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Cost-savings of community water fluoridation program; Kerman, Iran, 2016

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Original Article

Abstract

BACKGROUND AND AIM: Oral diseases are very important because they impose economic and social burden on societies. Given the resource scarcity, it is necessary to devise cost-effective and scientific strategies to prevent and control oral diseases. This study aimed to estimate the potential cost-savings for dental caries treatment associated with Community Water Fluoridation Program (CWFP) in Kerman, Iran.

METHODS: An economic model to compare the costs of CWFP with treatment savings achieved through averted tooth decay was developed. Direct cost of prevented caries was taken equal to treatment savings. Implementation cost and the associated savings was estimated for Kerman in 2016. We obtained required data and parameters for costs and savings estimation through published documents and other sources.

RESULTS: Annual cost-savings associated with implementing the water fluoridation in Kerman was estimated about $11160415.5 to $44350544.11. About $34.9 to $136 could be achieved per each dollar spent. Annual cost and benefit per capita was $0.66 and $23.4-$91.09 respectively. Net benefit per capita was $22.7 to $90.4.

CONCLUSION: This study indicates significant annual savings from CWFP; additional savings could be achieved if this program is implemented in other regions. We could also receive even more if this program is integrated with other public oral health programs such as screening school children, community dentistry and oral health education.

KEYWORDS: Water Fluoridation; Dental Caries; Cost Savings; Cost-Benefit; Oral Health

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Proper oral and dental performance along with human nutritional needs is not possible without growth and evolution, desirable daily performance and sense of pleasure.[1]

Dental caries is one of the most prevalent health problems that most of the people face. Reduction of decayed, missing, and filled teeth (DMFT) index to less than 1 until 2010 was one of the World Health Organization (WHO) and Fédération Dentaire International (FDI) goals. This index which depends on factors such as hygiene level, economic and cultural variables, community context, climate conditions and genetics was introduced by WHO as a parameter to measure oral health in different communities.[2] Despite significant advances

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in the field of oral health, many people, especially in the lower socio-economic class of society, both in developed and developing countries are suffering from oral diseases. Dental caries as a disease is still a major public health problem that affects 60 to 90 percent of school children and most adults.[3]

In 2000, Health and Human Services Department of United States in a report entitled "Oral health in America: A report of the Surgeon General" introduced oral disease as a silent epidemic.[4] Dental decay can be prevented by adding the appropriate amount of fluoride into drinking water. WHO considered water fluoridation program as one of the most effective strategies which can be implemented by encouraging governments to reduce dental caries. Fluoride can be obtained by drinking water, salt, milk and specialized ways such as toothpaste or mouthwash, however, the best way is adding fluoride to the drinking water.[5] Community Water Fluoridation Program (CWFP) has been implemented for 60 years to reduce dental decay. Water fluoridation is approved by Health Association of Canada, the WHO, the American Center for Disease Control and Prevention (CDC) and more than 90 agencies or health professional associations. Water fluoridation is considered safe, effective and economic by the scientific community. CDC regards water fluoridation as one of the best public health achievements of the 21st century for preventing dental decay in the last 60 years and it was stated that 38 dollars saved in oral diseases cost for each dollar spend on community water fluoridation.[6]

Dental caries is a prevalent disease among Iranian adults and also children. Water fluoridation has been considered as one of the most effective methods of preventing and controlling dental caries and it could be a potential solution to the problem of dental caries and oral health in Iran.[7] In Iran in 2004, mean DMFT index in children under 6 years (1.8 in 3-years-old children and 4.8 in 6-years-old children) was so high and the D component of this index composed about 90%-95% of this index.[8] Mean DMFT index at 6 years old children in Iran in 2011 was estimated 5.7 and D, M and F components were 5.2, 0.3 and 0.2 respectively.[9] Jahani et al. estimated that mean DMFT index in 12-years old students was 3.6 ± 2.2 and caries free index was 30.1% in Kerman in 2012.[10] Torabi et al. showed that mean DMFT index was 10.90 ± 6.47 in Kerman. The results of this study indicated the high prevalence of dental caries and periodontal disease in this age group.[11]

Pooreslami et al. showed that the amount of fluoride in Kerman drinking water was 0.17 ppm which was less than WHO standards (0/8-1 ppm).[12] Considering the low amount of fluoride in Kerman drinking water and given the role of fluoride in preventing tooth decay and lack of information about the cost-savings of implementing this method in our country, the study aimed to determine the costs savings due to drinking water fluoridation carried in Kerman.

