

# Economic Evaluation of Using Pesticides to Control Cutaneous Leishmaniasis in Isfahan

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ABSTRACT

**Objective:** Pesticides have been used as the main part of the national cutaneous leishmaniasis control program for several years in Iran. However, the cost-effectiveness of this strategy has not been yet analyzed. The aim of this study is to analyze the cost-effectiveness and cost-utility of using pesticides as the main strategy to prevent rural CL in Isfahan. **Methods:** This is an economic evaluation study performed from a health system perspective to estimate the cost-effectiveness and cost-utility of the control strategy with and without pesticides. The outcome measures are incidence rate of cutaneous leishmaniasis and the disability-adjusted life years (DALYs). The cost-effectiveness and cost-utility have been analyzed by calculating incremental cost-effectiveness ratio (ICER). Data of cost and incidence rate obtained from the health centers of Isfahan University of Medical Sciences and Vice-Chancellery for Health. The disability weight was obtained from the literature. A one-way sensitivity analysis was applied with a 20% increase and decrease in costs. **Findings:** The total cost of control program in 2013 and 2014 were US\$578,453 (ppp) and US\$14,978.2 (ppp), respectively. The incidence rate of cutaneous leishmaniasis was estimated at 1396 and 1277 (per 100,000 population in hyperendemic areas where pesticides have been used) in 2013 and 2014, respectively. DALY lost due to disease was estimated to be 8.024 and 7.342 in 2013 and 2014, correspondingly. Both the cost-effectiveness and the cost-utility analyses resulted in negative ICERs, lying in the rejection area of the ICER plane. **Conclusion:** The use of pesticides to prevent cutaneous leishmaniasis (rural sicker) in Isfahan province has not proved to offer a reduction in the incidence rate of cutaneous leishmaniasis as well as reduction in DALYs lost. However, due to data availability limitation, the time frame for this study was limited. A prospective design with longitudinal data is recommended to be used by future research. Other alternatives to raise population awareness about different aspects of disease should be also considered for evaluation.

**KEYWORDS:** Cost-effectiveness analysis, cost-utility analysis, cutaneous leishmaniasis, rural sicker

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## INTRODUCTION

The leishmaniasis are a group of diseases caused by protozoan parasites called leishmania. Having passed a complex life cycle, these parasites are transmitted to humans by the bites of the infected female phlebotomine sand fly. There are three main forms of leishmaniasis: cutaneous, visceral or kala-azar, and mucocutaneous. The disease encompasses wide range of

clinical symptoms from skin lesions to intra-abdominal infections, rarely leading to death.<sup>[1,2]</sup> Cutaneous leishmaniasis (CL) is the most common form causing skin lesions and scars for a lifetime if diagnosis and/or treatment delayed.<sup>[1,3-6]</sup> According to the WHO report, CL is considered as an endemic disease in 98 countries.

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About one and half million people are annually infected, of those, >90% are from eight countries, i.e., Iran, Afghanistan, Pakistan, Syria, Saudi Arabia, Algeria, Brazil, and Iraq.<sup>[7-13]</sup>

In Iran, two forms of CL exist, i.e., urban/dry CL and rural/wet CL. Each year, more than 30,000 new cases have been registered; of those, nearly 80% are rural CL. Rural CL has been observed in some provinces such as Fars, Isfahan, Central and Northern Khorasan, Golestan, Kerman, Khuzestan, Bushehr, Hormozgan, Semnan, Sistan and Baluchestan, Yazd, and Ilam.<sup>[1,4,5,14]</sup> In Isfahan province (particularly in the north and northeast), CL is considered as a hyperendemic disease. Nearly 85% of new cases in these areas are younger than 6 years old; of those, at least 25% are infants between 0 and 1 year old.<sup>[1,6,10]</sup> Figure 1 illustrates incidence rates of rural CL in Isfahan province during 2002–2014.

