Cost-Effectiveness analysis of malaria diagnosis techniques in patients with suspected malaria in Hormozgan province- 2012

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Original Article

Abstract

Introduction: Since ancient times Malaria in Iran has been considered as a serious health risk, especially in Hormozgan Province, as no other disease like Malaria has imposed irreparable financial and life losses to the country. Since saving costs in the healthcare sector comes as first priority in most countries, this study aims at launching a cost-effectiveness analysis on malaria diagnosis diseases in the fevered patients with suspected malaria in Hormozgan Province.

Methods: The target population of this study was all fevered patients with suspected malaria who have referred to the healthcare centers. All subjects whose disease was diagnosed correctly (both truly positive and truly negative) with microscopy methods and malaria rapid diagnostic tests (RDTs) were selected as the final population in this study. Decision tree analysis and Treeage2011 software were used for conducting cost-effectiveness analysis and sensitivity analysis of both abovementioned methods. Sensitivity analysis was performed for the key variables.

Results: Results of the study indicated that the total cost of the microscopy method was 18293576000.2 Rials and the total cost of RDT method was 1739980000 rials. Cost per each correct diagnosis by RDT was 17399 rials and cost per each correct diagnosis by microscopy method was 18293 rials. The total cost-effectiveness resulted from microscopy and RTD methods were 92135 and 90298 cases, respectively. The incremental cost-effectiveness ratio (ICER) for each correct diagnosis by the microscopy method in contrast to RTD method was 47052 rials. The mean cost-effectiveness ratio for RDT was 19289; whereas it was 19862 for the microscopy method. Sensitivity analysis results indicate that when sensitivity of the microscopy method for Plasmodium vivax is below 0.981, then RDT will be the cost effective method.

Conclusion: This study demonstrated that RDT in contrast to the microscopy method is cost-effective, if its high accuracy is maintained.

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Introduction:

Malaria is among the significant health problems of many countries, particularly tropical lands. Malaria causes anemia and several relapses and undermines workforce in these countries which is usually followed by negative consequences on their economic and agricultural situation. Despite improvement in socioeconomic situation of the involved countries and launching anti-malaria campaigns during the recent decades, sadly the mortality and death rate of malaria is so high that it is recorded as a serious health condition in the world (1). About 3.3 billion people in the world are at risk of malaria and about 1 million people in the world lose their life because of malaria. In 2009,108 countries in the world faced problems caused by malaria and 107 billion dollars have been devoted to fight against this disease (2). In Iran also, since ancient times, Malaria has been treated as a serious health problems of the country, especially in the Hormozgan Province, as no other disease like Malaria has imposed irreparable financial and life losses to the country (3).

Using reliable and efficient diagnostic techniques in the endemic countries is essential. Such techniques enable the healthcare centers and organizations to minimize quickly and properly risks, consequences, disease duration hence its economic and health losses (4). Microscopy of thick stained blood smears remains a standard method for diagnosing malaria (5). Today, malaria in Iran is diagnosed via observing the parasite in the smear prepared from the peripheral blood through microscopy method (6). This method enables the therapist to observe the parasite directly and this all species of plasmodium are diagnosed and their quantity in blood is counted. This method needs an advanced lab and trained microscopists. Another diagnostic technique, introduced in 1990, is rapid diagnostic tests (RDTs). RDT is able to diagnose certain antigens of plasmodium in the blood collected from the finger tips. Diagnosis with RDT can last only 15 minute and by technicians with the least possible training. It does not need electricity power or any other specialized equipment (7). Various studies have reported its high accuracy in Brazil, Colombia, Africa and Asia (8,9).

Moreover, Luble et al. (2007) (10), Chilkate et al. (2008) (11) and Roland et al. (2006) (12) concluded that alternative diagnostic techniques are needed because of low accuracy of the available diagnostic techniques.

Many studies about malaria have been carried out in Iran, so far. However, there is no study about cost-effectiveness analysis of using malaria diagnostic methods in Iran. Cost-effectiveness analysis helps decision makers to find the most economic strategy out of all interventions that have common outcomes. Thus, it will be possible to attribute the available resources for achieving the better healthcare outcomes. Likewise, since saving costs in the healthcare sector is one of the first priorities, using more cost effectiveness methods will help considerably the healthcare economy. Regarding the high prevalence of malaria in southern parts of Iran, including Hormozgan Province, and lack of precise information about cost-effectiveness ratios of malaria diagnostic methods in this area, this study started with the aim of analyzing cost-effectiveness ratio of malaria diagnostic methods in fevered patients with suspected Malaria in Hormozgan Province.

