

Original Article

Cost Effectiveness of Malaria Interventions from Preelimination through Elimination: a Study in Iran

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Abstract

Background: Malaria still is considered as a public health problem in Iran. The aim of the National Malaria Control Department is to reach the elimination by 2024. By decreasing the number of malaria cases in preelimination phase the cost effectiveness of malaria interventions decreases considerably. This study estimated the cost effectiveness of various strategies to combat malaria in preelimination and elimination phases in Iran.

Methods: running costs of the interventions at each level of intervention was estimated by using evidence and expert opinions. The effect of each intervention was estimated using the documentary evidence available and expert opinions. Using a point estimate and distribution of each variable the sensitivity was evaluated with the Monte Carlo method.

Results: The most cost-effective interventions were insecticide treated net (ITN), larviciding, surveillance for diagnosis and treatment of patients less than 24 hours, and indoor residual spraying (IRS) respectively, No related evidence found for the effectiveness of the border facilities.

Conclusion: This study showed that interventions in the elimination phase of malaria have low cost effectiveness in Iran like many other countries. However ITN is the most cost effective intervention among the available interventions.

Keywords: Malaria, prevention and control, Iran, cost effectiveness, IRS, ITN

Introduction

Based on the endemicity of the disease, malaria-hit areas are classified into four main groups: control, pre-elimination, elimination and prevention of reintroduction. The measures to be adopted to fight the disease are different in each of these stages. As the incidence of the disease reduces over time across the country elimination programs mainly focus on

malaria foci rather than whole region (Mendis et al. 2009).

The prevalence of malaria has reduced in Iran during the past few years, placing Iran among the countries classified as nations in the pre-elimination phase (Edrissian 2006). As a result, the intervention strategies have changed upon the decline noted in the num-

ber of affected cases. At the time being, various measures, such as vector control activities, early diagnosis systems and some other complementary measures have been adopted to fight malaria in elimination phase around the world (Moonen et al. 2007), but there are limited studies about their efficacy and cost-effectiveness in this phase, in addition many of the previously-approved strategies including early warning system have never been adopted in the Iranian health care system.

Many researchers have studied the cost-effectiveness of different strategies adopted to fight malaria across the globe; but most of them were conducted in malaria-endemic areas. In other words, not many studies have targeted the low-endemic areas (Goodman et al. 2000, Yukich et al. 2008, Kang et al. 2008) so using models seems necessary in this situation. Developing an accurate model, therefore, can play an important role in this regard, particularly in conditions in which there is limited evidence or unapproved documents and reports. The importance of these modeling is highlighted at times when the policy-makers are to decide upon setting up a program (Goodman et al. 2000).

The present study aims to estimate the cost as well as cost-effectiveness of main strategies to combat malaria in the pre-elimination and elimination phases in a malaria focus as a unit of malaria combat operation in Iran.

Materials and Methods

Interventions assessed

A total of seven interventions were assessed. These interventions include: larviciding, indoor residual spraying (IRS), distributing insecticide treated net (ITN), set up the diagnosis and treatment in less than 24 hours, and set up the border facilities.

General consideration

This study was conducted in perspective

of Ministry of Health and Medical Education (MOHME), time period for effects was considered one year, we consider the case averted as outcome. Basis for evaluating most of intervention was a focus with 500 peoples population. The interventions defined as bellow:

Larviciding: a focus with 200m² water resource area, which needs 10 times larviciding operation every year.

IRS: A focus with 200 building, in each building there is 100m² area needs to insecticide spraying two rounds a year.

ITN distribution: A focus with 100 households (each having an average of 5 members), for each household a bed net would be distributed with 5 years life time.

Establishment diagnosis and treatment in less than 24 hours: it means intensified activities for detecting and treatment of malaria cases using the current structure of health care system in affected regions.

Set up border posts: The intervention included the establishment of a facility that has been deployed in the border areas. Their task is providing diagnosis and treatment services to those who live and travel to the edge of the border.

Cost assessment

Cost for each intervention were assessed in different central and peripheral levels in five expenses groups, by using expert opinions, current evidences and documents. When a resource was used for several tasks, its cost was calculated proportionally. These five groups consist of: building and its currents expense (water, electricity power, telephone, warming and cooling), capital expenses, operational expenses, human force, and transport. In case of building we consider the rent of similar building, in addition a 3% discount rate considered for capital goods.

