

## Necessity of water fluoridation in Iran: A review on water fluoridation and prevention of dental caries

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### Review Article

#### Abstract

**BACKGROUND AND AIM:** Water fluoridation is one of the methods for prevention of dental caries. The purpose of this study was to review water fluoridation in the world and in Iran, and its effectiveness in reported literature.

**METHODS:** This paper is not a systematic review, but reviews the literature. "Water fluoridation" was used as a keyword for searching (electronic and hand search) in specialist databases. Many studies show that fluoride ion is lower than its optimal level in almost of all of Iran's provinces.

**RESULTS:** Dental caries is prevalent among Iranian children and adults. Water fluoridation has chosen as a method for prevention and control dental caries in most of the countries. This method can be of a great for help to the Iran health policies to find a solution in Iran.

**CONCLUSION:** The cities in Iran need a careful and scientific program for water fluoridation according to their climate.

**KEYWORDS:** Dental Caries, Fluoride, Iran, Water Fluoridation

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Dental caries remains a major public health concern in most countries, affecting 60-90% of school children and majority of young people and adults.<sup>1</sup> It is also prevalent among preschool children and school children. The average score of the decayed, missing, and filled teeth (DMFT) index was reported in 1.54 in Iranian 12-years old. The DMFT scores of 3.6 and 5 were reported for 6-year and 9-year old children, respectively. The DMFT score of 1.86 was reported for 12 years old Iranian children.<sup>2</sup> Water fluoridation is the controlled addition of fluoride to a public water supply to reduce dental caries. Water fluoridation prevents cavities in both children and adults with studies estimating an 18-40% reduction in cavities when water fluoridation is used by children who already have access to

toothpaste and other sources of fluoride.<sup>3</sup> Its use began in 1945, following studies on children in a region where higher levels of fluoride occur naturally in the water. Researchers discovered that moderate fluoridation prevents tooth decay.

Water fluoridation has been one of the 10 great public health achievements of the 20<sup>th</sup> century. This method was first started in US, and then practiced in many other countries, such as in Europe, using fluoridated salts and milk.<sup>4</sup>

Water fluoridation is a process which in the US has cost about \$1 per person a year. Defluoridation is a process for reduction of excessive fluoride when water has naturally fluoride more than recommended levels.<sup>5</sup> Some of the water filters remove some or all fluoride of bottled water.<sup>6</sup> In general, the goal

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of water fluoridation is to prevent dental caries which is known as one of most prevalent chronic disease.

### Methods

It is not a systematic review but this paper has a review on the literature. "Water fluoridation" was used as a key word for searching (electronic and hand search) in the specialist databases. Many studies shows fluoride ion is less than of optimal level in almost of all of Iran provinces.

#### *Mechanism of the effects*

Fluoride ion in water acts on enamel surface: low levels of this ion via saliva reduces the level of enamel demineralization and increases the level of remineralization in the early phases of caries. People living in regions with fluoridated water have about 0.04 mg/l of fluoride concentration in their saliva several times during a day.<sup>7</sup> This level of fluoride is not enough for prevention of caries develop individually.<sup>8</sup> Fluoride ions which are present in dental plaque fluid next to dissolved hydroxyapatite, formed a fluorapatite-like remineralized veneer which is more resistant against the acid attack than original hydroxyapatite.<sup>9</sup> The cavity-prevention effect of fluoride is mostly due to these surface effects, which occur during and after tooth eruption.<sup>10</sup> Although some systemic (whole-body) fluoride returns to the saliva via blood plasma, and to unerupted teeth via plasma or crypt fluid, there is little data to determine what percentages of fluoride's anticavity effect comes from these systemic mechanisms. Furthermore, although fluoride affects the physiology of dental bacteria, its effect on bacterial growth does not seem to be relevant to cavity prevention.<sup>11</sup>

Fluoride's effects depend on the total daily intake of fluoride from all sources. About 70-90% of ingested fluoride is absorbed into the blood, where it distributes throughout the body. In infants 80-90% of absorbed fluoride is retained, with the rest excreted, mostly via urine; in adults about 60% is retained. About