Methods:

As an economic assessment, this study analyzes two diagnostic methods of Malaria including microscopy and RDT from the viewpoint of a healthcare service provider, i.e. Hormozgan University of Medical Sciences, for a full year (2012). The target population in this study was all fevered patients with suspected malaria which has been modeled and measured for a hypothetical cohort of 100000 people and the targeted outcome was number of patients who have been diagnosed correctly (truly positive and truly negative) by microscopy and RDT methods. Decision tree analysis and Treeage2011 software were used for conducting cost-effectiveness analysis and analyzing sensitivity of both abovementioned strategies.

Calculating Costs

Costs included direct medical costs which were collected from the available resources of Hormozgan University of Medical Sciences and healthcare networks of the province. All costs were measured in Rial (Iranian formal currency). Costs of microscopy method included costs of buying

slides, consumer goods and relevant requirements, cost of equipments (buying microscopes) annual salaries of employees, microscopists and training them. Costs of RDT technique include cost of buying diagnostic tests, salaries of healthcare staff and cost of training them. Cost of equipment and staff were divided among healthcare tasks, regarding the project's volume. It is necessary to note that costs of quality control process in microscopy method and diagnostic tests and costs of maintaining lab equipment were not calculated in this study.

As you can see in this figure, the cohort of 100000 fevered patients with suspected malaria who refer to healthcare centers and they are decided to be diagnosed with microscopy or RDT methods in the diagnosis process are included. They may have or have not malaria. If someone has malaria, his/her diagnostic test will be positive (i.e. he/she has Plasmodium falciparum or Plasmodium vivax) and as a result he/she is truly positive (sensitivity). Likewise, if a patient has malaria but his/her test result is negative, the results will be false negative (-1 sensitivity). On the other hand, if a patient has not malaria and his/her test becomes negative, he/she will be truly negative (specificity) but if his/her test become positive, he/she will false positive (-1 specificity). Both truly negative and positive cases are considered cases with correct diagnosis, whereas false positive and negative are considered cases with incorrect diagnosis and both are used as the outcome of each diagnostic technique in the terminal node of the decision tree.

Cost-Effectiveness Analysis:

All costs incurred for diagnosing malaria in 2012 for both strategies have been estimated for a cohort of 100000 patients. In this study, cost-effectiveness analysis is conducted based on the number of correct diagnoses among fevered patients with suspected malaria and costs of each diagnostic method. Incremental cost effectiveness ratio (ICER) was calculated regarding the required incremental cost for correct diagnosis of a fevered patient with suspected malaria in RDT strategy versus microscopy method.

Information Collection Resource:

Epidemiologic information and probabilities were collected from the annual reports of Ministry of Health, scientific references and authenticated domestic and international articles. This information includes prevalence of Malaria in Hormozgan Province, malaria prevalence ratio in terms of Plasmodium falciparum, sensitivity and specificity of microscopy and RDT methods for Plasmodium falciparum and Plasmodium vivax (Table 1).

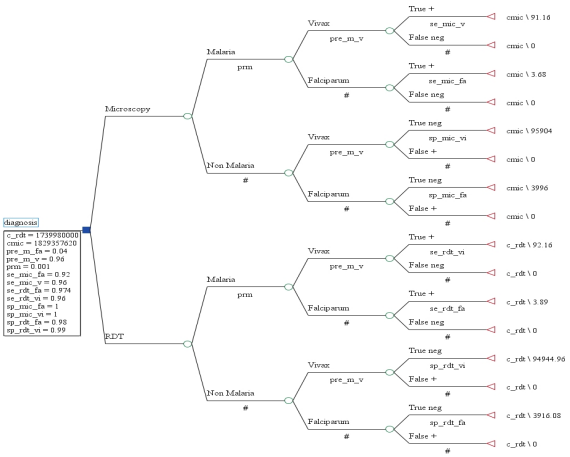

Figure 1. Decision tree for two strategies of malaria diagnosis in fevered patients with suspected malaria

(c_rdt: cost RDT, cmic: cost_microscopy, pre_m_f: prevalence_malaria_falciparom, pre_m_v: prevalence_vivax, prm: prevalence malaria,se_mic_fa: Sensitivity_ microscopy_ falciparom, ,se_mic_v: Sensitivity_ microscopy_ vivax, ,se_rdt_fa: Sensitivity_ rdt_ falciparom ,se_rdt_v: Sensitivity_ rdt_ vivax, sp_mic_fa: specificity _ microscopy_ falciparom, sp_mic_vi: specificity _ microscopy_ vivax, sp_mic_rdt: specificity _ rdt_ falciparom, sp_rdt_vi: specificity _ rdt_ vivax)

Results:

Since this model has been considered for a cohort of 100000 people, the total cost of microscopy method was 18293576000.2 rials and the total cost of RDT method was 1739980000 rials (Table 2). Cost per each correct diagnosis by RDT was 17399 rials and cost per each correct diagnosis by microscopy method was 18293 rials. The total cost-effectiveness gained from microscopy and RTD methods were 92135 and 90298 cases, respectively (Table 3).