Effectiveness

The cost effectiveness of the interventions was assessed based on evidence-based con-

trolled trials and meta-analyses if possible. The case averted considered as outcome variable in our study. The evidence was selected from studies in low-endemic areas and as for conditions with no reliable evidence expert panels were held. The comparison was made based on the epidemiologic status of the region (control, pre-elimination, elimination) as well as the endemicity status at the time when no strategy against the disease had been adopted (Raeisi et al. 2004).

Sensitivity analysis

Considering the effect of undetermined variables of cost and efficacy on the intervention, Mont Carlo analysis was used to assess the sensitivity of the interventions. In this regard the triangle distribution was used to calculate the cost for each variable. The point estimation, as the most likely estimate, was considered the vertices of the triangle distribution (Goodman et al. 2000) As for the maximum and minimum values, 10 percent was added to and subtracted from the point estimation value, respectively. Sampling was repeated in 20000 times.

Results

Table 1 provides a list of different costs met in this study. As mentioned in the material and methods section, these interventions have been followed at different levels and therefore var-

ious numbers of individuals may have benefited from the intervention. The development of border posts and providing prophylactic treatment accounted for the highest cost per capita. Figure 1 shows the combination of fees spent on different strategies. Similarly, the highest fee was paid for human resources for border posts and diagnostic and therapeutic system in less than 24 hours. Building charges hold the smallest share in the funds.

In view of the available evidence and the expert panel, the relative risk of the protective properties of each of these strategies were determined, the highest case averted was for diagnosing and treating the patients in less than 24 hours. No evidence was found regarding the development of border posts. The decline noted in the number of affected cases was then calculated in four different scenarios based on the incidence of malaria in the region (Table 2).

IRS (Indoor Residual Spraying), ITN (Insecticide Treated Net), API (Annual Parasite Incidence). The most cost-effective interventions, were the use of insecticide-treated nets, larviciding, diagnosis and treatment in less than 24 hours and indoor residual spraying (Table 3, Fig. 2) along with the changes made in the cost effectiveness as the incident of the disease declines over time are shown. As shown in the Fig. 2, the cost per averted cases increases considerably as the number of affected cases decreases.

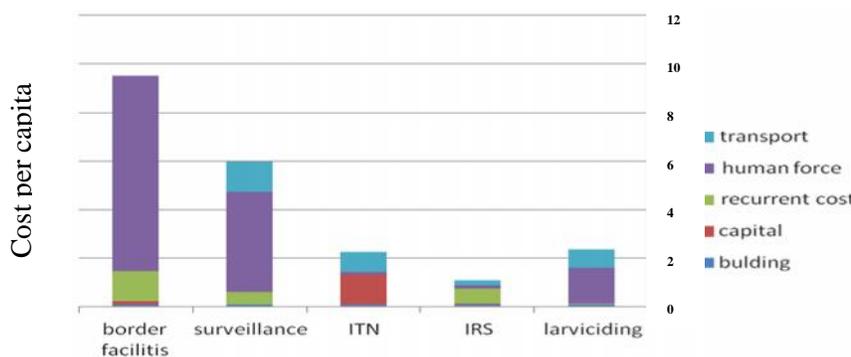


Fig. 1. Cost per capita for each intervention based on its components (US Dollar) IRS (Indoor Residual Spraying), ITN (Insecticide Treated Net)

Table 1. Annual cost of studied intervention based on their components and their cost per capita (US Dollar)

Costs	Building	Capital expense	Operational expense	Human force	Transport	Total	Population*	Per capita
larviciding	49	0	24	741	370	1184	500	2.37
IRS	49	12	309	74	111	555	500	1.11
ITN	49	311	0	57	407	824	500	1.65
Surveillance	49	0	267	2052	630	2997	500	5.99
Border facilities	49	63	630	4024	0	4765	500	9.53

* This includes the proportion of whole cost needed for each interventions. IRS (Indoor Residual Spraying), ITN (Insecticide Treated Net), API (Annual Parasite Incidence)

* population under service ** cost per capita for each intervention, calculated by dividing total price by population