Methods

This cost-benefit economic evaluation study estimated cost-saving of water fluoridation of Kerman in 2014. The studied population was people residing in Kerman (621347 individuals).[13] Based on the evidence, the highest impact of water fluoridation to prevent dental caries belonged to the people under 45 years of age.[3] Therefore, the population of Kerman who were under 45 years (490493 people, 78.9%) were used as the purpose population of the study to calculate benefits of water fluoridation.[13] The data related to mean DMFT in various age groups was extracted from Najafipour et al.[14] and Jahani et al.[10] study. The study was carried out in three steps: in the first step, annual cost of the water fluoridation was estimated. The benefits of the project (in monetary unit) were estimated in the second step and in the third step, the difference between the costs and benefits was calculated and the annual cost-savings was determined

(all the costs and benefits have been reported based on US dollars).

The perspective of this study was societal and the discounting was not necessary because of annual out costs and benefits.

First step: calculating the project cost

Three compounds used for water fluoridation are: H_2SiF_6, NaF and F_6Na_2Si. Based on evidence, H_2SiF_6 is recommended because of safety, economic, and accessibility reasons.[4,15] Therefore, it was used for calculating the cost as the optimal compound in this study.

At first, the annual consumption of water was estimated to calculate the CWFP in Kerman, and then the difference between natural fluorides and the standard amount of fluoride for preventing dental caries was determined. Next, based on the H_2SiF_6 molecular weight, the annual required amount of fluoride to reach to standard level was calculated. Then the annual required amount of H_2SiF_6 was multiplied to the price of H_2SiF_6, so that the total annual cost of providing H_2SiF_6 was obtained. Finally, the other costs including required manpower and water fluoridation equipment were estimated and add to H_2SiF_6 cost so that annual cost of the project was estimated.

Total annual cost of project = annual cost of providing H_2SiF_6 + annual manpower cost + annual cost of buying and maintenance of equipment for implementation of water fluoridation projects

Second step: calculating the benefits obtained from the project (the dental caries treatment cost saved by project implementation)

First, based on the rate of DMFT, prevalence of caries in Kerman population per year was estimated to calculate the benefit of the project. This index rate was extracted from Najafipour et al.[14] and Jahani et al. studies.[10] Then the prevalence of dental caries and the effect of water fluoridation on decreasing the rate of tooth decay based on previous studies done in this area was estimated between 30-50 percent,[4,6,15-17] and was multiplied to determine total prevented caries due to implementation of the project. In the next step, to convert the benefits of plan into money, the total amount of decay prevented was multiplied into average cost of treatment for each decayed tooth, and the benefits of the plan was determined.

Project benefit = caries incidence per year per person × population × effect size of water fluoridation in caries reduction × average treatment cost per decay tooth

In this study, indirect and intangible benefits were not calculated because of data limitations.

Third Step: determining the amount of savings

To calculate the amount of potential savings, the total estimated costs of implementing water fluoridation program has been subtracted from the potential benefits of the program.

The annual cost-savings = total benefits obtained from project - total cost of the project.

Results

Calculating the project expenses:

a. estimating the cost of providing H_2SiF_6

Total population of Kerman = 621374

Per capita consumption of water per day per person = 180 liter

Total annual water consumption of Kerman = Kerman population × per capita water consumption over one year = 621374 × 65700 = 40824271800 lit/year

Based on previous studies, the amount of natural fluoride in drinking water of Kerman was 0.17 mg per liter and since the standard rate of fluoride to reduce tooth decay has been determined 1 mg per liter, the required amount of fluoride that should be added to drinking water was 0.83 mg per liter:

Required amount of fluoride per liter = 1-0.17 = 0.83 mg/liter

Net amount of fluoride needed per year = 40824271800 × 0.83 = 33904145594 mg

The amount of net fluoride required annually was estimated 33904145594 mg per year (33904 kg). Since in this study the composition of fluoride was H2SiF6 55% and

the molecular weight and the amount of fluoride in H_2SiF_6 are 144.08 and 79.20 percent respectively, based on the following formula, 77832 kg of fluoride must be purchased per year in order to supply the sufficient amount of fluoride in drinking water by this composition:

The amount of H_2SiF_6 55% required = 0.792 × 0.55 × 33904 = 77832 kg/year

The cost of providing each ton of H_2SiF_6 with calculating transportation cost was estimated $3823.5 so total cost to provide 77.832 ton of this material would be more than $297592.9.