The different preventive strategies for CL exist including affixing mosquito net for the windows and the doors of buildings, using insect repellents, improvement of waste collection system, destruction and reconstructing of vacant, destroyed or abandoned buildings, collection and disposal of animal wastes in a healthy way, and using pesticide to control the vector and reservoirs of the disease. A combination of various strategies is being used in Iran. The main strategies are based on using various pesticides sprayed in homes, using mosquito nets stained with deltamethrin 25% to control the vector and using zinc phosphide 2.5% as a rodenticide as well as aluminum phosphate tablets and chlorates to control the reservoir.<sup>[1,7,15,16]</sup>

Since 2003, CL Care and Control Protocol has been published by Ministry of Health and Medical Education in Iran. Since then and based on that protocol, killing rodents has been carried out each year quarterly in 52 districts in Isfahan province except 2014. To control vector in two epidemic districts of Varzaneh and Hashtom Shekari, deltamethrin 2.5% has been also sprayed in the form of fog on the buildings in the size of 9000 hectares.

Despite the high cost of CL prevention using pesticide, there are few studies on cost-effectiveness of this strategy.<sup>[7,16-18]</sup> Although this strategy is being carried out annually in the infected areas of the Isfahan province, the cost-effectiveness of this strategy has not yet been analyzed.

Therefore, the current study aims to analyze the cost-effectiveness and cost-utility of using pesticides as the main strategy to prevent rural CL in Isfahan. The results of this study can help decision-makers in public health sector to optimize resource allocation and to properly encounter this disease.

## METHODS

This is an economic evaluation analysis carried out from a health system perspective. The cost-effectiveness and cost-utility of the control strategy with pesticides has been compared to the control strategy without using pesticides. The cost-effectiveness and cost-utility have been analyzed by calculating incremental cost-effectiveness ratio (ICER). The study was reviewed and approved by the Ethics Committee of Isfahan University of Medical Sciences (ethical code: 395049).

In this study, a time horizon of 1 year from 2013 to 2014 was considered to calculate costs and consequences. In 2013, the CL control strategy combined both using pesticides and promotion programs. However, in 2014, it only included promotion programs and pesticides have not been used in this year. We compared the costs and consequences for these two strategies during 2013–2014.

The direct costs of the interventions paid by health-care system were calculated. Costs were classified into six groups including personnel costs, pesticides and supplies costs, transportation costs, the costs of promotion program, the costs of building and physical space, and other costs. Currency conversion was carried out based on the Purchasing Power Parity Index.

As consequence measures, incidence rate of cutaneous leishmaniasis (per 100,000 people in intervention centers) and the number of total disability-adjusted life years (DALYs) have been calculated for the year of 2013 and 2014. Data on costs and consequences have been obtained from District Health center involved in CL control program as well as provincial health center. The disability weight was obtained from the literature. Because a 1-year time horizon has been considered, it was not necessary to use the discount rate. Given that rural CL cannot lead to death, sum of the years of life lost due to premature mortality (YLL) considered as zero to calculate DALYs. According to Murray and Lopez study on global burden of disease, we applied a disability weight of 0.023 due to CL.<sup>[17,19,20]</sup> Disability duration, i.e., the time a patient lives with the disability due to the disease, was estimated at 0.25 years or 3 months.<sup>[11,16,17]</sup> To calculate DALYs, incidence rate in target population in a given year was multiplied by disability duration and disability weight. The result revealed the DALYs. Obtained values from ICER were expressed in terms of International US dollar per one more unit reduction in incidence rate or one more averted DALYs. A one-way sensitivity analysis was applied.

## RESULTS

A total cost of 578,453US\$ (ppp) was detected in association with the prevention strategy of using pesticides and promotion program in 2013. Personnel costs identified as the highest amount in this respect (approximately 69% of total cost). The costs of pesticides and supplies were 13% of total cost. In 2014, the costs of prevention strategy were merely the costs related to promotion program, i.e., prints, copies, dispensing of banners, posters, and pamphlets in at-risk areas and were estimated to be US\$14,978.2 (ppp) [Table 1].

The incidence rates were estimated 1395 and 1277 (per 100,000 population) in 2013 and 2014, respectively. The relevant DALYs were estimated to be about 8 and 7.5/100,000 population in 2013 and 2014, respectively. As presented in Table 2, the values of ICER calculated for both consequences including reduction in incidence rate and averted DALYs were negative. The results indicate that despite a higher cost on this intervention of using pesticide, less benefit was gained. Thus, the intervention lies in rejection area of ICER plane.