Table 2. The composition of cost for each intervention

Costs	building	Specialized equipment. (life time> 1year)	Supply (life time< 1year)	Human force
larviciding		0	Larvicide	Larviciding activity and supervision
IRS		Pump	Insecticide	IRS operation and supervision
ITN		200 ITN	0	Distribution, training and supervision
surveillance		0	RDT, antimalaria drug	Active and passive surveillance, supervision
border facilities	Rent for building, cost of warming and cooling, office equipment and current expense	Microscope, medical equipment	RDT, antimalaria drug	Active and passive surveillance, supervision

Table 3. Estimating the efficacy of the strategies in reducing the incidence of the disease and the number of affected cases (relative risk)

intervention	Point estimate	Interval	Reference	Number of averted cases in different epidemiologic setting			
				Elimination API= 0.34	Preelimination API=2.4	Control, API=12.9	Historical evidence API=350
Larviciding	0,35	0,3–0,4	(Invest and Lucas 2008)	0.0595	0.42	2.2575	61.25
IRS	0,12	0.10–0.14	(Pluess et al. 2010)	0.0204	0.144	0.774	21
ITN	0,48	0,52–0,44	(Lengeler 2004)	0.0816	0.576	3.096	84
Diagnosis, treatment in less than 24 hours	0,66	0,7–0,62	(Carrara et al. 2006)	0.1122	0.792	4.257	115.5

Table 4. The cost-effectiveness rate for case averted in each intervention

Intervention	Cost effectiveness in assumed population			
	Point estimate (CI 95%)			
	Elimination API= 0.34	Preelimination API= 2.4	control API= 12.9	Historical evidence API= 350
Larviciding	22378.4 (20247.52–24901)	3170.27 (2865.58–3541.81)	589.82 (533.59–656.1)	21.74 (19.65–24.2)
IRS	30582.42 (27373.73–34550.42)	4332.51(3864.05–4886.9)	806.05(720.8–910.85)	29.71(26.57–33.6)
ITN	19891.91 (17646.76–22617.98)	2818.02 (2497.5–3214.54)	524.28 (465.11–596.94)	19.32 (17.11–21.97)
Diagnosis, treatment in less than 24 hours	30049.15 (28246.64–31928.47)	4256.96 (3999.47–4524.27)	791.99 (743.78–841.09)	29.19 (27.45–31.04)

IRS (Indoor Residual Spraying), ITN (Insecticide Treated Net), API (Annual Parasite Incidence)

Table 5. The cost-effectiveness of the intervention in other studies

Intervention	Location	Cost effectiveness	Cost per capita (US \$)	Program phase	Reference
ITN	South Africa	18	-----	control	(Goodman et al. 2001)
IRS	Mozambique	20–29	3,84	control	(Conteh et al. 2004)
IRS	Eritrea- Togo	-----	1.2–6	control	(Yukich et al. 2008)
ITN	Eritrea- Togo	-----	1.38–1.91	control	(Yukich et al. 2008)
ITN	Togo	3.26	-----	control	(Mueller et al. 2008)
Larviciding	Sri lanka	0,50	-----	control	(Konradsen et al. 1999)

