Original Article

Economic Evaluation of Iodine Deficiency Disorder Control Program in Sikkim: A Cost Effectiveness Study

*Chandrakant S. Pandav

Professor and Head, Center for Community Medicine, All India Institute of Medical Sciences, New Delhi, India

Abstract

Background: Edible salt iodization and iodized oil injections are the two most commonly used vehicles for iodine supplementation. In year 1989, the state government of Sikkim was planning to implement Iodine Deficiency Disorder control program in state and had following two options to choose from, based on existing knowledge; a) a salt iodization program, b) an iodized oil injection program. No information was available at that point of time on comparative advantages of the above stated two approaches. **Objectives:** To identify the most cost-effective alternative for IDD elimination in Sikkim, amongst the following 3 alternatives: a) Iodized salt program (ISP), b) Iodized oil injection program (IOP) to high risk group, c) no preventive program. **Materials and Methods:** Study population was the general population of state of Sikkim, India in year 1990. Cost- effective analysis was undertaken comparing 3 alternative programs, targeted towards IDD elimination in state of Sikkim. Identification, measurement and valuation of the costs of ISP and IOP and identification and measurement of the consequences of IDD were done to carry out the cost-effective analysis. Visible goiter person years (VGPY), endemic cretinism, IDD attributable death were used to assess the health consequences/ disease burden of IDD. **Results:** The cost per VGPY, endemic cretinism and IDD attributable death were ₹ 76.67, ₹ 24,469 and ₹ 9,720, respectively for ISP. The cost per VGPY, endemic cretinism and IDD attributable death were ₹ 75.82, ₹ 19,106 and ₹ 7,709, respectively for IOP. **Conclusion:** The results of the analysis showed that iodized oil program is more cost-effective for prevention of irreversible IDDs than the iodated salt program in state of Sikkim, India.

Key words: Cost effective analysis, Iodine deficiency disorder, Iodized salt, Iodized oil, Sikkim

Introduction

In India, 200 million people are living in iodine deficient areas; 71 million persons are suffering from goiter and other iodine deficiency disorders (IDDs).[1] It is estimated that there are 2.2 million endemic cretins and 6.6 million individuals, who have mild motor and mental impairment.[2]

***Corresponding Author:** Dr. Chandrakant S. Pandav, Professor and Head, Center for Community Medicine, Old OT Block, All India Institute of Medical Sciences, Ansari Nagar, New Delhi – 110 029, India.
E-mail - cpandav@iqplusin.org

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The strategy of prevention and control of iodine deficiency is based on iodine supplementation. Iodine supplementation can be done in different ways; edible salt iodization, iodized oil injections, flour/bread fortification, addition of iodine to drinking water and oral tablets. Edible salt iodization and iodized oil injections are the two most commonly used vehicles for iodine supplementation.

The results of controlled trials with iodized salt in Kangra Valley, India[3,4] and Guatemala,[5] and iodized oil in Papua New Guinea[6,7] have demonstrated the prevention and reduction of endemic cretinism and endemic goiter by iodine supplementation. A controlled trial with iodized oil in Zaire[8,9] has shown reduction of perinatal and infant mortality and improvement in birth weight. In a number of iodization programs, a reduction in stillbirths has also been reported.[10] Salt iodization has been accepted as the primary strategy for IDD control.

The current article is based on the work done in year 1990, in state of Sikkim, India. The results of a population survey, carried out in 1989 in the south district of

Sikkim, reported a goiter prevalence of 54.7%. The state government was planning to implement IDD control program in state. The policy makers at state level had following 2 options to choose from, based on existing knowledge; a) a salt iodization program, b) an iodized oil injection program. No information was available at that point of time on comparative advantages of the above stated 3 approaches.

