ECONOMIC EVALUATION OF WATER IODIZATION PROGRAM IN THAILAND

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Abstract. In Thailand, iodine deficiency disorders (IDD) are endemic in 57 out of 75 provinces with an estimated 15 million people at risk of IDD. A three pronged control program with iodized salt, iodized water and iodized oil capsules is being implemented. The water iodization program is both school based and household based. In the household, the residents are given iodine solution, two drops of which is to be added to 10 l of drinking water. In the schools, in addition to this method, an iodinator is used. This releases a fixed amount of iodine into the drinking water. This study examines the cost of the water iodization program in Thailand for the year 1996 in terms of cost per beneficiary, cost per µg iodine consumed daily and cost per goiter person years averted. We used a discount rate of 5%. Field visit and interviews of health personnel from Ministry to village level were conducted to gather primary data. Review of existing papers and reports of the Department of Health, Government of Thailand was done for secondary data. The costs included the capital cost of equipments, initial training and the recurrent costs of potassium iodate, proportional salaries of personnel involved, monitoring and communication activities. The cost per beneficiary of school based iodinator method (US$ 0.72) and school based drop method (US$ 0.64) were similar and much higher than the household based approach (US$ 0.12). The cost per µg of iodine consumed daily was ten times higher in the school based approach (US$ 0.01) compared to the household approach (US$ 0.001). The cost per goiter case averted for the whole strategy of water iodization was US$ 194.50. Water iodization appears to be a low cost intervention. However, the need for behavioral modification raises the issue of long term sustainability.

INTRODUCTION

Iodine deficiency disorders (IDD) are a major public health problem in Thailand. The initial reports on the "goiter belt" in northern Thailand by Pringpuangkao in 1953 and Ramalingaswami in 1955 were confirmed by Klerks in 1957 (Ministry of Public Health, 1992). With the assistance from World Health Organization (WHO) and UNICEF, the Ministry of Public Health began a pilot salt iodization project in Prae Province in 1965. This project was successful in decreasing the prevalence of goiter. The program was later expanded to the rest of the country in a phased manner (Ministry of Public Health, 1992).

In the resurvey conducted in 1988, it was noted that the situation had worsened. In eight to fourteen provinces of northern Thailand endemic goiter was widely prevalent. This necessitated urgent remedial measures. (Ministry of Public Health, 1992). Therefore in May 1989, The National IDD Control Project was started. It was felt that the current situation called for use of all the available control measures which included iodized salt, iodized water and iodized oil capsules (Ministry of Public Health, 1992).

Surveys till 1993 revealed that 57 out of the 75 provinces covering all regions have IDD as a public health problem. The overall prevalence rate of goiter was 9.8% with an estimated population of 15 million people belonging to the, "risk group" (Ministry of Public Health 1994, 1996). It was decided that salt iodization would be the principal measure to combat IDD. Social marketing of adequately iodized salt was supported by appropriate legislation and its enforcement. Other supplementary measures such as iodized drinking water, fish sauce were also encouraged wherever and whenever possible. Iodized oil was reserved for application only in some specific high endemic areas and high-risk target groups. To make this program effective, communication activities and inter-sectoral co-ordination were also strengthened (Ministry of Public Health, 1994).

Currently in Thailand, the measures for IDD prevention and control are the following (Pisolabutra, 1994):

1. Iodized salt : All districts of all provinces.

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2. Iodized water: All primary schools and households in 39 project provinces, as well as some provinces in southern Thailand are covered. An estimated 50% of the population of Thailand is covered by this strategy. The iodization of water is carried out at school and household. Two methods are used for iodization: drop method and iodinator method. The schools use either drop method or iodinator method. The Households use only Drop method.

3. Iodized oil capsules are administered to pregnant women, women in the childbearing age, school children. The capsule program is being carried out only in districts with goiter prevalence above 20%. The capsule strategy is to discontinued when the prevalence of these districts fall below 20%.

