



UNIVERSITY OF TORONTO
FACULTY OF DENTISTRY

WATER FLUORIDATION

QUESTIONS & ANSWERS

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Acknowledgement

I would like to acknowledge and extend my heartfelt gratitude to the many individuals who have supported this project and made valuable contributions to the development of this report.

Preamble

Dental decay is the most common chronic disease in North America, affecting over 96 per cent of Canadians. The use of water fluoridation for the prevention of tooth decay has been used for over 60 years and is endorsed by over 90 national and international government and health organizations, including Health Canada, the Canadian Public Health Association, the Canadian Dental Association, the Canadian Medical Association and the World Health Organization.

Since its inception, extensive research has consistently demonstrated the safety and effectiveness of fluorides in the prevention of dental caries. In addition, there has been continual monitoring of this scientific literature by the world's major national and international health organizations, committees of experts and special councils of governments. To date the results of these reviews reaffirm that water fluoridation, at the recommended level, is a safe and effective means of reducing dental decay and does not pose a risk for health problems.

This document has been prepared for public health professionals and councils, including those of the medical and dental fields, to address common questions about the safety and efficacy of water fluoridation. A number of these questions address myths and misconceptions advanced by opponents of water fluoridation. The answers are based on generally accepted, peer-reviewed, scientific literature, including recent publications from the Public Health Agency of Canada and Health Canada. This report is intended as resource to advise the community and respond to media-related questions surrounding the issue of fluoridation. Each response comprises a scientific, technical answer, as well as an appropriate media response.

Special Note: This report was completed as part of a practicum project associated with the Dental Public Health program at Faculty of Dentistry, University of Toronto.

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What is Fluoride?

1. What is fluoride?

The fluoride ion comes from the element fluorine. Fluoride is a naturally occurring mineral found in soil, air, plants, animals and water supplies. Individuals are exposed to small amounts of fluoride by breathing air, drinking water, and eating food (1). In particular, fluorides are frequently added to drinking water supplies and to dental products such as toothpaste, mouth rinses and professionally applied fluorides to prevent dental decay. Fluoride is considered a beneficial nutrient based on its proven effects on dental health (2). It strengthens tooth enamel making the teeth more resistant to decay.

Media Response

The fluoride ion comes from the element fluorine. Fluoride is a naturally occurring mineral found in soil, air, plants, animals and water supplies. Individuals are exposed to small amounts of fluoride by breathing air, drinking water, and eating food. Fluoride is considered a beneficial nutrient based on its proven effects on dental health. Fluorides are frequently added to drinking water supplies and to dental products such as toothpaste, mouth rinses and professionally applied fluorides to prevent dental decay.

2. What type of fluoride is used to fluoridate water?

Fluorosilicic acid is the most commonly used compound to fluoridate water supplies, followed by two additives—sodium fluorosilicate and sodium fluoride. Fluorosilicic acid is derived from the reduction of phosphate fertilizers. Both sodium fluorosilicate and sodium fluoride are produced by neutralizing fluorosilicic acid with either sodium chloride (table salt) or caustic soda (3).

Media Response

Fluorosilicic acid is the most commonly used compound for water fluoridation, followed by two additives—sodium fluorosilicate and sodium fluoride.

3. What is the history of water fluoridation?

The history of water fluoridation dates back to the early 1900s when Dr. Frederick McKay, a dentist in Colorado Springs, Colorado, discovered many of his patients exhibited brown staining and mottled enamel on their permanent teeth. He sought to determine the cause of the staining and enamel mottling, along with his colleague Dr. G.V Black. Through their years of research together,

Drs. Black and McKay also noticed that individuals exhibiting these brown stains or mottled enamel were also surprisingly resistant to decay (4).

Following additional studies conducted in the 1930s, it was discovered that high levels of naturally occurring fluoride in the drinking water were causing the mysterious staining. This stain was then labeled “Colorado Brown Stain”, now known as moderate or severe dental fluorosis.

During the 1930s, Dr. H. Trendley Dean, a dental officer of the U.S Public Health Service, collected and analyzed epidemiological data on the geographical distribution and severity of dental fluorosis. Dean and his colleagues discovered that fluoride levels in the drinking water up to 1 ppm were low and revealed signs of very mild dental fluorosis (5). By 1939, Dr. Gerald J. Cox and his associates published a paper that proposed adding fluoride to drinking water as a means to prevent dental decay (4).