Since cost per each correct diagnosis by RDT was 17399 rials and cost per each correct diagnosis by microscopy method was 18293 rials, the extra charge for each diagnosis in microscopy method was 894 rials.

Table 1. Epidemiologic parameters used in cost-effectiveness analysis model of malaria diagnostic methods

Definition	Estimations	References
Malaria prevalence in population	(0.0001-0.2) 0.001	Ministry of Health and Hormozgan University of Medical Sciences
Patients with malaria because of P. vivax	0.96 (0.8-0.98)	Ministry of Health and Hormozgan University of Medical Sciences
Patients with malaria because of P. falciparum	0.04 (0.02 -0.2)	Ministry of Health and Hormozgan University of Medical Sciences
Microscopy sensitivity for P. vivax	0.96 (0.77-1)	(15-17)
Microscopy sensitivity for P, falciparum	0.92 (0.75-1)	(16,17)
Microscopy specificity for vivax	1 (0.95-1)	(15)
Microscopy specificity for falciparum	1 (0.59-1)	(11,16)
RDT sensitivity for P. vivax	0.96 (0.62-1)	(7), experts, the developer
RDT sensitivity for P. falciparum	0.97 (0.84-1)	(7,11), experts, the developer
RDT specificity for P. vivax	0.99 (0.8-1)	(7), experts, the developer
RDT specificity for P. falciparum	0.98 (0.9-1)	(7,11) experts, the developer

Table 2. Unit and total costs of strategies used to diagnose malaria with a cohort group of 1000000 patients

Options	Unit cost (basic and variable) 1000 rials	Microscopy strategy (1000 rials)	RDT strategy (1000 rials)
Thick and thin blood smear	6.5 (3.92-15.99)	650000	-
Rapid diagnostic test	12 (7.356-30.65)	-	1200000
Annual salaries of microscopists	42000	588000	-
Annual salaries of healthcare staff	38400	537600	537600
Annual costs of microscopes	1123.26	15725.64	-
Costs of training	2716.57	38031.98	-
Costs of training RDT	170	-	2380
Total costs	-	182935.62	1739980

Table 3. Results of cost-effectiveness of microscopy method versus RDT method; Hormozgan Province- 2012

Strategy	Cost per each correct diagnosis (rials)	Extra charge (rials)	Cost-effectiveness per each correct diagnosis	Extra cost-effectiveness	ACER	ICER (rials)
RDT	17399	-	0.902	-	19289	-
Microscopy	18293	894	0.921	0.019	19862	47052

The mean cost-effectiveness ratio for RDT was 19289 which is calculate by dividing cost of each diagnosis by each case of diagnosis; whereas it was 19862 for the microscopy method; it indicates that the mean cost-effectiveness ratio is lower for RDT. Since the const-effectiveness ratio in the basic scenario of RDT method is higher than that in the microscopy method, the ICER per each correct diagnosis by microscopy in contrast to RDT method was measured 47052 rials. It indicates that in contrast to RDT method, the cost needed to achieve a more unit of effectiveness by microscopy method is equal to 47052000 rials (Table 3).

Sensitivity Analysis

Sensitivity analysis is a method used for analyzing the effect of uncertain parameters on the results. In this study, sensitivity analysis was used for some variables such as sensitivity and specificity of diagnostic methods, malaria prevalence, ratio of malaria subjects because of P. vivax and P. falciparum and costs of each diagnostic strategies through one-way sensitivity analysis method.

Sensitivity analysis showed that cost-effectiveness ratio is sensitive to some variables and this model is sensitive to trivial variations on specificity of both microscopy and RDT methods in diagnosing malaria. The highest effect on result is seen when the specificity of microscopy method for P. vivax is below 0.981, in this case RDT will be cost effectiveness. If the specificity of RDT is increased from 0.8 to 0.99 and 1 for P. viva, cost per each extra diagnosis for microscopy method will increase from 6470 to 48663 and 96511. When

the ratio of malaria cases because of P. vivax is changed from 0.8 to 0.98, the cost per each extra diagnosis for microscopy method will decrease from 57408 to 47754 and when the total cost of RDT is more than 1829357000.62 rials and the total cost of microscopy method is less than 1739980000 rials, then the microscopy method will be cost effectiveness (Table 4).