The authors carried out a study, targeted towards enabling policy makers to identify the best approach in context of IDD elimination, in state of Sikkim. The research question was "whether from the viewpoint of the society of Sikkim, an IDD control program of iodized salt program (ISP) or iodized oil injection program (IOP) to high risk group is preferable in terms of an economic efficiency to a no preventive program? The study was conducted in 1990, and the results and findings of the study cannot be and should not be extrapolated to the present day Sikkim state. We acknowledge this serious limitation of the article upfront. However, the methodology of the article is highly relevant and topical to the current practice of public health in India. The primary objective of this article is to share the methodology of the study, and we hope that the detailed methodology will be helpful to the young researchers and wider public health fraternity of India.

Materials and Methods

Study Population: General population of state of Sikkim, India.

Study Design: Cost-effective analysis comparing 3 alternative programs, targeted towards IDD elimination in state of Sikkim; 1) No preventive program (NPP), 2) Iodized salt program (ISP), 3) Iodized oil program (IOP).

Description of the alternatives: No preventive program (NPP) describes the current situation wherein there is no preventive program of iodine supplementation either in the form of provision of iodized salt or iodized oil injections. Iodized salt program (ISP) describes the situation when universal iodized salt program is introduced and implemented in Sikkim. The salt iodization program will cover the entire population of the Sikkim. Iodized oil program (IOP) describes the situation when the iodized oil for iodine supplementation will be introduced and implemented in Sikkim. The population to be covered by the IOP is the high risk group of women in the child bearing age group (15 to 44 years) and all children in the age group of 0 to 14 years.

Identification of costs

Iodized Salt Program (ISP): The costs associated with the ISP are mainly related to the cost of salt iodization, monitoring and communication campaign. [Table 1]
Iodized Oil Program (IOP): The direct costs of iodized oil program include the cost of iodized oil, the cost of disposable syringes and needles, the cost of personnel required for the program, the cost of transportation, and the cost of a communication program [Table 1].

Measurement of costs

Salt iodization program

a. Salt Iodization: The land and the building specifications were provided by the Ministry of Public Works, Government of Sikkim. The specifications required for the iodization plant and other details were provided by the Salt Commissioner to the Government of India and the Salt Consultant to UNICEF, WHO, and UNDP. One iodization plant with a capacity of 6 tons kg per hour, can meet the requirements of the entire state, i.e. 4,000 tons. b. *Monitoring:* A total of 5 iodine monitoring laboratories (IML) will be established. Each laboratory

Table 1: Identified cost and consequences of iodine deficiency disorder prevention program

Cost	Consequences
Iodized Salt Program	Health Effects
Direct	Averted cases of a cretinism
Health	Mild motor or mental impairments
Monitoring activities	Still births and neonatal deaths
Communication strategy	Visible goiter
Non – Health	Social / Emotional Effects
Land and building	Not included in the present analysis.
Equipment	Resource Use
Potassium iodate	Reduction in treatments costs of IDD
Personnel	Productivity gain due to reduction of mild IDD and cretinism
Maintenance	Productivity gain due to freeing of caretakers of averted cretins
Electricity	Quality of life
Administrative overhead	Not included
Indirect	
Nil	
Iodised Oil Programme	
Direct	
Health	
Iodized oil	
Syringes and needles	
Personnel	
Transportation	
Communication strategy	
Non – Health	
Nil	
Indirect (Not Included)	
Time lost by care taker	
Travel cost	

would have 1 laboratory technician and 1 laboratory attendant. Assuming 200 working days in a year, total 4000 salt samples would be analyzed in each of the laboratories every year. The costs include the capital cost of building, land and equipments and operating cost every year. c. *Communication Campaign***:** The cost of organizing 1 session of 1 day duration for an average PHC would be the cost of time of the participants and the expenses required for organizing the session. It was estimated that 250 posters and 1000 leaflets would be required for a PHC.