The three pronged campaign is a short term measure. In the near future, only a single strategy would be adopted for the country. The choice would depend upon the effectiveness of the strategy including acceptability and compliance, cost of the strategy and sustainability of the strategy. With this objective in mind, an economic analysis of water iodization program in Thailand was performed. The outcome measures were:

i) Cost per beneficiary
ii) Cost per μg iodine consumed daily
iii) Cost per goiter person years averted.

MATERIALS AND METHODS

This study was done at the request of International Council for Control of Iodine Deficiency Disorders. The Government of Thailand, especially the Division of Nutrition in the Ministry of Public Health, co-operated fully in providing all the relevant details and also arranging field visits. For this study, a societal viewpoint was adopted. A discount rate of 5% was used and all the costs were calculated with 1996 as the reference year. The information for the study was collected by (i) interviews of concerned people, (ii) field visits and (iii) review of published literature of existing papers and reports.

Interviews were held with the Director of Public Health; Director and Staff of Division of Nutrition, Provincial, District and Village Health Officials; school principal, teachers and students; community leaders, village health volunteers and community members. Field visits were made to Chom Thong, Chaiprakarn and Samoeng districts of Chiang Mai Province and Lampang Province. Interviews were conducted with the help of interpreters.

This field visit was carried out in September, 1996. During the field visit, information on time devoted for IDD activities was collected from the service providers as well as the dynamics of use at household and school level. The studies conducted by the Ministry of Public Health on water iodization were also reviewed.

Method of iodization of water

Two methods of water iodization are followed in Thailand; iodinator method and drop method (Ministry of Health, 1994; Pisolyabutra, 1994). The schools use either drop method or iodinator method. At the household level, only the Drop method is used.

Drop method

The Public Health Department gives packets of potassium iodate to the health workers and teachers. Each packet contains 24 g of KIO_3. The teachers are trained to prepare KIO_3 solution by adding 725 ml of water (For measuring 725 ml, a Mekong whisky bottle which is readily available is used). This solution is then poured into 24 plastic bottles of 30 ml each (single bottle kit). This plastic bottle is then given to the student leader who has the duty of adding the KIO_3 solution to the drinking water of the school on a daily basis. Two drops of this solution is added to 10 l of drinking water. This provides 200 μg iodine per liter of water. In the school, a glass of 200 ml is used for drinking iodized water. Every day, each child has to drink a minimum of two glasses. This activity is supervised by the school head boy and a designated teacher. For a child who drinks two glasses of water (400 ml), this method would ensure a minimum intake of 80 μg of iodine per day.

Household

The health workers prepare the solution as described above and give it to the health volunteers. The volunteers collect this and supply the single bottle kit to the households. They also explain to the community about its use. At household level, the family designates a member, usually a young adult who puts two drops of solution for every 10 l of water on a daily basis. This provides 200 μg of iodine per liter of water.

Iodinator method

Iodinator is a device for slow release of potassium iodate (KIO_3) into water supply for drinking. Iodinator is fitted into the outlet of the water reservoir. It contains a small jar which holds the concentrated potassium iodate solution. The amount of iodine released depends upon the pressure of the uniodized water falling upon a valve. The main water flows at a rate of 5 liters/minute and the KIO_3 at 1 drop/minute. The falling water and concentrated iodine solution are then collected together in another tank which is used for drinking purposes. The iodinated water then contains iodine in the concentration of 100 to 400 μg/l.

Monitoring

The monitoring of iodinated salt and iodized water is done with the help of a kit developed by Suwanik (Ministry of Public Health, 1992). Monitoring is carried out by the health workers at regular intervals of three months on a random sampling basis. There is currently no system of record keeping for the monitoring. Therefore, there is no mechanism in place for giving feedback to the system. An appropriate Management Information System (MIS) is being developed.

Costing methodology

All the costs were measured initially in Bahts. The final results were then converted to US$ using the exchange rate of 1 US$ = 25 Baht. The costs were divided into capital costs and recurrent costs.

Capital costs: Capital cost includes cost of items which have a life of more than one year. That is, items which are needed at the onset of program, like equipments, etc but whose cost is applicable for a period exceeding one year. The categories included under capital costs are shown in Table 1. It can be seen that the initial training is also a capital cost as it is a one time activity but its use lasts for a period of more than one year. The cost of installation of water supply system like filtration tanks etc have not been included in the cost as these would have to be provided irrespective of water iodization program. Based on the life of each equipment and discount rate, equivalent annual cost (EAC) was calculated.