b. The cost of purchasing and maintaining the water fluoridation equipment

According to the Kerman drinking water authority, distribution of drinking water in Kerman is conducted through 4 main tanks, so in order to fluoridate drinking water fluoridation, four water fluoridation equipment was needed. Based on the calculations, the cost of purchasing, installing and commissioning of each water fluoridation equipment was $5882.3. Assuming a useful life of 5 years for each machine and 20 percent of the purchase price paid for annual repairs and maintenance, $4705.8 for the annual purchase and $4705.8 annual cost of repairs and maintenance was considered making up a total of $9411.7 per year for 4 water fluoridation sets.

c. Manpower recruitment cost

For the operation of the injection and monitoring of fluoride in drinking, water four trained manpower are required. Assuming that they are paid $441 per person, including $294 for a total cost of training, cost of hiring manpower was estimated at $21470.5 for one year.

Costs of fluoridating: Taking into account total costs for providing H2SiF6, costs of the purchase and maintenance of equipment and labor costs, total implementation costs of water fluoridation in Kerman was estimated $328475.2 per year.

Annual total cost of the project = $297592.9 + $9411.7 + $21470.5 = $328475.2

Annual cost of the project per person = $328475.2 / 490493 = $0.66 per person

The calculation of the total benefits derived from the project (prevented costs through water fluoridation):

To calculate the benefits of the project in the first stage, the annual average rate of tooth decay and annual total decay in each age group of the study was estimated based on studies by Najafipour et al.[14] and Jahani et al.[10] which can be seen in table 1.

The mean DMFT per year in each age group = Mean DMFT in each age group/average period (year)

Estimates of averted decay: According to the above table, the total number of decayed teeth in all age groups during the year was estimated 434024.76. Since the effect of fluoride in reducing tooth decay in different studies have been reported between 30 and 50 percent which expressed the benefits of assuming the impact of 30%, 40% and 50% of fluoride in reducing tooth decay, these amounts of assuming impacts were calculated. Total numbers of caries-prevented effect with the assumption of 30%, 40% and 50%, were 130207.42, 173609.90 and 217012.38 teeth respectively.

Table 1. The estimated annual average rate of decay and annual total decay in each age group

Age group (year)	Mean DMFT in each age group	Average period (year)	Mean DMFT per year in each age group	Population of each group	Total decay in each age group per year
under 6	4.7	6.0	0.8	51560	40216.8
7-14	3.6	4.0	0.9	96575	86917.5
15-24	9.5	9.0	1.1	130972	137520.6
25-34	12.1	14.0	0.9	128572	110571.9
35-45	14.0	19.5	0.7	82814	58797.9
Total decay in all age groups per year					434024.8

DMFT: decayed, missing, and filled teeth

Table 2. The cost-benefit ratio of drinking water fluoridation project in Kerman (US$)

The impact of fluoride on decay reduction	Treatment cost of each decayed tooth	Total benefit	Total cost	Total net benefit	Cost-benefit ratio
Scenario 30%	88.2	11488890.70	328475.2	11160415.50	34.9
	147.0	19148151.17	328475.2	18819675.88	58.2
	205.8	26807411.64	328475.2	26478936.35	81.6
Scenario 40%	88.2	15318520.94	328475.2	14990045.64	46.6
	147.0	25530868.23	328475.2	25202392.94	77.7
	205.8	35743215.58	328475.2	35414740.29	108.8
Scenario 50%	88.2	19148151.17	328475.2	18819675.88	58.2
	147.0	31913585.29	328475.2	31585110.00	97.1
	205.8	44679019.41	328475.2	44350544.11	136.0

Next, considering the cost of treatment of a decayed tooth and also cost of total preventable decayed teeth through the implementation of fluoride program for all age groups per year, total benefits from the project (cost of treatment prevented decay for the project) were calculated. It was estimated that the cost of repairing decayed teeth by dental specialists were estimated between $88.2 to $205.8 that our calculations for the three scenarios would be, $88.2, $147 and $205.8, respectively.

The total annual benefits from the implementation = cost of treatment per tooth decay × total number of caries prevention through the implementation of drinking water fluoridation per year

Cost-savings from averted decay:

Based on the table above, the obtained benefits per year were estimated about $34.9 to $136 for each dollar spent. Total net benefit was about $11160415.5 to $44350544.11 per year. The total net benefit per person was estimated about $22.7 to $90.4 per year.