### Sensitivity analysis

Given that prices of used resources vary over time, a one-way sensitivity analysis was applied with a 20% increase and decrease in costs. With an increase of 20% in total cost, the calculated ICER calculated as US\$ 5,677.5 (ppp). With a decrease of 20% in total cost, ICER calculated as US\$3,785 (ppp). The area of ICER did not vary according to the new cost values and it

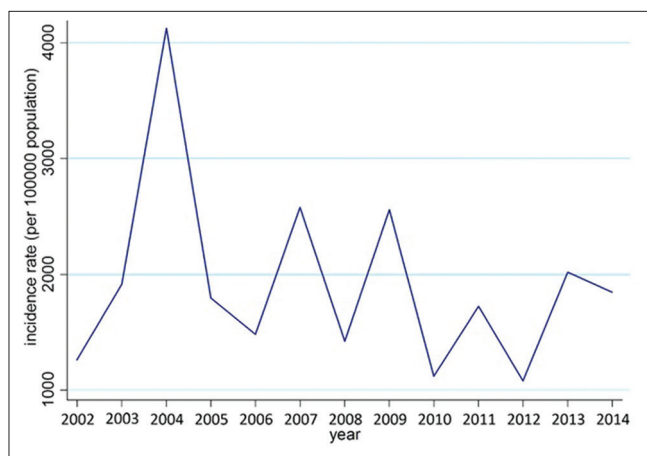


Figure 1: Trendline for incidence rates of rural cutaneous leishmaniasis in Isfahan province during 2002–2014

remained in rejection area, meaning that the results were not sensitive to changes in costs.

## DISCUSSION

Despite implementing programs to control the reservoir host and the vector of CL using various pesticides in Iran since 2008, a cost-effectiveness analysis of these strategies has not been yet carried. This study aimed to conduct the cost-effectiveness and cost-utility analyses of using pesticides (as an intervention) to prevent rural CL in Isfahan province during 2013–2014. The main alternative was the intervention of using chemical pesticides in 2013 versus the prevention without using pesticides strategy in 2014.

The results showed that higher costs do not lead to a benefit. It may be concluded that using pesticides is not a cost-effective strategy to prevent rural CL in Isfahan province.

There are few studies about the cost-effectiveness of preventive strategies for CL worldwide. Orellano *et al.* (2013) in Argentina provided a cost-effective analysis of staining workers' clothes and mosquito nets with pyrethroids compared versus the strategy of training workers providing services for early diagnosis and/or treatment of CL and finally found out that the strategy of using pyrethroids was not cost-effective.<sup>[17]</sup> Asilian (2002) reported the effectiveness of staining Iranian soldiers' clothes with permethrin to prevent CL is close to zero. Aflatoonian *et al.* (2010) suggested that measures such as spraying pesticide, using mosquito nets and nets stained with pesticide, may slightly help to control the disease and it appears that best alternatives to control CL are training, detecting, and treating patients. The cost of treatment also estimated at 6.6% of prevention cost.<sup>[7,16]</sup> Intervention programs focused on the natural reservoir of leishmania have also been tried but with mixed efficiency. One study in vaccinating dogs with a prophylactic vaccine found a significant reduction in the number of leishmania new cases.<sup>[21]</sup> Impregnated dog collars and the treatment of dings with insecticide drops have also shown a significant reduction in leishmaniasis disease burden. In contrast, in an intervention program performed between 1988 and 1996 in Brazil, 150,000 leishmania seropositive dogs were sprayed with insecticide in an attempt to cut the leishmaniasis life cycle.<sup>[22]</sup>

Table 1: Costs of preventing rural cutaneous leishmaniasis in Isfahan province during 2013-2014

Year	Costs						Total cost
	Personnel	Disposables	Transportation	Other	Training	Physical environment	
2013	400,941.4\$	74,625.1\$	29,727.4\$	46,818.5\$	25,645.1\$	695.4\$	578,453 \$
2014	-	-	-	-	14,978.2\$	-	14,978.2 \$

**Table 2: Incremental cost-effectiveness ratio of using pesticides strategy compared to incremental cost-effectiveness ratio of not using pesticides strategy to prevent rural cutaneous leishmaniasis in Isfahan province during 2013-2014**