99% of retained fluoride is stored in bone, teeth, and other calcium-rich areas, where excess quantities can cause fluorosis.<sup>12</sup> Drinking water is typically the largest source of fluoride, in many industrialized countries swallowed toothpaste is the main source of fluoride exposure in unfluoridated communities.<sup>13</sup>

Other sources include dental products other than toothpaste; air pollution from fluoride-containing coal or from phosphate fertilizers; Trona, used to tenderize meat in Tanzania; and tea leaves, particularly the tea bricks favored in parts of China. High fluoride levels have been found in other foods, including barley, cassava, corn, rice, taro, yams, and fish protein concentrate. The US Institute of Medicine has established dietary reference intakes for fluoride: adequate intake values range from 0.01 mg/day for infants aged 6 months or less to 4 mg/day for men aged 19 years and up; and the tolerable upper intake level is 0.10 mg/kg/day for infants and children through age 8 years, and 10 mg/day thereafter. A rough estimate is that an adult in a temperate climate consumes 0.6 mg/day of fluoride without fluoridation, and 2 mg/day with fluoridation. However, these values differ greatly among the world's regions: for example, in Sichuan, China the average daily fluoride intake is only 0.1 mg/day in drinking water but 8.9 mg/day in food and 0.7 mg/day directly from the air due to the use of high-fluoride soft coal for cooking and drying foodstuffs indoors. Existing evidence strongly suggests that water fluoridation reduces tooth decay. There is also consistent evidence that it causes dental fluorosis, most of which is mild and not usually of aesthetic concern.<sup>14</sup> There is no clear evidence of other adverse effects. With regard to potential adverse effects, there are a few studies which have done in Iran, China, and India.<sup>15</sup>

#### *Effectiveness*

Water fluoridation is effective for prevention of dental caries in both primary and

permanent dentitions. In primary dentition, water fluoridation led to reductions about 50-60% (last studies), 18-40% (recent studies). This difference in last and recent findings is probably due to increasing use of fluoride from other sources such as toothpastes, as well as food products which made in fluoridated regions.<sup>3</sup>

Fluoride also prevents cavities in adults of all ages. There are fewer studies in adults however, and the design of water fluoridation studies in adults is inferior to that of studies of self or clinically applied fluoride. A 2007 meta-analysis found that water fluoridation prevented an estimated 27% of cavities in adults [95% confidence interval (CI) 19-34%], about the same fraction as prevented by exposure to any delivery method of fluoride (29% average, 95% CI: 16-42%).<sup>16</sup> Most countries in Europe have experienced substantial declines in cavities without the use of water fluoridation.<sup>7</sup> For example, in Finland and Germany, tooth decay rates remained stable or continued to decline after water fluoridation stopped. Fluoridation may be useful in the US because unlike most European countries, the US does not have school-based dental care, many children do not visit a dentist regularly, and for many US children water fluoridation is the prime source of exposure to fluoride.<sup>17</sup>

The effectiveness of water fluoridation can vary according to circumstances such as whether preventive dental care is free to all children. Some studies suggest that fluoridation reduces oral health inequalities between the rich and poor, but the evidence is limited. There is anecdotal but not scientific evidence that fluoride allows more time for dental treatment by slowing the progression of tooth decay, and that it simplifies treatment by causing most cavities to occur in pits and fissures of teeth.<sup>7</sup>

#### *Water fluoridation around the world*

The earliest studies on the relation between fluoride and dental health were done by researchers in the US during the last century.

After that, this country was pioneer in public water fluoridation.<sup>8</sup> It has been introduced to varying degrees in many countries and territories outside the US, including Argentina, Australia, Brazil, Canada, Chile, Colombia, Hong Kong, Ireland, Israel, Korea, Malaysia, New Zealand, the Philippines, Singapore, Spain, the UK, and Vietnam. An estimated 12 million people in western Europe, 204 million in the US (66% of the US population), and 355 million worldwide receive artificially fluoridated water, in addition to at least 50 million worldwide who receive water naturally fluoridated to recommended levels.