Further studies refined the relationship between fluoride levels and decay prevention by looking at the role of climate and water consumption. Such research led to the recommendation that fluoride levels in drinking water be established at 0.7 to 1.2 parts per million, depending on the average daily air temperature for each community. At these fluoride levels, the maximum reduction in tooth decay occurred with the minimum risk of dental fluorosis (4).

In 1945, Grand Rapids, Michigan was the first city in the world to adjust its water fluoride level to 1 ppm, followed by Brantford, Ontario. From 1945 to 1954, clinical trials were conducted to compare the dental and medical results of the fluoridation of Grand Rapids, Michigan with the clinical findings from non-fluoridated Muskegon, Michigan. Similar comparisons were made between fluoridated Brantford, Ontario and non-fluoridated Sarnia, Ontario. Early clinical data were so impressive that other cities began fluoridating before the classic trials were completed (6).

During the 1950s and 60s in Canada, the following cities began fluoridating their drinking water: Toronto, Halifax, Saskatoon, Oshawa, Pointe-Claire, Dartmouth, Brandon, Dorval and Red Deer (7). From the mid 1950's to present day, there has been a national effort to implement water fluoridation in all communities that have treated drinking water. The worldwide evidence supporting water fluoridation continues to grow. The Canadian Dental Association, American Dental Association, World Health Organization and the U.S. Public Health Service and its Centers for Disease Control continue to endorse water fluoridation but also continue to monitor health effects of fluoride. Currently throughout the world, over 400 million people in more than 60 countries benefit from water fluoridation (8).

4. How does fluoride strengthen the teeth?

The enamel and dentin of a tooth are composed of millions of tiny mineral crystals embedded in a protein/lipid matrix. During demineralization of the tooth, acids produced by bacteria diffuse into the porous enamel (or dentin if exposed), causing a loss of calcium and phosphorus minerals (9). Dental mineral is readily dissolved by acid unless it can be protected in some way. If fluoride is

present surrounding the tooth crystals, it is absorbed into the surface of the enamel crystals acting as a protective mechanism against acid dissolution of the mineral crystals (9).

Fluoride works to reduce tooth decay in two ways—systemically and topically. The systemic effect of fluoride occurs pre-eruptively during tooth formation. Fluoride has to be ingested in order for it to reach the teeth that are developing before they appear in the mouth. Systemic fluoride (i.e. fluoridated drinking water) is incorporated into the developing tooth enamel to strengthen the enamel and create a tooth surface which is more resistant to decay (10; 11; 12). In essence, fluoride enters into the crystal structure of the enamel whereby hydroxyapatite becomes fluorapatite (13) (14). Research has shown that different tooth surfaces are affected differently, and in different stages, by fluoride ions (10; 14; 15). For example, the pits and fissures of a tooth have less favourable physical conditions for the uptake of topical fluoride. Inhibition of the progression of caries might not occur in the pits in fissures in the same way as for the smooth surfaces, on exposure post-eruptively, for reasons of lack of accessibility of the fluoride ions. Therefore, pre-eruptive, or systemic exposure to fluoride is important in inhibiting the initiation of decay in pit and fissure surfaces (10; 14).

The second and predominant way fluoride acts to reduce dental decay is topically, or post-eruptive (i.e. after the tooth erupts). Topical fluorides include toothpastes, mouth rinses and professionally applied fluoride gels, foams and varnishes. Fluoride makes the tooth more resistant to decay and helps reinforce the tooth when acid attacks the enamel. Fluoridated water, although it contains a much lower concentration of fluoride, also provides significant topical benefits when it flows over the teeth (13). Systemic fluorides also provide topical benefits as it becomes integrated in saliva which continually bathes the teeth. In addition, fluoride has a multitude of direct and indirect effects on plaque and the oral bacteria responsible for plaque formation (16). For example, fluoride becomes incorporated into dental plaque to facilitate further remineralization of the tooth enamel (17) and reduces carbohydrate metabolism by oral plaque microflora, in part, by inhibiting the glycolytic enzyme, enolase (16).

