
I found that reading this article and many of the references cited gave me a good overview of the history and scope of the controversy surrounding water fluoridation. Overall, the article has a moderate majority of cited material that is pro-fluoridation. However, many references are anti-fluoridation. The tone of most of the article is that the quality of the supporting information on both sides of the issue is of modest quality, at best. A more robust anti-fluoridation discussion can be found in Wikipedia at the article entitled “Opposition to Water Fluoridation”. Neither of these articles is going to unambiguously answer the question of the wisdom and desirability of fluoridation of public drinking water supplies.

I have attempted to present some of the salient points in each of the dozen or so sections of this article. In some cases, I have attempted to summarize. In other cases, I have copied and pasted the most compelling discussion points.

From the ‘TALK’ Page

“Water fluoridation is a featured article; it (or a previous version of it) has been identified as one of the best articles produced by the Wikipedia community.”

“This topic contains controversial issues, some of which have reached a consensus for approach and neutrality, and some of which may be disputed.”

INTRODUCTORY MATERIAL

There is a moderately positive paragraph in the introduction. “Dental cavities remain a major public health concern in most industrialized countries, affecting 60–90% of schoolchildren and the vast majority of adults.\(^8\) Water fluoridation prevents cavities in both children and adults,\(^9\) 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.\(^2\) Although water fluoridation can cause dental fluorosis, which can alter the appearance of developing teeth, most of this is mild and usually not considered to be of aesthetic or public-health concern.\(^10\) There is no clear evidence of other adverse effects. Moderate-quality studies have investigated effectiveness; studies on adverse effects have been mostly of low quality.\(^11\) “

“The U.S. Centers for Disease Control listed water fluoridation as one of the ten great public health achievements of the 20th century.\(^14\) In contrast, most European countries have experienced substantial declines in tooth decay without its use, primarily due to the introduction of fluoride toothpaste in the 1970s.\(^3\) Fluoridation may be more justified in the U.S. because of socioeconomic inequalities in dental health and dental care.\(^15\)”

There is then a mild reference to opposition. “Its use presents a conflict between the common good and individual rights.\(^17\) It is controversial,\(^18\) and opposition to it has been based on ethical, legal, safety, and efficacy grounds.\(^19\)”

GOAL

A paragraph starting “The goal of water fluoridation is to prevent tooth decay”. And elaborating “Although it is rarely life-threatening, tooth decay can cause pain and impair eating, speaking, facial appearance, and acceptance into society.\(^23\) and it greatly affects the quality of life of children, particularly those of low socioeconomic status.\(^19\)”
IMPLEMENTATION

“Fluoridation does not affect the appearance, taste, or smell of drinking water. It is normally accomplished by adding one of three compounds to the water: sodium fluoride, fluorosilicic acid, or sodium fluorosilicate.” The properties of these three compounds are then presented. A discussion of details of use in public water systems, presence in bottled and natural water, and removal by filters follows.

MECHANISM

The discussion in each of the four paragraphs begins with a strong statement, followed by elaboration of details of the mechanism described.

“Fluoride exerts its major effect by interfering with the demineralization mechanism of tooth decay.” This is followed by a paragraph describing the demineralization process mediated by bacteria.

“All fluoridation methods, including water fluoridation, create low levels of fluoride ions in saliva and plaque fluid, thus exerting a topical or surface effect.”

“Fluoride's effects depend on the total daily intake of fluoride from all sources.”

EVIDENCE BASIS

“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[10]. There is no clear evidence of other adverse effects. Moderate-quality research exists as to water fluoridation's effectiveness and its potential association with cancer; research into other potential adverse effects has been almost all of low quality. Little high-quality research has been performed.[11]”

EFFECTIVENESS

“Water fluoridation is effective at reducing cavities in both children and adults.[9] Earlier studies showed that water fluoridation led to reductions of 50–60% in childhood cavities; more recent studies show lower reductions (18–40%), likely due to increasing use of fluoride from other sources, notably toothpaste, and also to the halo effect of food and drink made in fluoridated areas and consumed in unfluoridated ones.[2]

A 2000 systematic review found that water fluoridation was statistically associated with a decreased proportion of children with cavities (the median of mean decreases was 14.6%, the range –5 to 64%), and with a decrease in decayed, missing, and filled primary teeth (the median of mean decreases was 2.25 teeth, the range 0.5–4.4 teeth)[11] which is roughly equivalent to preventing 40% of cavities. An effect of water fluoridation was evident even in the assumed presence of fluoride from other sources such as toothpaste. The review found that the evidence was of moderate quality: many studies did not attempt to reduce observer bias, control for confounding factors, report variance measures, or use appropriate analysis. Although no major differences between natural and artificial fluoridation were apparent, the evidence was inadequate to reach a conclusion about any differences.[11] 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%).[51] A 2002 systematic review found strong evidence that water fluoridation is effective at reducing overall tooth decay in communities.[52]