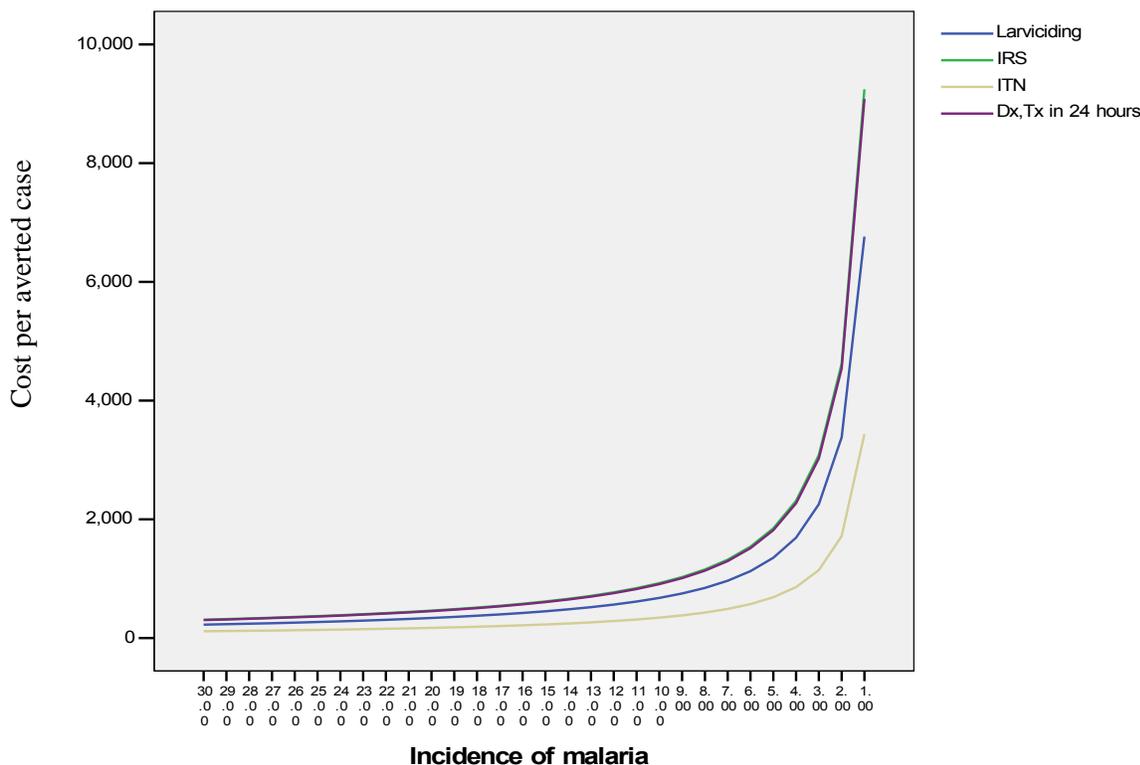


Fig. 2. Changes of cost effectiveness of different strategies with changes of malaria incidence

Discussion

The present study suggested that the most cost effective strategies in fighting malaria were the use of insecticide-treated nets, larviciding, diagnosing and treating the affected cases in less than 24 hours and indoor residual spraying respectively. The most important point in all of these strategies is the reduction noted in the cost effectiveness as the incidence declines. As a result, the cost effectiveness of the strategies has been reported to be much lower in our study in comparison with the malaria-endemic areas. The difference is believed to increase as the incidence declines. Compared with the cost-effectiveness rate of other researches (Table 4), our study had the highest rate. As shown in the table, there is a considerable difference in the our cost-effectiveness rate and the cost per capita which could be due to the difference noted in the fees,

effectiveness and the incidence. The latter is the main reason contributing to the difference. This also points out the considerable difference noted in the control and elimination phase.

Larviciding

Larviciding is among the strategies long been used in this regard. It had the second rank of cost effectiveness among used intervention but yet it seems so expensive in comparison with other studies (Table 5). It is more frequently adopted in areas with limited water resources and obviously the urban areas. The three Iranian malaria-endemic provinces are also reported to have low and scattered water resources. The adaptation of the technique in these areas, however, needs to consider its technical feasibility and efficiency.

Distributing insecticide-treated nets

Our study showed ITN as the most cost effective intervention, and considering its better acceptance in comparison with IRS, however it is less cost effective comparing with control setting in other studies (Table 5). Moreover, its use doesn't need any specific expertise or skilled human resources. In addition, the longevity of its effects lowers the distribution cost.

Indoor residual spraying

Vector control is one of the main components in malaria-elimination programs (Greenwood et al. 2008). This intervention had a lesser cost effectiveness and there is a high difference between our finding and similar studies (Table 5), furthermore it needs some equipments which make it harder to than other intervention, despite these fact, indoor residual spraying is one of the most important tools in this regard yet. Its use, however, is associated with certain challenges including resistance to the poison and not well being accepted in the society. Recent improvements in the housing conditions has also lowered the acceptability of spraying, limiting the measure to places used for keeping animals. It should be added that using the techniques in these places worsens the condition through forcing the mosquitoes to move to the places where humans live.

Diagnosing and treating the patients in less than 24 hours

The measure is among the priciest malaria-control interventions, and this is mainly because of its high cost of human resources. During the elimination phase, while the number of vector-control activities decline that of the healthcare activities increase. Referring to the WHO list for granting the malaria-elimination certificate, a vast number of activities should be adopted in the malaria care system, each of which is pricey and time consuming (Elimination 2007). Their main objec

tive is to develop an efficient system for rapid diagnosis and treatment of the patients and at the same time preventing from the spread of the disease in its early stages. As a result, the act, regardless of its cost, is necessary for achieving an elimination phase and hence one should benefit from the available healthcare system to lower the cost of surveillance to the lowest amount possible. For instance, using a delivery system by using motorcycle to send the samples to the laboratories equipped with microscopes can help considerably lower the cost of diagnosis and improve the accuracy of detecting the suspicious samples. This delivery system currently is used in some part the malarial region and it is successful.