Fluoride enhances remineralization by speeding up the growth of a new surface on the partially demineralized sub-surface of the enamel. The new crystalized surface is fluorapatite-like and is much more resistant to subsequent acid attacks (9).

Media Response

During demineralization of the tooth, acids produced by bacteria diffuse into the enamel (or dentin if exposed), causing a loss of calcium and phosphorus minerals. Dental mineral is readily dissolved by acid unless it can be protected in some way. If fluoride is present surrounding the tooth crystals, it is absorbed into the surface of the enamel crystals acting as a protective mechanism against acid dissolution of the mineral crystals.

There are beneficial effects of fluoride from both topical and systemic exposures. The maximum reduction in dental decay is achieved when fluoride is available pre-eruptively (systemically) for incorporation during all stages of tooth formation and post-eruptively (topically) at the tooth surface.

5. Why do we need water fluoridation?

Dental decay is the most common chronic disease in children, affecting 5 to 8 times as many children as asthma (18). According to recent data from the Canadian Health Measures Survey (CHMS), 56.8 percent of children in Canada aged 6 to 11 years are affected by dental caries and 58.8 percent of adolescents aged 12 to 19 have experienced decay in 1 or more permanent teeth. By adulthood, nearly 96 percent of dentate Canadians have experienced coronal decay, with a mean count of 10.7 DMFT (decayed, missing and filled teeth) (19).

There appears to be some evidence that water fluoridation reduces inequalities in dental health across social classes (20). Research has demonstrated that fluoridation has a greater effect on populations of low socioeconomic status. The absolute difference in decayed, missing and filled tooth surface (dmfs or DMFS) scores between populations living in fluoridated and non-fluoridated communities has been shown to be consistently larger in children of lower socioeconomic status than in children with higher socioeconomic status (20).

The people who benefit the most from water fluoridation are those who have the most tooth decay—typically the most disadvantaged members of society. Unfortunately, these are individuals who may not have adequate funds to purchase other forms of fluoride such as toothpaste, mouthrinses or professionally applied fluoride treatment (4). Other populations with difficulty accessing professional dental care, including the mentally and physically challenged populations as well as the frail elderly, all benefit from water fluoridation.

Water fluoridation benefits the entire community regardless of age or socioeconomic status. Everyone who consumes the water, or consumes foods and beverages prepared with the water automatically receives the benefits. Benefits do not depend on the availability of professional dental services or the ability to afford them.

The Centers for Disease Control and Prevention recognize that daily exposure to a low concentration of fluoride from water fluoridation is the most effective way to prevent dental decay and states, “daily and frequent exposure to small amounts of fluoride best reduces tooth decay for all age groups” (21).

Media Response

The fluoridation of drinking water supplies is a well-accepted measure to protect public health by preventing tooth decay and is strongly supported by scientific evidence. It has been added to public drinking water supplies around the world for more than half a century, as a public health measure.

Adding fluoride to water is the best way to provide fluoride protection to a large number of people at a low cost. The big advantage of water fluoridation is that it benefits all residents in a community, regardless of age, socioeconomic status, education, employment, or dental insurance status. It

promotes equality amongst all segments of the population, particularly the underprivileged and the hardest to reach where other preventive measures may be inaccessible.

6. What is the difference between topical fluoride and systemic fluoride?

Topical fluorides include modalities such as fluoridated toothpaste, fluoride mouth rinses, and fluoride applied in a dental office in the form of gels, varnishes or foams. Topical fluoride is applied directly to the exposed surface of the tooth in your mouth and increases the tooth's resistance to decay by reinforcing the tooth minerals after an acid attack. All methods of topical fluoride can be used in combination to reduce tooth decay (22).

Examples of systemic fluorides are fluoridated water, fluoridated salt, fluoridated milk and fluoride supplements. The fluoride is ingested and absorbed so that it can reach the developing teeth and bones. Systemic fluoride is incorporated into the developing tooth enamel to strengthen the tooth structure and create an enamel surface which is more resistant to decay (10; 11; 12; 13). Unlike topical fluorides, only one source of systemic fluoride is required, for example, either water, salt or milk fluoridation or supplements, but not both (23).

