC and UH but to compare both LJ and MGIT technologies in two different scenarios, an outpatient clinic and one in a hospital. To do this, we calculated the ICER admitting the range of variations effectiveness of tests between the 25th and 75th percentiles and found the variation in time indicators for the adoption of appropriate treatment (100 – the average time), as shown in Table 4 and in Figure 1. From the patient's perspective, the ICER ranged from US$ 1.39 to US$ 0.64 at HC and from US$ 6.52 to US$ 2.91 in University Hospital.

Table 1: Mean cost of patient in health clinic by gender

Gender	First visiting/collect				Regress/output				Total	
	Transport	Companion	Meal	Income loss*	Transport	Companion	Meal	Income loss**	2011**	2020***
Female (US$)	2.20	5.50	0.46	14.85	5.72	4.05	1.57	18.28	52.62	20.27
Male (US$)	0.59	0.00	0.45	38.75	2.50	0.00	0.12	39.38	81.78	31.51

*Due to how much the patient left to win because he or she had to go to the clinic, *Total using the conversion rate of U$1.00=R$ 2.00, ***Total using the conversion rate of U$1.00=R$ 5.19

Table 2: Costs disaggregated of patient seen at health center and university hospital per cost category

Costs variable	Outpatient at health clinic		Inpatient at university hospital	
	LJ, US$ (%)	MGIT, US$ (%)	LJ, US$ (%)	MGIT, US$ (%)
Direct				
Transport	7.18 (16)	8.58 (12)	6.48 (2)	6.48 (1)
Lunch	1.74 (4)	0.41 (1)	0.18 (0)	0.38 (0)
Patient companions	8.88 (20)	8.88 (12)	3.37 (1)	3.37 (1)
Drugs	$- (0)	$- (0)	6.67 (2)	25.00 (5)
Indirect				
Loss of income due to the time spent in the unit before and after diagnosis	26.11 (59)	56.61 (76)	330.27 (95)	435.82 (93)
Total*	43.90 (100)	74.48 (100)	346.97 (100)	471.05 (100)
Total**	16.91 (100)	20.27 (100)	133.7 (100)	181.5 (100)

MGIT: Bactec™MGIT™960 system. *Total using the conversion rate of U$1.00=R$ 2.00, **Total using the conversion rate of U$1.00=R$ 5.19. LJ: Löwenstein–Jensen

Table 3: Institute for Clinical and Economic Review at health center and university hospital

Intervention arm	Cost (US$)	Mean time to adopt appropriate treatment (days)	100-mean time	Incremental effectiveness	Incremental cost (US$)	ICER (US$)
Health center						
LJ	43.90	64.3	35.7	-	-	
MGIT	74.45	29.6	70.4	34.7	30.55	0.88
University hospital						
LJ	341.32	52.2	47.8	-	-	
MGIT	471.00	20.0	80	32.2	129.68	4.03

MGIT: Bactec™MGIT™960 system. LJ: Löwenstein–Jensen, ICER: Institute for Clinical and Economic Review

Table 4: Sensitivity analysis

	Variation of time to adopt appropriate treatment								
	25%	Median	75%	IND 25	IND median	IND 75	ICER 25	ICER median	ICER 75
Health center									
LJ	43.5	66.0	85.1	56.5	34	14.9			
MGIT	21.5	26.0	37.7	78.5	74	62.3	U$1.39	U$0.76	U$0.64
University hospital									
LJ	29.2	52.2	75.1	70.8	47.8	24.9			
MGIT	9.3	20.0	30.6	90.7	80	69.4	U$6.52	U$4.03	U$2.91

IND median: Indicator using the median, ICER median: ICER calculated using the median. ICER: Incremental cost-effectiveness ratio, LJ: Löwenstein–Jensen, MGIT: Bactec™MGIT™960 system

Table 5 shows the patient costs in relation to his monthly household income for the diagnosis of TB. It was higher than 10% in the Health Center and reached almost 50% in the University Hospital. In addition, the mean total costs incurred by patients at University Hospital (US$ 373.4 [2011]–US$ 143.89 [2020]) were higher than at Health Center (US$ 277.2 [2011]–US$ 106.8 [2020]). As seen in Table 2, the greater weight in the total cost refers to the indirect cost item associated with the loss of income cost and refers to the amount of income that has not been received due to being involved with the process of diagnosis. At the Health Center, this proportion was higher in the MGIT than LJ arm,

Table 5: Patient costs as a percentage of household income

	Household income average in minimal wage (SD)	Household income (US$)	Patient cost (US$)	Percentage patient cost of household income
Health center				
LJ+MGIT	1.65 (1.12)	420.75	57.87	14
LJ	1.80 (1.22)	459.00	43.90	10
MGIT	1.50 (1.03)	382.50	74.45	19
University hospital				
LJ+MGIT	3.33 (2.10)	850.00	410.53	48
LJ	2.41 (1.11)	614.32	341.32	56
MGIT	3.97 (2.40)	1.012.03	471.00	47