The main variables affecting the results of the study were the prevalence of dental caries, effect of fluoride in reducing tooth decay and dental treatment costs. As demonstrated in table 2, to increase the effectiveness of fluoride from 30% to 50%, the cost of treatment per tooth decay increased from $88.2 to $205.8, and the cost-benefit ratio of the project was increased from $34.9 to $136.

Discussion

The cost-savings of this project was about $34.9 to $136 per dollar spent. Based on calculations, the annual cost of the project per person per year was $0.66 and the annual benefit of the project per person per year was about $23.4 to $91.09. Net annual benefit of this project was about $22.7 to $90.4 per person.

In the study by Wright et al. in New Zealand, water fluoridation in communities with more than 1000 people led to savings in costs that varied based on population, size of region, and level of dental decay and savings cost from the implementation of the project was estimated to be between $24-$40.[18] In another study by Griffin et al. the savings resulting from water fluoridation per person ranged from $15.95 in small communities to $18.62 in large communities.[15]

Tchouaket et al. reported that the average effectiveness of water fluoridation programs in dental decay reduction was around 30% and each dollar invested in drinking water fluoridation program led to a saving of $71.5-$82.83 per person in dental decay treatment cost or over 560 million dollars savings for the entire Quebec.[19] Assuming 30% caries reduction as a result of fluoride impact, per dollars expenses in project resulted $34.9-$81.6 saving in costs related to dental decay treatment and this measures are in line with Tchouaket et al. ($71.5-$82.83)[19] and O'Connell et al. ($46.97 to $76.41)[4] studies but is higher than the results of the studies by Griffin et al. ($15.95 - $18.62)[15] and Wright et al. ($24-$40).[18]

Since in Tchouaket et al.'s study,[19] the impact of fluoride was also considered 30 percent, it is more logical to compare our results with this study. The reasons for the

difference observed in results of Griffin et al.[15] and Wright et al.[18] studies could be related to differences in the population size, population age composition, the level of socio-economic development, the amount of dental caries, the natural level of fluoride in drinking water and also providing other interventions for the prevention of dental caries in any community.

Assuming 40% effect for fluoride on caries reduction, per dollars expenses in project resulted in $46.6-$108.8 saving in costs and 30% impact assumption is consistent with Tchouaket et al. ($71.5-$82.83)[19] and O'Connell et al.'s ($46.97 to $76.41)[4] study, but is higher than the amount obtained from the Griffin et al.[15] and Wright et al.'s[18] studies. However, like 30% effect of fluoride, these differences are related to differences in the variables affecting the cost-savings of drinking water fluoridation projects.

Given the 50% impact of fluoride in caries reduction, per dollars in the project costs, between 58.2 to 136 dollars in costs related to caries treatment will be saved. This rate was higher than studies in this area. The comparison of the results of the study which considered 30% and 40% in caries reduction in decayed rate with other studies was more logical.

In general, the cost-savings resulting from the implementation of the project per each dollar was between 34.9 to 136 dollars and this is consistent with the studies by Tchouaket et al.[19] and O'Connell et al.[4] and is higher than Griffin et al.[15] and Wright et al.'s[18] studies. Based on conducted calculations, the annual cost of implementation of this project was $0.66 per person and annual benefit was about $23.4 to $91.09 per person. Annual net benefit of project was about $22.7 to $90.4 per person. The reasons for the differences between the results of the present study and Griffin et al.[15] and Wright et al.'s[18] studies can be due to the differences in prevalence of dental caries, cost of tooth decay treatment in various populations and water fluoridation effectiveness in different communities.

Since oral health status and the prevalence of dental caries, tooth decay treatment costs and the level of natural fluoride in the water is different in various communities, the benefits resulted from this project would be different in various countries. Also, according to the results of previous studies in this area, the size and age structure of the population affect the benefits resulting from this project so that in communities with larger population and countries with young population and more number of children will benefit from this project more.

Conclusion

Based on the review of the literature in this area and the results of the present study, this health action was a safe, effective and cost-effective method in the reduction of dental caries, so that the cost-savings of this project was about $34.9 to $136 per dollar spent for this project. Based on calculations, the annual cost of the project per person per year was $0.66 and the annual benefit of the project per person per year was about $23.4 to $91.09. Net annual benefit of this project was about $22.7 to $90.4 per person. It is noteworthy that the health policy makers should pay attention to this issue and implement other actions to do this project.

Conflict of Interests

Authors have no conflict of interest.

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