Systemic fluorides also provide topical benefits by way of the saliva. Fluoride is absorbed from the gastrointestinal tract and redistributed into salivary glands and then into saliva (24; 25; 26). This fluoride-containing saliva then washes over the teeth over extended periods of time, remineralizing tooth structure which has commenced demineralisation. In addition, fluoride also becomes incorporated into dental plaque to facilitate further remineralization of the tooth enamel (23). Thus, fluorides function systemically and topically on tooth surfaces resulting in benefits that begin in childhood and extend throughout life.

Research shows that systemic fluoride has decay reducing effects above and beyond the effects from other (topical) sources of fluoride. A systematic review of the literature in 2000 concluded that, "water fluoridation has an effect over and above that of fluoridated toothpaste (and other sources of fluoride)" (20). A combination of both systemic and topical fluoride use may be recommended to obtain maximum decay reducing benefits.

Note: Systemic fluoride in drinking water is consumed at concentrations around 0.7 ppm. Topical fluorides, which are not ingested, have a relatively high fluoride concentration, ranging from 1000 to 22,000 ppm.

Media Response

Topical fluoride is applied directly to the tooth surface in the mouth. Topical fluoride increases the tooth's resistance to decay by reinforcing the tooth minerals after an acid attack. Examples include: fluoridated toothpaste, fluoride mouth rinses, and fluoride applied in a dental office in the form of gels, varnishes or foams. Systemic fluoride is ingested and absorbed in the body so that it can reach the developing teeth and bones. Systemic fluoride is incorporated into the developing tooth enamel

to strengthen the enamel and create a tooth surface which is more resistant to decay. Examples include: fluoridated water, fluoridated salt and fluoridated milk. A combination of both systemic and topical fluoride use may be recommended to obtain maximum decay reducing benefits.

7. Is there a difference between natural fluoride and the “artificial” fluoride used in fluoridating water supplies?

No. Fluoride is a mineral found in nature and is not artificially created.

Some individuals use the term “artificial fluoridation” to imply that the process of water fluoridation is unnatural or that it delivers a foreign substance into the water supply. Fluoridation is merely an adjustment of the naturally occurring fluoride level present in the drinking water supply (27). As such, when fluoride is added under controlled conditions to fluoride-deficient water, the dental benefits are the same as those obtained from naturally fluoridated water.

Using the term “artificial fluoridation” often causes confusion. The objective of fluoridation is to adjust the existing natural level of fluoride to the recommended level (0.7 ppm) for preventing tooth decay.

In a study conducted by Brown and Poplove, the authors compared decay rates of individuals living in Brantford (optimally fluoridated by adjustment), Stratford (optimally fluoridated naturally) and Sarnia (fluoride-deficient). Their findings revealed much lower dental decay rates in both Brantford and Stratford as compared to Sarnia. Importantly, there was no observable difference in decay-reducing effect between the naturally occurring fluoride and adjusted fluoride concentration community water supplies, demonstrating that the dental benefits are the same, regardless of the source of fluoride (28).

Media Response

Fluoride is a mineral found in nature and is not artificially created. The objective of fluoridation is to adjust the existing natural level of fluoride to the recommended level (0.7 ppm) for preventing tooth decay. There is no difference in the decay-reducing effects of naturally occurring fluoride and adjusted fluoride concentrations in community water supplies— the dental benefits are the same, regardless of the source of fluoride.

8. Is fluoride a nutrient?

Nutrients are components of food that help to nourish the body. They provide energy, serve as building material, or help to maintain or repair body parts. Prevention of chronic disease may be considered to be a factor in deciding essential nutrients for the body (29). Fluoride is considered a non-essential mineral nutrient for the prevention of dental disease. Health Canada considers

fluoride to be a beneficial mineral nutrient that occurs naturally in most sources of drinking water (2).

In a recent report, the World Health Organization (WHO) lists fluoride as one of the 14 minerals considered important for good health (29). Due to its health benefits, the Institute of Medicine of the National Academies of Sciences declared that fluoride was an important nutrient (30) and a report by the U.S. Surgeon General in 2004 states that fluoride is a nutrient that is potentially beneficial for bones (31).