Most countries in Europe have experienced substantial declines in cavities without the use of water fluoridation.[3] 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 U.S. because unlike most European countries, the U.S. does not have school-based dental care, many children do not visit a dentist regularly, and for many U.S. children water fluoridation is the prime source of exposure to fluoride.[15] The effectiveness of water fluoridation can vary according to circumstances such as whether preventive dental care is free.[53] Some studies suggest that fluoridation reduces oral health inequalities between the rich and poor, but the evidence is limited.[3] 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.[54].”

SAFETY—Bullet points and elaboration.

- Fluoride's adverse effects depend on total fluoride dosage from all sources.
- Fluoridation has little effect on risk of bone fracture (broken bones)
- There is no clear association between fluoridation and cancer or deaths due to cancer
- Other adverse effects lack sufficient evidence to reach a confident conclusion.
- Fear that water is fluoridated may have a psychological effect with a large variety of symptoms, regardless of whether the water is actually fluoridated.

In addition, “In rare cases improper implementation of water fluoridation can result in overfluoridation that causes outbreaks of acute fluoride poisoning, with symptoms that include nausea, vomiting, and diarrhea. Three such outbreaks were reported in the U.S. between 1991 and 1998, caused by fluoride concentrations as high as 220 mg/L; in the 1992 Alaska outbreak, 262 people became ill and one person died.”

“Although it has been hypothesized that hydrofluorosilicic acid and sodium silicofluoride might increase human lead uptake from water, a 2006 statistical analysis did not support concerns that these chemicals cause higher blood lead concentrations in children.[60] Trace levels of arsenic and lead may be present in fluoride compounds added to water, but no credible evidence exists that their presence is of concern: concentrations are below measurement limits.[59]

The effect of water fluoridation on the natural environment has been investigated, and no adverse effects have been established. Issues studied have included fluoride concentrations in groundwater and downstream rivers; lawns, gardens, and plants; consumption of plants grown in fluoridated water; air emissions; and equipment noise.[59].”

ALTERNATIVES

“Although water fluoridation is the most effective means of achieving fluoride exposure that is community-wide,[10] other fluoride therapies are also effective in preventing tooth decay,[16] they include fluoride toothpaste, mouthwash, gel, and varnish,[61] and fluoridation of salt and milk.[13] Dental sealants are effective as well,[16] with estimates of prevented cavities ranging from 33% to 86%, depending on age of sealant and type of study.[61].”

“The effectiveness of salt fluoridation is about the same as that of water fluoridation”
“Milk fluoridation is practiced by the Borrow Foundation in some parts of Bulgaria, Chile, Peru, Russia, Thailand and the UK.”

“Other public-health strategies to control tooth decay, such as education to change behavior and diet, have lacked impressive results.”

“A 2007 Australian review concluded that water fluoridation is the most effective and socially the most equitable way to expose entire communities to fluoride's cavity-prevention effects. A 2002 U.S. review estimated that sealants decreased cavities by about 60% overall, compared to about 18–50% for fluoride. A 2007 Italian review suggested that water fluoridation may not be needed, particularly in the industrialized countries where cavities have become rare, and concluded that toothpaste and other topical fluoride offers a best way to prevent cavities worldwide. A 2004 World Health Organization review stated that water fluoridation, when it is culturally acceptable and technically feasible, has substantial advantages in preventing tooth decay, especially for subgroups at high risk.”

ECONOMICS

“Fluoridation costs an estimated $0.94 per person-year on the average (range: $0.22–$9.95; all costs in this paragraph are for the U.S. and are in 2010 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. In affluent countries the cost of salt fluoridation is also negligible; developing countries may find it prohibitively expensive to import the fluoride additive. By comparison, fluoride toothpaste costs an estimated $8–$16 per person-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 $86 per person-year. Assuming the worst case, with the lowest estimated effectiveness and highest estimated operating costs for small cities, fluoridation costs an estimated $14–$22 per saved tooth-decay surface, which is lower than the estimated $85 to restore the surface and the estimated $144 average discounted lifetime cost of the decayed surface, which includes the cost to maintain the restored tooth surface. It is not known how much is spent in industrial countries to treat dental fluorosis, which is mostly due to fluoride from swallowed toothpaste.