MGIT: Bactec™MGIT™960 system. LJ: Löwenstein–Jensen, SD: Standard deviation

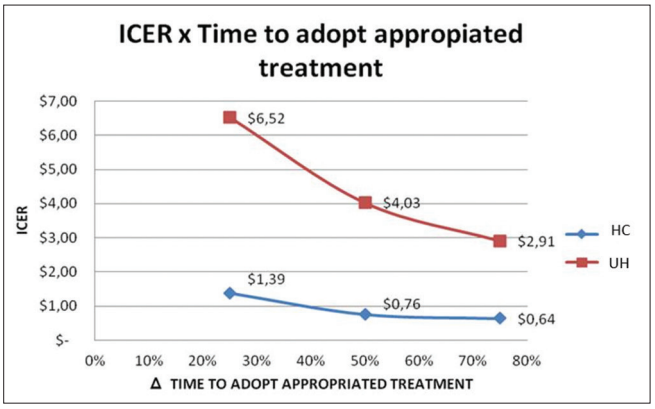

Figure 1: Incremental cost-effectiveness ratio according to different time to adopt appropriate treatment. HC: Health clinic; UH: University Hospital

while in the University hospital environment, MGIT weight was lower than in arm LJ.

Discussion

The desired improvement in the mean time needed for adopting the appropriate anti-TB treatment associated with new diagnostic interventions implies that this reduction should be achieved by low incremental costs. In our study, the changing time for TB diagnosis, in the Health Center, the MGIT showed a low ICER compared to LJ, while at the university hospital, the ICER was four and half times higher for the MGIT. These scenarios refer to the opportunity cost had greater losses in proportion, given the losses associated with hospitalization in case of inpatients.

The high proportion (40% at Health Center and 41% at University Hospital) of patients that had to visit more than two health units to get the correct diagnosis and begin the appropriate TB treatment was a key cost factor incurred to the patient during the TB diagnosis. In Health Center, the proportion of patients with more than two visits to get the correct diagnosis was similar in LJ and MGIT arm in 37% and 45%, respectively. In University Hospital, this proportion was lower in LJ arm (8%) compared to MGIT arm (61%).

Our study is innovative when comparing the costs of patients attended at a health center with the costs of hospitalized patients specifically linked to the laboratory method used to perform the culture; however, our results are similar to those found in a study carried out in India where the highest costs related to TB were from hospitalized patients.[8]

Minimal wages were higher among patients attended at hospital than those patients attended in Health Center. Probably, it is related to the fact that only 16% of patients attended in Health Center have employment and social security comparing to 34.4% of those attended at University Hospital. These data highlight the importance of social security programs as an auxiliary tool to guarantee the patient the right of access to health services, which in the case of Brazil is public and universal, highlighting the management of TB that is guaranteed by SUS.[11,15]

Although the government provides the infrastructure, materials, and key services involved in the TB diagnosis, since while the correct diagnosis and initiation of appropriate treatment does not occur, the patient visits various health-care units, thereby incurring expenditures on transportation, food, companion, and estimated costs related to the time devoted to these visits.[8,15,16]

The same occurs when the patient is hospitalized, in which case these costs are even higher, since the patient as a rule is unable to carry out their professional activities as reported in the literature.[10]

In our study, there was no difference on costs incurred by age as described by Wingfield *et al.*,[17] and different from mentioned by Mesfin *et al*.[16] and Umar *et al*.[18] where was higher for women. In our study, the major component of total patient costs was indirect costs,[17] at health post and at hospital, in both the approaches (MGIT or LJ) similar to described by others.[8,16,19]

Another interesting point, in our study, in Health Center, 52% of patients stated that they had one or more persons under their financial dependence. This suggests that in case of loss of income from patient more people would also be indirectly affected. The measure of indirect costs within the loss of income suffered by these patients based on the TB diagnosis is important to establish the catastrophic costs, defined by the WHO for the total costs due to TB, as defined by the 20% of annual income threshold, of each household.[20]

In this study, the catastrophic cost was not calculated due to the fact of poor dates of the patient's and household incomes, and it is one limitations of this study. This study has some other limitations: we enrolled a small number of TB patients that precluded robust statistical analysis, and we relied on self-reported costs. Thus, recall and reporting bias cannot be excluded, even conducting interviews within 30 days of starting treatment. However, this study has some strengths as including patients who were enrolled in a pragmatic clinical trial and it was the first study that evaluated the ICER of MGIT compared to standard reference at health post and at hospital, in a high-burden country.

Conclusions

The changing time for TB diagnosis, in the Health Center, the MGIT showed a low ICER compared to LJ, while at the University hospital, the ICER was four and half times higher. Despite the patients do not have to pay medical consultation in the units nor the needed diagnostic tests, as these services are offered by the Universal Health System in Brazil, the income loss reported by patients to the process of TB diagnosis presents as a significant portion of the costs and may be contributing to loss of savings and aggravating catastrophic costs for families with patients with TB.

Ethical clearance

The research project was approved by the Ethics Committee in Research of UFRJ, under number 020/07 and the Clinical Trial Registry: ISRCTN79888843.

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Conflicts of interest

There are no conflicts of interest.

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