Media Response

Fluoride is considered a non-essential, mineral nutrient. Prevention of chronic disease may be considered to be a factor in deciding essential nutrients for the body. Fluoride is considered a beneficial mineral nutrient for the prevention of dental disease. In a recent report, the WHO lists fluoride as one of the 14 minerals considered important to good health.

9. Is fluoride a fertilizer?

No. Fluoride is a naturally occurring mineral found in soil, air, plants, animals and water supplies in the environment.

Phosphate, which is a fertilizer, is often found in the same rocks and minerals as fluoride. During the phosphate fertilizer manufacturing process, fluoride is collected separately from phosphate (6). When phosphate is removed from rock, an extra step in the refining process is used to collect fluoride. As such, fluoride is not a waste product of the fertiliser manufacturing process, but rather, a co-product (32).

Fluoridation opponents often claim that fluoride is a byproduct of the fertilizer industry in an effort to make fluoride additives appear unsafe. By-products in the chemical industry are simply materials produced in addition to the most important product produced economically. In fact, by-products are often valuable resources themselves. Other examples include mineral oil from refining crude oil to produce gasoline, salt from desalination and glycerol from the production of biodiesel.

Media Response

Fluoride is not a fertilizer. Fluoride is a naturally occurring mineral found in soil, air, plants, animals and water supplies in the environment.

Water Fluoridation in Canada

10. What percent of the Canadian population have access to fluoridated water?

Approximately 42.6 percent of Canada's population, on public water supplies, is receiving water fluoridation. Over 13 million Canadian's are receiving the benefits of water fluoridation, while another 1 percent (270,000 people) have naturally fluoridated water.

See Table 1 below for a list of the provincial and territorial estimates for community water fluoridation coverage in Canada (estimates are from 2005 to 2007). (NOTE: The University of Toronto is currently working to update these values and will provide up-to-date information by the end of 2012.)

Table 1: Provincial/Territorial Estimates for Water Fluoridation Coverage in Canada 2007
(33)

| Province | Total population | Population with fluoridated water | Population without fluoridated water | Percent with fluoridated water (%) | Percent without fluoridated water (%) |
|----------|------------------|-----------------------------------|--------------------------------------|--------------------------------------|---|
| BC | 4,113,000 | 152,241 | 3,960,759 | 3.7% | 96.3% |
| AB | 3,290,350 | 2,457,406 | 832,944 | 74.7% | 25.3% |
| SK | 968,157 | 356,096 | 612,061 | 36.8% | 63.2% |
| MB | 1,148,401 | 803,116 | 345,285 | 69.9% | 30.1% |
| ON | 12,160,282 | 9,229,015 | 2,931,267 | 75.9% | 24.1% |
| QC | 7,546,131 | 489,420 | 7,067,711 | 6.4% | 93.7% |
| NB | 729,498 | 188,607 | 540,891 | 25.9% | 74.2% |
| NS | 913,462 | 519,031 | 394,431 | 56.8% | 43.2% |
| PEI | 135,851 | 32,174 | 103,677 | 23.7% | 76.3% |
| NL | 505,469 | 7,572 | 497,897 | 1.5% | 98.5% |
| NU | 29,474 | 0 | 29,474 | 0.0% | 100.0% |
| NT | 41,464 | 23,400 | 18,034 | 56.4% | 43.6% |
| YT | 30,372 | 0 | 30,372 | 0.0% | 100.0% |

| | | | | | |
|--------|------------|------------|------------|-------|-------|
| Canada | 31,611,911 | 14,258,078 | 17,364,803 | 45.1% | 54.9% |
|--------|------------|------------|------------|-------|-------|

Media Response

Approximately 42.6 percent of Canada's population, on public water supplies, is receiving water fluoridation. Over 13 million Canadian's are receiving the benefits of water fluoridation, while another 1 percent (270,000 people) has access to naturally fluoridated water.

11. Which large Canadian cities do not fluoridate their water supply?

As of 2011, the large Canadian cities that do not fluoridate their water supplies include:

- Vancouver
- Regina
- Montreal
- Calgary

Media Response

As of 2011, the large Canadian cities without water fluoridation are Vancouver, Regina, Montreal and Calgary.