Establishing border posts

This strategy is adopted in many parts of the world and there are sufficient evidence supporting its efficacy, particularly when used in confined areas. In this regard, one could highlight the successful attempt in Saudi Arabia, where the country built several posts on its border with Yemen and is paying for more than half of the total cost of the program (Meleigy 2007). In view of Iran's long border (2000 km) with Pakistan and Afghanistan, the adaptation of the strategy seems rather challenging, making it a great concern in the country's malaria elimination program (Tatem et al. 2010). Despite all these, establishing such posts play an important role in reducing the number of infected cases entering Iran and subsequently lowering the parasite reservoir in the country. Hence, despite its high cost, adopting such a measure seems necessary and more research is needed to be conducted to assess its impact.

Costs

As mentioned in figure 1, the establishment of border posts accounted for the highest. During the elimination phase when the incident cases declines, it is expected not to see

a considerable difference between their effectiveness. As a result, the most important factor in choosing the most appropriate intervention is its technical feasibility and efficiency and its cost. For instance, WHO stresses that indoor residual spraying is effective only if the whole area is sprayed (Najera and Zaim 2001). As a result, the strategy would not be effective if less than 80–85% of the area is sprayed and in these conditions, other efficient interventions should be considered.

Another important point is the composition of costs (Fig. 1), we can see in costs of two relatively expensive intervention, border facility and diagnosis and treatment of patients less than 24 hours the most component is human force expense, so applying multi-function staff can be considered an effective strategy to decrease their costs.

The present study showed a reduction in the cost-effectiveness of the interventions as the number of affected cases decline. As a result, assessing outcomes such as mortality and the number of affected cases on their own cannot be used as an acceptable indicator of cost-effectiveness and thus different aspects of the disease should be studied. In other words, each country should develop a criteria based on its current condition.

It should be noted that success of malaria elimination in many countries needs accepting financial risk which necessitate the paradigm shift to investing in malaria instead of a rapid and striking result (Sachs and McArthur 2005).

Malaria elimination program needs long term expenses until the disease totally eliminated (Sabot et al. 2010). Several studies have pointed out that the policymakers should not expect a short- or mid-term positive economic feedback from the program (Sabot et al. 2010). The high cost of the program, even at the time when the incidence of the disease is low, is the main point which should be highlighted before launching a control or elimination program. It should be kept in mind that the costs

may even increase in the latter condition and this is because of the high charges of intensified surveillance. Hence, the policymakers should be informed that several decades may be needed before malaria is completely eliminated and thus they should be committed to support the program for long-term at the beginning (Lines et al. 2007). It should be kept in mind that the only and at the same time the most important reason which caused the failure of the malaria program in 1960s was the governments' irresponsibility regarding the program (Hommel 2008). This comes while the results of a control plan are more noticeable than those of the elimination programs in the policymakers' point of view. As a result, policymakers should be briefed regarding the cost of the program and possible forthcoming challenges.

Considering the decline noted in the number of malaria cases and uncertainty regarding the efficacy of other interventions in Iran, the best measure for fighting malaria should be selected based on technical concerns and the cost. Moreover, it is necessary to define a more comprehensive outcome rather than conventional outcome like, morbidity and mortality of malaria for convincing the policy maker to sustain the elimination malaria program.

Limitations

The present study was based on the data gathered from the Iranian MOHME as well as the expert panels held to discuss specific scenarios regarding the disease. This comes while various variables such as population, area and ... may affect the results in the real life and thus may negatively influence the accuracy of our study. Despite all this, adopting certain modeling can play an important role in health care decision makings particularly at times when there is not much information available (Janssen and Martens 1997). It should also be added that the authors failed to find any evidence regarding the efficacy of establishing border posts in fighting malaria.

One of criteria for search strategy was finding evidence of effectiveness in low endemicity region, but yet we expect difference in efficacy in different low endemic area due to variation in climate, health system, ... We, however, had tried to reduce this bias through adopting the most conservative method.

Conclusion

This study showed that interventions in the elimination phase of malaria have low cost effectiveness in Iran like many other countries. However ITN is the most cost effective intervention among the available interventions.

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