Table 4. Sensitivity analysis of key parameters of the results, Hormozgan Province-2012

Parameter and its values		ICER (rials)
Microscopy specificity for P.vivax	1	48633
	0.981	1003109
	0.98	Microscopy dominated
RDT specificity for P.vivax	0.8	6470
	0.99	48663
	1	96511
P. vivax prevalence	0.8	57408
	0.98	47754
Total cost of microscopy strategy less than 1739980000 rials		Rapid test dominated
	1740000000 rials	184
	2770000000 rials	565367
Total cost of RDT strategy more than 1829357000.62 rials		Rapid test dominated
	1820000000 rials	3467
	1270000000 rials	301516

Conclusion:

In this study, when we consider just costs of diagnosis process, then RDT method will be more expensive than microscopy method; however, when the total costs are considered, then microscopy method will be dominated. In this study, cost of diagnosis process without considering other costs of RDT for a 100000 patients' cohort is equal to 1200000000 rials and for microscopy method will be 650000000 rials; thus, in this case RDT is the dominated method. However, when other costs are added to the cost of extra diagnosis cost, the total cost of microscopy cost will be 1829357000.62 rials and the total cost of RDT method will be 1799980000 rials and the former will be more expensive. As a result, regarding results of this study, cost per each diagnosis case by RDT is 17399 rials and for microscopy method is 18293 rials. Thus, there is a trivial difference between the two strategies in terms of cost for each diagnosis.

In this study the average cost effectivenessness of RDT and microscopy methods is 19289 and 19862 rials, respectively which shows that the average cost effectiveness ratio of RDT is less than the other method and the incremental cost effectiveness ratio for each correct diagnosis by microscopy method was 47052 rials. Paskalina Chanda et al. in Zambia showed that RDT in contrast to other clinical and microscopy methods is more cost effective in diagnosing malaria in the healthcare centers in Zambia. In this study, the average cost-effectiveness ratios showed that RDT (US$ 6.5) was more effective than microscopy method (US$ 11.9) and clinical diagnosis (US$ 17.1) for the positive cases that have been diagnosed correctly. The results also showed that RDT in contrast to microscopy method will be more cost effective and inexpensive (10).

When in this study it was seen that the specificity of microscopy method for P. vivax is below 0.981, RDT will be cost-effective. If specificity of RDT for P. vivax is increased from 0.8 to 0.99 and 1, then cost per each extra diagnosis for microscopy method will increase from 6470 to 48663 and 96511, respectively. Oliviera et al. (2010) made a study in remote parts of Amazon in Brazil and concluded that if in this region the high specificity of microscopy method is maintained (its sensitivity for P. falciparum and P. vivax was 92% and 95% and its specificity was 100%), it would be more cost-effective in contrast to RDTs. This study also demonstrated that this model is sensitive to variations of specificity and sensitivity of microscopy method for diagnosing malaria; as when sensitivity and specificity of microscopy method for P. vivax are 0.90 and 0.98 and also its sensitivity for P. falciparum is 0.83, then RDT would be more cost-effective in contrast to microscopy method (7).

Sensitivity analysis in this study indicated that parallel with variations of malarial prevalence because of P. vivax from 0.8 to 0.98, ICER for microscopy method will change from 57408 to 47754, which it suggests that parallel with increasing prevalence of P. vivax, cost per each extra diagnosis for microscopy method will decrease. Chilateet al (2008) in a study, cost-

effectiveness of malaria diagnostic method in southern African countries in a course of combined treatment, concluded that in a confidence level of 95% and prevalence rate of below 62% RDTs were more cost-effective rather the hypothetical treatment and in the same confidence level and a prevalence rate higher than 90%, RDTs were not cost-effective in contrast to the hypothetical treatment. Similarly, in all prevalence levels of this disease, RDT in contrast to microscopy method, with the probability of higher than 85%, is cost-effective; with higher cost effectiveness of RDT fundamentally will result in improvement of this treatment and saving costs of anti-malaria drugs and increasing health outcomes for people who are not in the area (11). Since saving costs in the healthcare sector comes as first priority in most countries, using less expensive methods or methods with similar effectiveness will considerably help the healthcare sector's economy and this issue was dealt with in this study. After doing several analyses, this study demonstrated that RDT in contrast to microscopy method, if its high accuracy is kept, is more effective.

Finally, the results of this study showed that making decision for using microscopy method or RDT as an alternative diagnostic method in Hormozgan Province in terms of cost-effectiveness ratio heavily depends on identifying the real accuracy of microscopy method and RDT in the field and RDT is the best available diagnostic method as the alternative strategy in the field where there are not necessary infrastructure and the high accuracy of microscopy method is not reliable.

Lack of information resources on sensitivity and specificity of RDT in Iran and also lack of references, information and previous studies on this subject in Iran were among the constraints of this study.

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