12. Does the federal government regulate water fluoridation in Canada?

No. The federal government is not responsible for the regulation of drinking water in Canada. Provincial and territorial governments regulate the quality of drinking water in their jurisdiction. The fluoridation of drinking water supplies is a decision that is made by each municipality, in collaboration with the appropriate provincial or territorial authority. This decision is often taken in consultation with residents through a referendum (34).

Media Response

The federal government is not responsible for the regulation of drinking water in Canada. Provincial and territorial governments regulate the quality of drinking water in their jurisdiction. The fluoridation of drinking water supplies is a decision that is made by each municipality, in collaboration with the appropriate provincial or territorial authority. This decision is often taken in consultation with residents through a referendum.

13. Why is the optimal level of fluoride different from the Maximum Acceptable Concentration (MAC) guideline for drinking water?

The drinking water guidelines differ because they have different purposes. The recommended optimal level of 0.7 mg/L is set to promote public health benefits of fluoride for preventing tooth decay while minimizing the chance for dental fluorosis. The Guidelines for Canadian Drinking Water Quality, published by Health Canada, states the maximum acceptable concentration of fluoride in public water supplies is 1.5 mg/L to protect against health risks from exposure to too much fluoride. The MAC is well below the Maximum Contaminant Level (MCL) of 4 mg/L set by the Environmental Protection Agency in the United States (35).

Media Response

The drinking water guidelines differ because they have different purposes. The recommended optimal level of 0.7 mg/L is set to promote public health benefits of fluoride for preventing tooth decay while minimizing the chance for dental fluorosis. The Guidelines for Canadian Drinking Water Quality, published by Health Canada, states the maximum acceptable concentration of fluoride in public water supplies is 1.5 mg/L to protect against health risks from exposure to too much fluoride.

14. Do fluoride compounds in community water fluoridation meet national standards?

Health Canada does not regulate fluoride compounds for use in drinking water fluoridation, but recommends that drinking water materials (including drinking water additives) be certified as meeting the appropriate National Sanitation Foundation (NSF) standard. NSF International prepares standards pertinent to impurities of drinking water treatment additives from their production and distribution (3). This certification process ensures the safety and efficacy of products. The application of NSF Standard for drinking water additives is voluntary, unless required under legislation or regulations. As drinking water quality in Canada is regulated at the provincial and territorial level, the adoption and enforcement of regulatory requirements would fall within the mandate of the individual provincial and territorial governments. For further information, the individual provincial and territorial government should be contacted directly.

Media Response

Health Canada does not regulate fluoride compounds for use in drinking water fluoridation, but recommends that drinking water materials (including drinking water additives) be certified as meeting the appropriate NSF standard. The certification process ensures the safety and efficacy of products. The adoption and enforcement of regulatory requirements falls within the mandate of the individual provincial and territorial governments.

15. Does Health Canada support community water fluoridation?

Yes. Health Canada endorses water fluoridation as a public health measure to prevent dental decay. The use of drinking water fluoridation in the prevention of dental cavities continues to be endorsed by over 90 national and international professional health organizations, including Health Canada.

Health Canada works in collaboration with the provinces and territories to maintain and improve drinking water quality. Together, both levels of government establish the Guidelines for Canadian Drinking Water Quality. These guidelines are reviewed and revised periodically to take into account new scientific evidence on the safety of fluoride in drinking water.

Media Response

Health Canada endorses water fluoridation as a public health measure to prevent dental decay. The use of drinking water fluoridation in the prevention of dental cavities continues to be endorsed by over 90 national and international professional health organizations, including Health Canada.

Fluoride Internationally

16. Is community water fluoridation accepted internationally?

Yes. Approximately 400 million people in over 60 countries benefit from adjusted or natural water fluoridation (8). Countries exercising community fluoridation in addition to Canada include the United Kingdom, Chile, South Korea, Singapore, Spain, Ireland, Israel, the United States, Brazil, Malaysia, Vietnam, Australia, New Zealand, Hong Kong, among many others.

Visit the British Fluoridation Society website for a list of countries with natural and adjusted water fluoridation: <http://www.bfsweb.org/index.htm>.