Recurrent costs: This includes the cost of items which are incurred on an annual basis, *eg* potassium iodate, salary of personnel etc. The complete list is given in Table 2.

Total annual cost

The total annual cost incurred on a strategy is the sum of equivalent annual cost and recurrent cost calculated for each year.

Description of unit costs

The average population of a village in Thailand is estimated to be around 1,000 (Ministry of Public Health, 1996). All the calculations have been estimated for such a village.

Cost per beneficiary

For the household strategy, as the beneficiaries will be the whole village, the cost per beneficiary is the total cost of the strategy divided by 1,000.

Table 1
Estimated capital cost (in Bahts) of different strategies for water iodization in Thailand for the year 1996.

Item	School based using iodinator method		School based using drop method		Household-based with drop method	
	Total cost	Equivalent annual Cost	Total cost	Equivalent annual cost	Total cost	Equivalent annual cost
Iodinator, accessories and installation cost	8,000	1,036	NA[a]	NA[a]	NA[a]	NA[a]
Manuals/books	1,500	194	1,500	194	-	-
Training	800	104	800	104	300	41.5
Total	10,300	1,334	2,300	298	300	41.5

[a]NA : Not applicable.

For the school based strategy, the cost per beneficiary is the total cost divided by the number of school children. From the available statistics of Thailand, it can be inferred that the number of beneficiary school children in the age group of 6 to 14 years in a village of 1,000 will be around 200. For the calculation, the student enrollment and attendance has been taken as 100%. On the basis of interviews of school staff, the total period of functional schooldays in a year has been estimated as 200 days.

Cost per μg iodine consumed daily

For both the strategies, especially for household strategy, the compliance of villagers in adding iodine is an important determinant of effectiveness of the strategy. This issue is not addressed in the above indicator, as ultimately the impact depends on the actual iodine intake of the population. A new costing unit (cost per μg iodine consumed daily or mg iodine consumed per year) was used in this study. The expected daily dose of iodine (300 μg for a person consuming 1.5 l of water iodine concentration of 200 μg/l) multiplied by compliance would give the actual dose of iodine consumed. The estimates of compliance were based on a study conducted by the Ministry of Public Health (1993). This came to 187.5 μg per day. The cost per μg iodine consumed daily was calculated by dividing the total daily cost of household water iodization by daily dose of iodine consumed.

Cost per goiter person year averted in school children

For this estimation, the information on the decline in the goiter prevalence after introduction of water iodization program was required. However in Thailand, as all the three strategies were introduced simultaneously in an area, it was difficult to estimate the impact of water iodization program alone on IDD indicators. Though some data on effectiveness were available from different pilot studies of water iodization done at different times, the results were not generalizable to the actual implementation of the program. Based on data from selected provinces in Thailand, first, we calculated the rate of decline in goiter prevalence due to a combined water and salt iodization strategy. We then assumed that both the strategies are equally effective and if implemented optimally, their individual impact would be proportional to their utilization.

RESULTS

The costs of three different strategies of water iodization for control of IDD in Thailand was estimated. These costs have been estimated for a village of 1,000 population having one school with an estimated population of 200 school children in the age group 6-14 years with 100% school attendance.

The capital costs of different strategies of water iodization is shown in Table 1. The equivalent annual cost (EAC) was maximum for school based water iodization method (Bahts 1,334, US$ 53.4) followed by school based drop method (Bahts 298, US$ 12) and household based drop method (Bahts 41.5, US$ 1.7). The cost of school based iodinator method was high because of the high cost of iodinator and its installation.

The annual recurrent costs of the three strategies are shown in Table 2. The recurrent cost for household based drop method was maximum (Baht 2,930, US$ 117.2) compared to school based drop method (Baht 2,885, US$ 115.4) and school based iodinator method (Baht 2,241, US$ 89.6). The cost in the household method was high because it is for 1,000 population compared to a school based strategy which is for 200 school children only. It should also be noted that more than 50% of the recurrent cost was on Information, Education and Communication. This appears to be logical as all the three strategies aim at behavioral change in the community.