Although a 1989 workshop on cost-effectiveness of cavity prevention concluded that water fluoridation is one of the few public health measures that save more money than they cost, little high-quality research has been done on the cost-effectiveness and solid data are scarce. Dental sealants are cost-effective only when applied to high-risk children and teeth. A 2002 U.S. review estimated that on average, sealing first permanent molars saves costs when they are decaying faster than 0.47 surfaces per person-year whereas water fluoridation saves costs when total decay incidence exceeds 0.06 surfaces per person-year. In the U.S., 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.”

ETHICS AND POLITICS

Further information: Opposition to water fluoridation

“Like vaccination and food fortification, fluoridation presents a conflict between benefiting the common good and infringing on individual rights. Fluoridation can be viewed...
as a violation of ethical or legal rules that prohibit medical treatment without medical supervision or informed consent, and that prohibit administration of unlicensed medical substances.\footnote{74} It can also be viewed as a public intervention to replicate the benefits of naturally fluoridated water in order to free people from the misery of toothache and dental work, with greatest benefit to those least able to help themselves, and where it would be unethical to withhold such treatment.\footnote{72} National and international health agencies and dental associations throughout the world have endorsed water fluoridation’s safety and effectiveness.\footnote{13} The Centers for Disease Control and Prevention listed water fluoridation as one of the ten great public health achievements of the 20th century\footnote{74} alongside vaccination, family planning, recognition of the dangers of smoking, and other achievements.\footnote{14} Other organizations endorsing fluoridation include the World Health Organization,\footnote{81}\footnote{27} the U.S. Surgeon General,\footnote{75} the American Public Health Association,\footnote{76} the European Academy of Paediatric Dentistry,\footnote{77} and the national dental associations of Australia,\footnote{78} Canada,\footnote{79} and the U.S.\footnote{80}

Despite support by public health organizations and authorities, efforts to introduce water fluoridation have met considerable opposition whenever it has been proposed.\footnote{19} Since fluoridation’s inception, proponents have argued for scientific optimism and faith in experts, while opponents have drawn on distrust of experts and unease about medicine and science.\footnote{81} Controversies include disputes over fluoridation’s benefits and the strength of the evidence basis for these benefits, the difficulty of identifying harms, legal issues over whether water fluoridation is a medicine, and the ethics of mass intervention.\footnote{18} U.S. opponents of fluoridation were heartened by a 2006 National Research Council report about hazards of water naturally fluoridated to high levels;\footnote{83} the report recommended lowering the U.S. maximum limit of 4 mg/L for fluoride in drinking water.\footnote{83} Opposition campaigns involve newspaper articles, talk radio, and public forums. Media reporters are often poorly equipped to explain the scientific issues, and are motivated to present controversy regardless of the underlying scientific merits. Internet websites, which are increasingly used by the public for health information, contain a wide range of material about fluoridation ranging from factual to fraudulent, with a disproportionate percentage opposed to fluoridation. Anti-fluoridationist literature links fluoride exposure to a wide variety of effects, including AIDS, allergy, Alzheimer’s, arthritis, cancer, and low IQ, along with diseases of the gastrointestinal tract, kidney, pineal gland, and thyroid.\footnote{19}

USE AROUND THE WORLD

Main article: Fluoridation by country

Water fluoridation’s science and practice are predominantly American.\footnote{94} It has been introduced to varying degrees in many countries and territories outside the U.S., 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, 171 million in the U.S. (61.5% of U.S. population\footnote{95}), and 355 million worldwide receive artificially fluoridated water, in addition to at least 50 million worldwide who receive water naturally fluoridated to recommended levels.\footnote{42} In addition, at least 50 million people worldwide drink water that is naturally fluoridated to optimal levels; the actual number is unknown and is likely to be much higher. Naturally fluoridated water is used in many countries, including Argentina, France, Gabon, Libya, Mexico, Senegal, Sri Lanka, Tanzania, the U.S., 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.\footnote{22}
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.

HISTORY
“The relationship between fluoride and teeth has been studied since the early 19th century. By 1850, investigators had established that fluoride occurs with varying concentrations in teeth, bone, and drinking water. By 1900, they had speculated that fluoride would protect against tooth decay, proposed supplementing the diet with fluoride, and observed mottled tooth enamel (now called dental fluorosis) without knowing the cause.”