Media Response

Approximately 400 million people in over 60 countries benefit from adjusted or natural water fluoridation. Countries exercising community fluoridation in addition to Canada include the United Kingdom, Chile, South Korea, Singapore, Spain, Ireland, Israel, the United States, Brazil, Malaysia, Vietnam, Australia, New Zealand, Hong Kong, among many others.

17. Are there countries that have “banned” fluoridation?

No. Contrary to opponents’ claims, fluoridation has not been banned in any country.

The claim that fluoridation has been banned in other countries has been used often by opponents of fluoride. There are a number of countries that do not fluoridate their water supplies; however, this should not be misconstrued as concern over safety or effectiveness. Inaction is not synonymous with banning; some countries have simply not implemented a fluoridation system for a variety of technical, legal, financial or political reasons (6). In many parts of the world, fluoridation is not feasible for several reasons; lack of a central water supply, the presence of more urgent health needs and lack of sufficient funds for startup and maintenance costs (6).

Political actions contrary to the recommendations of health authorities should not be interpreted as a negative response to water fluoridation. To illustrate, although fluoridation is not practiced in Sweden and the Netherlands, both countries support the WHO’s recommendations regarding fluoridation as a preventive health measure. France has not implemented communal water fluoridation due to distribution difficulties, but has implemented the fluoridation of milk and salt. Furthermore, approximately one million people in France drink water with a natural fluoride content of 0.7 ppm or more. Switzerland, Germany, Mexico, Jamaica and Costa Rica receive benefits from salt fluoridation (6).

It should be noted that the amount of people with access to water fluoridation is actually increasing. For example, in the United States, the proportion of the population served by community water systems has increased from 62.1 per cent in 1992, to 65.0 per cent in 2000, and 69.2 per cent in 2006 (36).

While fluoridation of water supplies is not as extensive in Europe as it is in North America, it is important to note that fluoride—whether in water, salt, toothpaste, milk or tablets—is the foundation of prevention of tooth decay throughout Europe.

Media Response

Fluoridation has not been banned in any country. There are a number of countries that do not fluoride their water supplies; however, failure to fluoridate should not be misconstrued as concern over safety or effectiveness. Some countries have simply not implemented a fluoridation system for a variety of technical, legal, financial or political reasons. In many parts of the world, fluoridation is not feasible for several reasons; lack of a central water supply, the presence of more urgent health needs and the lack of sufficient funds for startup and maintenance costs.

18. Who supports water fluoridation?

Water fluoridation is supported locally, nationally and internationally by major medical, dental, and health organizations for the prevention of tooth decay. In fact, the use of fluoride for the prevention of dental decay continues to be endorsed by over 90 national and international professional organizations including Health Canada, the Canadian Dental Association, the Canadian Dental Hygienists Association, the Canadian Medical Association, American Dental Association, and the World Health Organization.

Thousands of studies on fluoride and community water fluoridation have been conducted in the last 60 years. There has been continual monitoring of this scientific literature by the world's major national and international health organizations, committees of experts and special councils of governments. To date, the results of these reviews reaffirm that water fluoridation, at the recommended level, is safe, effective and does not pose a risk for health problems.

Below is a list of some of the leading organizations in support of water fluoridation (as of October 2011):

- Alberta Dental Association
- American Academy of Pediatrics
- American Association for Dental Research
- American Association of Public Health Dentistry
- American College of Dentists
- American Council on Science and Health

American Dental Assistants Association
 American Dental Association
 American Dental Hygienists Association
 American Dietetic Association
 American Medical Association
 American Pharmaceutical Association
 American Public Health Association
 Association of State and Territorial Dental Directors
 Association of State and Territorial Health Officials
 Australian Dental Association
 British Dental Association
 British Medical Association
 Calgary & District Dental Society
 Canadian Association of Public Health Dentistry
 Canadian Dental Association
 Canadian Dental Hygienists Association
 Canadian Medical Association
 Canadian Nurses Association
 Canadian Paediatric Society
 Canadian Public Health Association
 Centers for Disease Control and Prevention
 European Organization for Caries Research
 Federation Dentaire Internationale
 Health Canada
 Indian Health Service
 International Association for Dental Research
 L'Association des dentistes en santé publique du Québec
 L'Association des pédiatres du Québec
 L'Hôpital de Montréal pour enfants
 L'Hôpital Ste-Justine pour enfants
 L'Ordre des dentistes du Québec
 L'Ordre des hygiénistes dentaires du Québec
 L'Ordre des pharmaciens du Québec
 La Direction de la santé publique de Montréal
 La Faculté de médecine dentaire de l'Université McGill
 La Fédération des médecins omnipraticiens du Québec
 La table de concertation des hygiénistes dentaires en santé communautaire des
 régions de Montréal, Laval, Laurentides et Lanaudière
 Le Collège des médecins du Québec
 Mayo Clinic
 National Health and Medical Research Council
 National Institute of Dental Research
 Ontario Association for Public Health Dentistry