The total cost (equivalent annual cost and recurrent cost) of the three strategies is shown in Table 3. The school based iodinator method had the highest cost (Baht 3,575, US$ 143) whereas the household based strategy had the least cost (Baht 2,971.50, US$ 119). The cost per beneficiary of the three strategies is shown in Table 4. The cost per beneficiary was the least in the household based approach as the total cost was spread over a larger population. The cost of both the school based approaches were roughly the same and was five to six times the unit cost of household based approach.

For the calculation of cost per μg iodine consumed daily, it is necessary to first estimate the iodine consumption through the iodized drinking water. For iodinator strategy, a 100% compliance was assumed as it is now a part of water supply. Thus, assuming a consumption of half a liter of

Table 2
Recurrent annual cost (in Bahts) of different strategies of water iodization in Thailand for a village with one school for a population of 1,000 for the year 1996.

Item	School based iodinator method	School based drop method	Household based drop method
Potassium iodate	10	10	1,250
Personnel	171	1,215	120
District officer	15	15	NA[a]
School principal	18	180	NA[a]
School teacher	12	900	NA[a]
School worker	6	NA[a]	NA[a]
Health worker	120	120	120
Health volunteer	NA[a]	NA[a]	Not included
Refresher training	45	45	45
IEC	1,500	1,500	1,500
Monitoring	15	15	15
Maintenance	500	100	0
Total	2,241	2,885	2,930

[a]NA : Not applicable.

Table 3
Total cost (in Baht) of different strategies of water iodization in Thailand for the year 1996.

Method	(EAC) capital costs	Recurrent annual cost	Total
School based iodinator	1,334.00	2,241.00	3,575.00
School based drop	298.00	2,885.00	3,183.00
Household based drop	41.50	2,930.00	2,971.50

Table 4
Comparison of cost per beneficiary of different strategies of water iodization in Thailand for the year 1996.

Strategy	Total cost	No. of beneficiaries	Cost per beneficiary
School based iodinator method	3,575.00 (US$ 143)[a]	200	17.90 (US$ 0.72)
School based drop method	3,183.00 (US$ 127)	200	15.90 (US$ 0.64)
Household drop method	2,971.00 (US$ 119)	1,000	3.00 (US$ 0.12)

[a]1 US$ = 25 Bahts.

water with the iodine concentration of 200 μg/l for 200 days in a year gave an daily consumption of 54.8 μg of iodine. For the school based drop method, the compliance rate of 80% was assumed (includes teacher/student forgetting to add iodine and children not drinking the water). This came to 43.8 μg (54.8 * 0.8) of iodine per day. For household strategy, it was assumed that, 40% of the population did not use iodized water, 12% use on some days (assumed to be 50% of the time) and 48% use every day. This gave a per capita daily consumption of 108 μg of iodine. The cost per μg of iodine consumed daily for the three strategies is shown in Table 5.

Table 5
Cost per μg of iodine consumed daily for the three strategies for the year 1996.

Strategy	Total cost (Bahts)	μg of iodine consumed daily	Cost (Baht) per μg of iodine consumed daily
School based iodinator	3,575 (US$ 143)[a]	54.8	0.33 (US$ 0.01)
School based drop method	3,183 (US$ 127)	43.8	0.36 (US$ 0.01)
Household	2,971 (US$ 119)	108.0	0.028 (US$ 0.001)

[a]1 US$ = 25 Baths.

Cost per goiter person year averted

This has been calculated for the strategy for water iodization as a whole. It was not possible to differentiate between the impact of school based strategy and household based strategy as both the strategies have been started simultaneously in all the places.