A SMALL NUMBER OF REFERENCE AND COMMENTS, MOSTLY FROM THE INTRODUCTION

Ref 3. Pizzo G, Piscopo MR, Pizzo I, Giuliana G. Community water fluoridation and caries prevention: a critical review. Clin Oral Investig. 2007;11(3):189–93. “For the past 50 years community water fluoridation has been considered the milestone of caries prevention and as one of the major public health measures of the 20th century. However, it is now accepted that the primary cariostatic action of fluoride occurs after tooth eruption. Moreover, the caries reduction directly attributable to water fluoridation have declined in the last decades as the use of topical fluoride had become more widespread, whereas enamel fluorosis has been reported as an emerging problem in fluoridated areas. Several studies conducted in fluoridated and nonfluoridated communities suggested that this method of delivering fluoride may be unnecessary for caries prevention, particularly in the industrialized countries where the caries level has became low. Although water fluoridation may still be a relevant public health measure in poor and disadvantaged populations, the use of topical fluoride offers an optimal opportunity to prevent caries among people living in both industrialized and developing countries.”

Ref 9. Parnell C, Whelton H, O’Mullane D. Water fluoridation. Eur Arch Paediatr Dent. 2009;10(3):141–8. A computerized review. “Of the 59 publications identified, 3 systematic reviews and 3 guidelines were included in this review. While the reviews themselves were of good methodological quality, the studies included in the reviews were generally of moderate to low quality. The results of the three reviews showed that water fluoridation is effective at reducing caries in children and adults. With the exception of dental fluorosis, no association between adverse effects and water fluoridation has been established. Water fluoridation reduces caries for all social classes, and there is some evidence that it may reduce the oral health gap between social classes. CONCLUSION: Water fluoridation, where technically feasible and culturally acceptable, remains a relevant and valid choice as a population measure for the prevention of dental caries.”
Ref 11. McDonagh M, Whiting P, Bradley M et al. A systematic review of public water fluoridation [PDF]; 2000. Report website: NHS Centre for Reviews and Dissemination. “A search of 25 electronic databases (with no language restrictions) and the world-wide-web was undertaken. 214 studies met full inclusion criteria for one or more of the objectives. No randomised controlled trials of the effects of water fluoridation were found.” The overall message is that virtually all of the reviewed articles, whether pro or anti, were of low to moderate quality, at best, and that bias is possible.


Ref. 17. (pro) McNally M, Downie J. The ethics of water fluoridation. J Can Dent Assoc. 2000;66(11):592–3. PMID 11253350. “Before closing, we would challenge CDA members to consider an important yet frequently ignored question: “In debates about fluoridation, are you hearing the voices of the vulnerable?” When political arguments erupt between policy-makers, interest groups and oral health professionals, are the groups who are most vulnerable even part of the discussions? For good reason, there is a great deal of concern being expressed by contemporary health care ethicists about health policies being made without consideration of the interests and desires of members of society who do not have a voice. When decisions are being made about public health policy, members of society who may be disadvantaged by a lack of education, resources and access to proper health care must be part of the discussions. It is not clear that they are when it comes to the issue of water fluoridation. CDA members should ensure that they seek out these voices before taking a final position on this issue. “

REF 17. (con) Cohen H, Locker D. The science and ethics of water fluoridation. J Can Dent Assoc. 2001;67(10):578–80. PMID 11737979. “Ethically, it cannot be argued that past benefits, by themselves, justify continuing the practice of fluoridation. This position presumes the constancy of the environment in which policy decisions are made. Questions of public health policy are relative, not absolute, and different stages of human progress not only will have, but ought to have, different needs and different means of meeting those needs. Standards regarding the optimal level of fluoride in the water supply were developed on the basis of epidemiological data collected more than 50 years ago. There is a need for new guidelines for water fluoridation that are based on sound, up-to-date science and sound ethics. In this context, we would argue that sound ethics presupposes sound science. “

Ref 18. Cheng KK, Chalmers I, Sheldon TA. Adding fluoride to water supplies [PDF]. BMJ. 2007;335(7622):699–702. “SUMMARY POINTS: Water fluoridation is highly controversial. Evidence is often misused or misinterpreted and uncertainties glossed over in polarised debates. Problems include identifying benefits and harms, whether fluoride is a medicine, and the ethical implications. This article provides professionals and the public with a framework for constructive public consultations.” Also, in reference to Ref. 11 above, “Given the certainty with which water fluoridation has been promoted and opposed, and the large number (around 3200) of
research papers identified, the reviewers were surprised by the poor quality of the evidence and the uncertainty surrounding the beneficial and adverse effects of fluoridation.”

Ref 19. Armfield JM. When public action undermines public health: a critical examination of antifluoridationist literature. Aust New Zealand Health Policy. 2007;4:25. “Summary: Water fluoridation is an important public health initiative that has been found to be safe and effective. Nonetheless, the implementation of water fluoridation is still regularly interrupted by a relatively small group of individuals who use misinformation and rhetoric to induce doubts in the minds of the public and government officials. It is important that public health officials are aware of these tactics so that they can better counter their negative effect.”