Iodized oil program

In order to control iodine deficiency disorders, iodized oil program (IOP) would be in operation "*ad infinitum*" and hence costs for this program will be incurred in perpetuity. IOP has no capital costs, and the operating costs are incurred only for the first year of the 5 year injection cycle.

a. Iodized Oil: The total eligible population for iodized oil injection in Sikkim is 241,808. The total requirement of iodized oil for Sikkim is 29,500 ampoules of 10 ml each, taking into account about 25% wastage. b. *Disposable Syringes and Needles:* The total requirement for Sikkim is 265,990 syringes and needles including 10% wastage. c. *Personnel***:** It has been estimated that 80 injections per day can be given by a team consisting of 1 doctor, 1 ANM and 1 male health worker. With 2 member teams, the total person-days for health workers required to cover the eligible population are 5,898. *d. Cost of Transportation***:** As IOP would be a community outreach program, it would hire jeeps with drivers. Based on the average time required to cover the eligible population per PHC in each of the districts, the total number of days required per team would be 130 days for east district, while for the west and south would be 150 days with north requiring 90 days. *e. Cost of Communication Campaign***:** Prior to the injection program, a communication campaign will be carried out. The cost would be same as for ISP.

Valuation of costs

The reference year for the costs was 1991, and the discount rate assumed was 10%. All the costs were converted to the year 2010 using wholesale price index data.

Salt iodization program

*a. Salt Iodization***:** The capital cost estimates of land and building have been provided by the Ministry of Public Works, Sikkim. The capital costs of salt iodization equipment and office equipment have been provided by the Salt Commissioner to the Government of India and the Salt Consultant to UNICEF, WHO, and UNDP. The capital costs were converted into equivalent annual costs (EAC) using the discount rate and the life of the equipment, as estimated by the experts. The price of potassium iodate is ₹ 1,676 per kg delivered in Sikkim. Therefore, the total expenses required, including freight and handling, for 200 kg of potassium iodate is ₹ 335,200 per year. *b. Monitoring***:** The buildings, land and equipments were valued on the market rate. The proportional salary of the involved personnel was used for training. The salary of the laboratory personnel was based on the actual salaries being received by them. The actual costs of the chemical reagents and stationery were used. *C. Communication Campaign:* The proportional cost of salaries was used for estimating the cost of an initial meeting at the district level. The travelling and refreshment costs were added to this cost. The cost of a poster was assumed to be ₹ 67, and the cost of each leaflet was assumed to be ₹ 10.

Iodized oil program

*a. Iodized Oil***:** The costs of supplies required for IOP that are available in India, were valued by the market prices in Sikkim. The cost of iodized oil which is imported from outside was valued by converting US dollar prices into Indian rupees. (Exchange rate US $ 1 = ₹ 26). The price per ampoule of 10 ml is ₹ 302. The total cost of iodized oil for Sikkim is ₹ 8,899,266. b. *Disposable Syringes and Needles:* In Sikkim, the price of 1 disposable syringe (1 ml) and needle is ₹ 7. The total cost of disposable syringes and needles then amounts to ₹ 1,783,138. C. *Personnel***:** The costs of various personnel in the IOP are estimated on the basis of annual salaries. Since the analysis is carried out from the viewpoint of society of Sikkim, the per *diem* are not included. The daily salary, assuming 200 working days in a year, is ₹ 352 as per the existing salary structure in Sikkim. The total salary of health workers is calculated by multiplying person-days by ₹ 352. The total cost of health workers for 5898 person-days is ₹ 2,075,791. A total of 28 Interns will be recruited for IOP. The government of Sikkim will spend a total of ₹ 46,926 per Intern for their services in the IOP. Based on these estimates, the total cost for Interns is ₹ 1,313,940 for a period of 6 months. d. *Cost of Transportation***:** Based on the experience of expanded program on immunization, an average expense of hiring a jeep with driver including petrol expenses for a day is

₹ 670. Thus, the total cost of transportation for the IOP is ₹ 2,493,806. e. *Communication Campaign***:** It will remain same as that for the salt iodization program.

Identification of Consequences: Since the present analysis is carried out from the viewpoint of the society of Sikkim, all the consequences to whomsoever they accrue are included. The consequences related to preventing iodine deficiency disorders are classified as given in Table 1. However, in the present analysis, only the consequences related to physical functioning and changes in resource use are included. Consequences related to changes in physical, social and emotional functioning (health effects) were expressed in natural units, that is, new cases averted of endemic cretinism, new cases averted of mild motor and mental impairment, and stillbirths and neonatal deaths averted due to iodine deficiency and visible goiter person years averted.