Naturally fluoridated water is used in many countries, including Argentina, France, Gabon, Libya, Mexico, Senegal, Sri Lanka, Tanzania, the US, and Zimbabwe. In some locations, notably parts of Africa, China, and India, natural fluoridation exceeds recommended levels; in China an estimated 200 million people receive water fluoridated at or above recommended levels. Communities have discontinued water fluoridation in some countries, including Finland, Germany, Japan, the Netherlands, Sweden, and Switzerland. This change was often motivated by political opposition to water fluoridation, but sometimes the need for water fluoridation was met by alternative strategies. The use of fluoride in its various forms is the foundation of tooth decay prevention throughout Europe; for example, France, Germany, and many other European countries use fluoridated salt.<sup>5,18</sup>

Australia is one of many countries that have water fluoridation programs currently operating. As of March 2012, artificially fluoridated drinking water is provided for 70% or more of the population in all states and territories.<sup>19</sup>

#### *Current situation in Iran*

Several studies have assessed fluoride content of drinking water in different areas of Iran (Table 1). World Health Organization expert committee suggested a level of fluoride from

0.5 to 1.0 mg/l or ppm and the US Public Health Service established an optimal standard for fluoride in the drinking water from 0.7 to 1.2 ppm, depending on climate.

It seems fluoride content in many of Iranian cities is lesser than of optimal level for prevention of dental caries. In few areas of Iran, such as Kuhbanan, Bandar Lengeh, Maku, and Behabad, naturally fluoride content of drinking water is higher than the optimum level (Table 1).

**Table 1.** Fluoride content of drinking waters in some of tap water sources of the cities and in some of bottled waters in Iran

City	Fluoride level (ppm)
Tehran <sup>20</sup>	0.15-0.52
Kerman <sup>21</sup>	0.17
Koohbanan <sup>21</sup>	2.36
Baft <sup>21</sup>	0.41
Rafsanjan <sup>21</sup>	0.39
Jiroft <sup>21</sup>	0.34
Sirjan <sup>21</sup>	0.39
Bam <sup>21</sup>	0.43
Maku <sup>22</sup>	0.40
Bandar Lengeh <sup>23</sup>	1.35
Kermanshah <sup>24</sup>	0.19
Behabad (Bafgh) <sup>25</sup>	3.00
Ahvaz <sup>26</sup>	0.31-0.51
Babol <sup>27</sup>	0.15
Ramian <sup>28</sup>	0.25
Urmia <sup>29</sup>	0.12
Zanjan <sup>30</sup>	0.56
Kashan <sup>31</sup>	0.25
Shahrud <sup>32</sup>	0.23-0.70
Hamadan <sup>33</sup>	0.19
Bottled waters <sup>21</sup>	0.04-0.27
Ardabil <sup>34</sup>	0.36
Isfahan <sup>34</sup>	0.38
Birjand <sup>34</sup>	0.25-0.51
Tabriz <sup>34</sup>	0.44
Torbat-e Heydarieh <sup>34</sup>	0.20-0.74
Bojnord <sup>34</sup>	0.56
Jahrom <sup>34</sup>	0.50
Damghan <sup>34</sup>	0.55
Semnan <sup>34</sup>	0.19-0.84
Zahedan <sup>34</sup>	0.24-0.86
Zabol <sup>34</sup>	0.83-1.36
Shiraz <sup>34</sup>	0.08-0.91
Gonabad <sup>34</sup>	0.23-0.86
Khorramabad <sup>34</sup>	0.20
Arak <sup>34</sup>	0.09-0.77
Nishabur <sup>34</sup>	0.27

Table 2 shows recommended optimal fluoride level of drinking water based upon the annual average of maximum daily air temperature.<sup>35</sup>

**Table 2.** Recommended optimal fluoride level of drinking water based upon the annual average of maximum daily air temperature<sup>35</sup>

Annual average of maximum daily air temperature (°C)	Optimal level of fluoride (ppm)
4.4-12.0	1.2
12.1-14.6	1.1
14.7-17.6	1.0
17.7-21.4	0.9
21.5-26.2	0.8
26.3-32.5	0.7

In recent years, since 2006, sodium fluoride 0.2% mouth wash has been distributed at Iranian primary school for prevention of dental caries among the students and they use it. But this preventive program has some problems such as exact supervision of the students. A study showed the students are not satisfied from the taste of the mouth wash so are not use it correctly.<sup>36</sup>

Effectiveness the mouth wash for control of dental caries among the students is not evaluated. In 2011 bureau of oral health, ministry of health and medical education has planned for application of varnish fluoride in nurseries at national level and it took a considerable amount of the bureau budget about two milliard tomans (unpublished data). However, it was not a successful plan because most of the provinces did not get the benefits of the plan due to personnel or suitable service limitation according to verbal reports of oral department's staffs at oral health symposium in Tehran.