To calculate the effectiveness of water iodization alone, data from school children in the provinces of Mae Hong Son, Uttaradit, and Tak from 1990 to 1993 was used (Ministry of Public Health, 1992; 1993; Pisolyabutra, 1994). We calculated the average rate of decrease in the goiter rate per year due to a combined strategy of water and salt iodization. The average decline in the three provinces was 2.36% (2.12 + 4.27 + 0.73 ÷ 3). The selection of the provinces was made on the basis of the existing prevalence *eg* more than 40% in Mae Hong Son and Uttaradit and more than 20% in Tak Province. This ensured that both high and moderately endemic areas, where water iodization has been implemented, were represented.

This decrease of 2.36% in the goiter rate could be attributable to a combined strategy of salt and water iodization. We then assumed that the individual impact of the two strategies depended upon the compliance with the two strategies. The average utilization of iodized salt by the household was 92.2% and average iodized water utilization was 58.2% (Ministry of Public Health, 1993). The ratio of impact attributable to iodized salt *vs* iodized water came to 1.5:1 (92.2:58.2; 60:40). Hence, the impact attributable to water iodization alone was 0.95% (40% of 2.36%).

Assuming that there was 200 school children in the age group 6-14 years the number of goiter cases averted came out to be 2 per year. The total cost of water iodization was estimated as 9,729 Baht (US$ 389). Thus the cost per goiter averted by a combined strategy of school and household water iodization strategy is 4,864.5 Bahts (US$ 195).

DISCUSSION

Thailand has adopted a three pronged strategy for IDD control in the high endemic areas so that IDD can be quickly reduced to a level where it ceases to be public health problem *ie* below 5%. This is only a short term measure to reach "the unreached and hard to reach" population groups. In many places, it has helped to reduce the goiter rate substantially. The household based water iodization is a low cost intervention as compared to the two school based intervention which had similar costs. The cost estimates arrived at in this study, would be useful in deciding the further course of action in Thailand. However, other issues are important in the decision making which are discussed later.

There are some limitations of this study which need to be kept in mind. It may be noted that, as of now, the exchange rate for US$ is at 35 to 45 Bahts which is about one and half times that of what it was in 1996 when the study was conducted. This limitation has to be kept in mind when making international comparisons. The study is based on limited observations only. As the different IDD prevention programs were implemented simultaneously, assessing effectiveness of water iodization program was difficult. However, lack of information on economic aspects of IDD control make this study worthwhile despite this limitation.

Water iodization program appears to be a low cost intervention. However, before this can be recommended as a strategy, issues related to sustainability needs to be addressed.

Technical sustainability

The vehicle used for iodine fortification should be such that it does not interfere with iodine availability. In case of water, especially in north and northeast where goiter prevalence is high, the source of water is rainwater, river, mountain reservoir etc. (Wanaratna 1994a,b). This water may be rich in organic content and may need chlorination. Both the organic matter and chlorine in the water are likely to interfere with iodine levels. We are not aware of any studies on the impact of these constituents on water iodization.

Managerial and behavioral sustainability

The three key factors in the success of water iodization program are the supply of potassium iodate solution (managerial), adding the appropriate amount of iodine in drinking water on a daily basis (behavioral) and monitoring of iodine content of water (managerial). The key persons involved in the above activities are service providers and household members. Their effective and continued involvement in this activity depends on their status of knowledge, skill and motivation. This raises the important issue of regular procurement and distribution of potassium iodate as per the requirement of the household/schools by the providers. For a better compliance, a continuing education program for providers and an appropriate IEC package for the consumers should be implemented. The success of all these activities depends on effective monitoring on a regular basis and its feedback into the system so that corrective measures can be taken. Without this, the sustainability of such an important program will be difficult.

Financial sustainability

Making available finances for all the three strategies is definitely a problem. For the same amount of effectiveness, the incremental cost of improving one strategy will usually be less than the cost of adopting another strategy.

The sustainability issue is also applicable to the salt iodization program especially as implemented in Thailand. Currently, the distribution of iodized salt is heavily dependent on the health system. Though such a system is acceptable as a short term measure, creation and maintenance of a "parallel system" of salt distribution may not be sustainable as a long term measure.

The Ministry of Public Health of Thailand has with great determination and combination of effective strategies controlled IDD to a significant level. But, the important task of sustainability lies ahead.

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