Measurement of consequences

Health effects: Data was available only on the goiter prevalence in Sikkim. Data on endemic cretinism, mild motor or mental impairment and stillbirths and neonatal deaths attributable to iodine deficiency, were not available and were estimated from an epidemiological IDD model based on the goiter prevalence, developed by Dulberg *et al*. The prevalence of cretinism in Sikkim was estimated as 3.27%; the prevalence of mild motor and mental impairment is 3 times the prevalence of cretinism, that is, 9.81%; and the incidence of ID attributed stillbirths and neonatal deaths is 41.1 per 1000 live births per year. Given the current population, presently in Sikkim, the total number of cretins is 13,200, the total number of people with mild motor and mental impairment was estimated to be 39,600, and the annual number of stillbirths and neonatal deaths attributable to IDD was estimated to be 552 per year.

In order to measure the health consequences of the program alternatives, a number of basic assumptions regarding the programs and the context in which they operate were made.

1. After the iodine supplementation programs are introduced, the incidence of these IDD will be 0.
2. Steady state population in Sikkim.
3. Iodized oil program will be effective at the beginning of the year of implementation.
4. This analysis will use the same discounting procedure as that of the cost scenarios and the same discount rate, which is 10%.

An incidence of the disease was estimated by the formula, incidence = prevalence / duration, where duration is a life span (60 years). The prevalence of cretinism in Sikkim is 3.27%. Therefore, the incidence of cretinism in Sikkim is 0.0545 % per year. Since a steady state population has been assumed; the incidence will be the same every year. Based on this incidence rate, for the total population of 403,612 in Sikkim, every year a total of 220 cretins are added. Based on this incidence rate, every year a total of 660 people with mild motor and mental impairment are added to the population.

In ISP group, it was assumed that all new cases of IDDs would be prevented in all the age groups. The incidence of irreversible; IDD will fall to 0 after an implementation of IOP. That is, an effective coverage of IOP would prevent all the IDD, related to iodine deficiency in high risk group.

In order to compare the burden of goiter in the 3 alternatives, the concept of a common unit that is visible goiter person years (VGPY) was introduced. The Sikkim IDD survey reported goiter prevalence for 5 age intervals. The age / sex population distribution of India, which is used as a proxy for Sikkim, was available in 13 five-year age intervals. The 13 age specific prevalence rates were estimated by fitting a line on the available Sikkim data, using a regression model. The visible goiter prevalence (VGP) for males and females in each of the 13 five-year age intervals were used to estimate the VGP for age cohorts as they progress through the 60 year life of the program.

In the no preventive program scenario, the age distribution of goiter prevalence remains the same over time. The product of visible goiter prevalence rates and the population distribution by sex and age is the number of people with visible goiter person years in a given population, for a given year. For example, consider the birth cohort of males in the age group 0 to 4 years. At year 0 of this analysis, the VGP was taken as 4.9%. 5 years later, this cohort, moves into 5 to 9 year age group. The VGP for age group 5 to 9 years was 12.29%. The annual increase in goiter prevalence is determined by linear interpolation. (12.29% - 4.90% = 7.39%; 7.39% is divided by 5 to obtain 1.48%). The 1.48% represents the yearly increase in goiter prevalence for the 0 to 4 years age group cohort. For each year, the prevalence rate was multiplied by the total population in the age group of 0 to 4 years. The summation of these 5 values

is the discounted number of visible goiter person years during that 5 year interval. In this cohort of 0 to 4 years, the result is 5,395 discounted VGPY. This process is repeated as the cohort ages, new cohorts are born and elderly cohorts die. For one entire generation of 60 years, the 12 five year-intervals are summed up to obtain the total 678,197 discounted VGPY for males. The total number of discounted VGPY for females for 60 years is 821,279. Therefore, the total for males and females for one generation is 1,499,576 visible goiter person years. The estimates of NPP are used as the baseline for the analysis for assessing the effectiveness of the two prevention programs.