#### *Safety of water fluoridation*

Water fluoridation presents a conflict between the common good and individual rights.<sup>37</sup> In this relation, there are controversial and opposition on efficacy, safety, and legal grounds. Oral and dental associations in the world have confirmed its benefits for dental health.<sup>7</sup> Fluoridation does not affect the quality of drinking water and

its bad effects depend on total its dosage from all sources.<sup>14</sup> The critical period of exposure for resulting dental fluorosis is between ages one and four years, with the risk ending around age eight. Fluorosis can be prevented by monitoring all sources of fluoride, with fluoridated water directly or indirectly responsible for an estimated 40% of risk and other sources, notably toothpaste, responsible for the remaining 60%. Fluoride can occur naturally in water in concentrations well above recommended levels, which can have several long-term adverse effects, including severe dental fluorosis, skeletal fluorosis, and weakened bones. The World Health Organization recommends a guideline maximum fluoride value of 1.5 mg/l as a level at which fluorosis should be minimal.<sup>12</sup>

#### *Economics related to fluoridation*

Fluoridation costs an estimated \$1 per person-year on the average (range: \$0.24-\$10.63; all costs in this paragraph are for the US and are in 2013 dollars, inflation-adjusted from earlier estimates). Larger water systems have lower per capita cost, and the cost is also affected by the number of fluoride injection points in the water system, the type of feeder and monitoring equipment, the fluoride chemical and its transportation and storage, and water plant personnel expertise. By comparison, fluoride toothpaste costs an estimated \$8-\$17 per person a year, with the incremental cost being zero for people who already brush their teeth for other reasons; and dental cleaning and application of fluoride varnish or gel costs an estimated \$92 per person a year.

Fluoridation costs an estimated \$15-\$24 per saved tooth-decay surface, which is lower than the estimated \$91 to restore the surface and the estimated \$153 average discounted lifetime cost of the decayed surface, which includes the cost to maintain the restored tooth surface. In the US, water fluoridation is more cost-effective than other methods to reduce tooth decay in children, and a 2008

review concluded that water fluoridation is the best tool for combating cavities in many countries, particularly among socially disadvantaged groups. US data from 1974 to 1992 indicate that when water fluoridation is introduced into a community, there are significant decreases in the number of employees per dental firm and the number of dental firms. The data suggest that some dentists respond to the demand shock by moving to non-fluoridated areas and by retraining as specialists.<sup>38,39</sup>

#### *Alternatives to water fluoridation*

There are many options for decrease the rate of dental caries. They are including: suitable diet and reduction in consumption of sugar plus using sugar substitutes; using tooth brush and toothpaste regularly, at least twice daily; using of fluoride ion in combination with milk and/or salt and in formulations of toothpastes, mouth washes gels and varnish; and dental sealants are effective as well, with estimates of prevented cavities ranging from 33% to 86%, depending on age of sealant and type of study.<sup>14,40</sup>

Although tap water and bottled water are the largest sources for daily intake of fluoride, toothpastes, mouthwashes, salt, and milk are other vehicles for it.<sup>41</sup> Water fluoridation, when feasible and culturally acceptable, has substantial advantages, especially for subgroups at high risk such as primary school children and disabled teenagers.<sup>1</sup>

### **Conclusion**

The studies have shown fluoride ion is less than of optimal level in almost of all of Iran provinces and these provinces need a careful and scientific program for water fluoridation according to their climate. Iran is a wide country which does not have regular programs for young people dental visits and applying preventive procedures. So, Iran needs an effective public solution.

A solution is public water fluoridation and/or schools water fluoridation or

production of bottles of mineral water which need to contain optimum level of fluoride ion.

### Conflict of Interests

Authors have no conflict of interest.

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