Variable	2013	2014
Intervention population	92,874	91,555
New cases (incidence)	1296	1169
Incidence rate	1395	1276.83
DALYs	8.024	7.342
Prevention cost	578,453\$	14,978.2\$
Reduction in incidence rate		-118.61
Averted DALYs		-0.682
ICER in terms of reduction in incidence rate (per 100,000 people in the intervention population)		-4750.62
ICER in terms of prevented DALYs (per 100,000 people in the intervention population)		-34,424,766.4\$

DALYs=Disability adjusted life years, ICER=Incremental cost-effectiveness ratio

Although our findings suggest that using pesticides to prevent rural CL is not cost-effective, it should be considered that the number of new infected cases was reduced in 2014. Therefore, other factors involved in the incidence of CL should be taken into account. The incidence rate may be associated with many factors such as war, earthquakes, and agricultural and climate changes.<sup>[1,7,14]</sup> As none of those happened in 2014, we have assumed that the incidence rates of CL would be comparable in 2013 and 2014.

It may be supposed that the reduction in the CL incidence rate in 2014, is affected by interventions occurred in the former years. It should be mentioned that, since 2008 when the use of chemical pesticides has been started, the CL incidence rate was fluctuating, meaning that there is no a decreasing trend. However, the CL incidence rate in the time period of 2002–2007 is 25% higher compared to the following period of 2008–2013 which the intervention was implemented. It should be noticed that this reduction could not merely be associated with the intervention of using pesticides. It is because many other activities have been done in that time period to prevent CL, i.e., improving physical environment, health promotion programs to increase the health literacy of those who reside in endemic area, etc. The contribution of these programs to reduce the incidence of CL is inseparable from potential impacts of pesticide use.

As it has been mentioned, in this study, the CL incidence rate has been obtained from existing statistics in provincial as well as district health centers. However, it should be noticed that there is no an active case finding process. Case registration is passively based on patients'

seeking behaviors. Hence, if a patient had not referred to health centers, he/she was not registered as those who were infected by rural CL. It is particularly important because the supply of meglumine antimonate, a basic medication which is providing free of charge in health centers, was not enough in some periods due to the budget deficit. Due to the lack of supply of meglumine antimonate in public health centers, patient might have no incentive to choose public centers for treatment, and thus formal report on incidence rate may have been influenced by this issue negatively.

This should be pointed out that this economic analysis has been performed from the health system perspective, so it includes only costs incurred by health sectors. However, pesticide use can be accompanied by adverse effects on the environment. Based on previous studies, exposure to pesticides can significantly increase the likelihood of developing various cancers and may cause many health problems in citizens.<sup>[23-27]</sup> Thus, an economic analysis from a societal perspective should be considered in the future research.

Given that the intervention of using pesticides was started in Isfahan province in 2008, it was more reasonable to compare the two time periods of before and after the intervention. However, due to data limitation, it did not happen, and we were limited to 2 years of 2013 and 2014. Moreover, due to inaccessibility to data on the time of training health workers, training costs in both alternatives may be underestimated. Another limitation in this study was inaccessibility to data on underlying incidence rate due to detecting patients with rural CL inactively.

As an overall conclusion, the strategy of using pesticide to prevent rural CL is not economically acceptable. Given that CL causes no mortality and also low disability and even can be recovered without any treatment during a couple of months, economic appraisals of universal training in preventive methods and recognition of clinical manifestations to early diagnosis and/or treatment to prevent disease transmission are recommended. Training is in many cases a very cost-effective preventive strategy. Informing population in CL endemic areas leads to a lower risk behavior, earlier help-seeking behavior, and earlier diagnosis and treatment.<sup>[28]</sup>

The results of this study can be helpful to policymakers in the field of communicable disease prevention to revise methods of controlling and preventing CL and using more cost-effective approaches.

## AUTHORS' CONTRIBUTION

Ehsanallah Jafari contributed in data collection, data analysis and manuscript writing. Maryam Moeeni



contributed in data analysis and manuscript revision. Reza Fadaei contributed in data collection and data analysis. Reza Rezayatmand contributed in study desing, data analysis and manuscript revision.

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### Conflicts of interest

There are no conflicts of interest.

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