The decrease in visible goiter prevalence due to the salt program is estimated using data from *Sooch* and *Ramalingaswani*. 4 The study reported data on the reduction of visible goiter prevalence by 5-years age intervals at a 5 year follow-up. Therefore, the reduction in prevalence for the first five-year follow-up period was used to model the reduction for each of the next 11 five year follow-up periods.

Therefore, under ISP, the total number of discounted VGPY for males, over one 60 year generation, is 385,099. The number of discounted VGPY for females is 341,945. Therefore, the total for males and females for one generation is 727,044 VGPY.

In IOP, only males in the range of 0-14 years and females in the range of 0-44 years are treated with iodized oil. Individuals outside these age ranges will become iodine deficient as they become older. This was modeled into the analysis of VGPY. The total number of VGPY for males, over one generation of 60 years, is 524,321. The number of (discounted) VGPY for females is 366,631. Therefore, the total for males and females for the 60 year life of the program is 890,952 VGPY.

Sensitivity Analysis: A sensitivity analysis was conducted with respect to the discount rate, the utilization rate, the duration of protection for iodized oil, and the price of iodine and iodized oil.

Results

Cost of iodized salt program

The total capital cost of the salt iodation plant in ISP was estimated to be ₹ 7,682,530. The annual equivalent cost of capital outlay of salt iodation was calculated to be ₹ 1,128,494. The total annual operating cost of salt iodation was ₹ 2,334,055. The total cost of salt iodation for "a given year" was ₹ 3,462,549.

The total cost of one monitoring laboratory was estimated to be ₹ 188,081 per year and for 5 laboratories, it came to ₹ 950,462. The total cost for the communication campaign including the meetings, leaflets, posters and radio spots was estimated at ₹ 990,819 for the whole of Sikkim.

The total cost of ISP for "a given year" was ₹ 5,403,829. This is the cost that is applicable for any year of the program. The major portion of the cost is accounted by the salt iodation (64.1%) with monitoring (17.6%) and communication (18.3%) sharing almost equally the remaining cost.

Cost of iodized oil program

The total cost of different components of Iodized oil program for Sikkim was estimated as ₹ 17,556,761. In the IOP, all the costs are incurred at the beginning of the program, that is, they occur at year 0. Based on the observations that iodized oil injection gives protection against IDD for 5 years, the annual equivalent cost for "a given year" of the program, using 10% discount rate for IOP, works out to be ₹ 4,210,355.

The total discounted costs of ISP for one generation of 60 years are ₹ 59,225,964. The discounted costs for IOP for one generation of 60 years are ₹ 46,145,491.

Cost-effective analysis

An estimated impact of the different intervention on IDD is shown in Table 2. It is estimated that in ISP, 727,044 VGPY will occur, while in IOP, 890,952 VGPY will occur. This means that due to ISP, 772,532 VGPYs will be averted and with IOP, 608,624 VGPYs will be averted.

The cost per IDD averted was calculated and the results are shown in Table 3. This was on the basis of the total cost of ISP and IOP for one generation and the number of IDD averted in that generation. The cost per VGPY averted was only 86 paisa less for IOP as compared to ISP, and the cost of endemic cretinism averted was ₹ 5,363 less for IOP as compared to ISP.

Sensitivity analysis

The results of the analysis using 5% discount rate were more in favor of IOP. In order to equate the costs averted of ISP and IOP, the utilization rate of health services

Table 2: Health effects of different alternative programs

Alternative	Endemic cretinism	Mild motor and mental impairment	Stillbirth and neonatal death	Visible goiter person year
NPP	2,411	7,233	6,050	1,499,576
ISP	0	0	0	727,044
IOP	0	0	0	890,952

has to increase from the assumed rate of 10% to 45%. The results of the analysis remain unchanged with the assumption of 4 years protection with iodized oil: The IOP is more cost-effective than the ISP. However, the difference had narrowed. The IOP with 5 years duration of protection will cost less than ISP, even if the price of iodized oil increases by 20%, the price of iodine in ISP remains the same as the current price. However, if the duration of protection with iodized oil is assumed to be 4 years, and then even with a concurrent increase in price of 20% of iodized oil and iodine in ISP, the cost of IOP is more than that of ISP.

Discussion

The results of the analysis show that Iodized oil program is more cost-effective for prevention of irreversible IDDs than the Iodated salt program in state of Sikkim, India. The iodized salt program was also cost-effective but the cost incurred per case of VGPY, endemic cretinism and death were marginally higher as compared to iodized oil program. The present analysis addressed only the health effects, related to physical functioning and resource savings in the form of costs averted. The effects of IDD on social and emotional functioning were not included. For the measurement of health effects, data was available only for the goiter prevalence in south district of Sikkim. The VGPY model appears to overestimate the increase in goiter prevalence in IOP for the cohort that graduates out of high risks groups. The present analysis addressed only the costs, averted to the government and modern private health sector utilization. The costs averted in traditional sector of medicine could not be identified due to data constraints and hence were not included. The other limitations for the measurement of the costs averted to the health care system were on the information on the current management of the IDDs in Sikkim. This was collected from a convenience sample of 4 physicians in Sikkim. Secondly, there was no information available on the utilization of health services in Sikkim. Information on utilization of health services (10% utilization for government and private health sector) from the only published study in India was taken.

Table 3: Cost (₹) per iodine deficiency disorder averted in iodized salt program and iodized oil program (discounted @10%)

Program	Cost per endemic cretinism averted	Cost per mild IDD averted	Cost per IDD attributable death averted	Cost per VGPY averted
ISP	24,469	8,045	9,720	76.67
IOP	19,106	6,369	7,709	75.82
ISP-IOP	5,363	1,676	2,011	0.85

IDD: Iodine deficiency disorder, VGPY: Visible goiter person years, ISP: Iodized salt program, IOP: Iodized oil program

The present analysis contributes to our knowledge in the area by its comprehensive identification, measurement and valuation of costs and consequences related to IDD. There have been only two studies that have attempted an economic evaluation of IDD. One of them was limited to an evaluation of the effects of iodine prophylaxis on moderate intelligent quotient retardation among children in Ecuador.[11] The second study, using the same data from Ecuador, attempts to assess the overall effect of a 20% reduction of cretinism on per capita income.[12]

There are operational difficulties in an implementation of iodized oil injection program. Availability of trained health manpower to administer injections is one of the serious hindrances for implementing iodized oil program. Iodized salt program on the other hand with its population approach, does overcome some of the limitations of iodized oil program. However, iodized salt program also has several bottlenecks like setting up of infrastructure for iodizing salt, resistance of population to change the type of salt they are consuming etc. In this study, we have only factored in the cost of both interventions. The program level and operational issues between the two options of iodized salt and iodized oil needs to be explored further in such high risk settings.

In severe endemic iodine deficiency areas, such as Sikkim, an incidence and prevalence of irreversible IDD's is very high. It is an emergency situation. The experience from different parts of the world, primarily from the developing countries and in India over last 40 years has demonstrated that, organization of an effective salt iodization program takes time to get the program in place. Therefore, in view of the severe iodine deficiency as well on the grounds of economic efficiency, the Iodized oil program for Sikkim is suggested as an *interim* emergency measure. The IOP can be organized

in a short time to cover the high risk population and prevent further occurrence of irreversible IDD's. The IOP will also give a lead time of 5 years. Depending on the reduction of IDDs, the situation would need a reassessment. During this period, necessary steps to organize effective salt iodization program can be initiated. These recommendations are specific for severe endemic areas like Sikkim and cannot be generalized to other situation of lower endemicity. There are problems for which solution is a matter of knowhow, and there are problems for which the solution is a matter of will. IDD is a good example of a major nutritional disorder, for which the techniques of prevention and control are available and appear affordable. All it takes is a strong will, wider awareness, and cooperation among those who hold a key to the solution of this problem. The additional information and research issues should not delay the implementation of interventions.

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