Ontario Medical Association
Ontario Dental Association
Pan American Health Organization
Public Health Ontario
Royal College of Dental Surgeons
UK Department of Health
World Health Organization

19. What do health organizations and agencies say about water fluoridation?

Below are the links to many national and international health organizations' positions on water fluoridation:

Health Canada

Office of the Chief Dental Officer

<http://www.hc-sc.gc.ca/ahc-asc/branch-dirgen/fnihb-dgspni/ocdo-bdc/index-eng.php>

Canadian Dental Association (CDA)

CDA's Position on the Use of Fluorides in Caries Prevention, revised April 2010.

http://www.cda-adc.ca/files/position_statements/Fluorides-English-2010-06-08.pdf

Canadian Dental Hygienists Association (CDHA)

CDHA Position Statement: Community Water Fluoridation, September 2011

http://www.cdha.ca/AM/Template.cfm?Section=News_and_Events&Template=/CM/ContentDisplay.cfm&CONTENTID=10805

Canadian Paediatric Society (CPS)

Position Statement on the Use of Fluoride in Infants and Children

<http://www.cps.ca/english/statements/N/n02-01.htm>

Canadian Public Health Association (CPHA)

Fight the Good Fight: Fluoridation of Drinking Water, 2010

<http://cpha100.ca/12-great-achievements/fighting-good-fight-fluoridation-drinking-water>

Ontario Medical Association

Ontario's Doctors Set the Record Straight on Fluoride in Drinking Water, October 2010

<https://www.oma.org/Mediaroom/PressReleases/Pages/OntariosDoctorsSetTheRecordStraightOnFluorideInDrinkingWater.aspx>

Ordre des dentistes du Québec

Position of the Ordre des dentistes du Québec on Water Fluoridation

<http://www.odq.qc.ca/Publications/PoliciesGuidelinesandPositionstatements/tabid/321/language/en-US/Default.aspx>

Royal College of Dental Surgeons of Ontario (RCDSO)
Policy Statement – Water Fluoridation
http://www.rcdso.org/pdf/policy_statements/policy_fluoridation.pdf

World Health Organization (WHO)
The World Oral Health Report, 2003
http://www.who.int/oral_health/media/en/orh_report03_en.pdf

Federation Dentaire Internationale (FDI)
Promoting Dental Health through Water Fluoridation, 2008
http://www.fdiworldental.org/c/document_library/get_file?uuid=7c81a88f-2087-447a-954c-d575efea357f&groupId=10157

American Dental Association (ADA)
Statement on Water Fluoridation and Efficacy and Safety, updated 2002
<http://www.ada.org/2109.aspx>

Centers for Disease Control and Prevention (CDC)
Community Water Fluoridation, reviewed and updated January 7, 2011
<http://www.cdc.gov/fluoridation/>
<http://www.cdc.gov/fluoridation/benefits.htm#sg>

Surgeon General's Statement on Community Water Fluoridation, 2004
<http://www.cdc.gov/fluoridation/pdf/SGstatement.pdf>

Australian Dental Association
Water Fluoridation Position Statement, April 2007
<http://www.ada.org.au/OralHealth/FLN/flinaust.aspx>

British Medical Association
Fluoridation of Water, January 2010
http://www.bma.org.uk/health_promotion_ethics/environmental_health/Fluoriwater.jsp

National Health and Medical Research Council of Australia
The Efficacy and Safety of Fluoridation 2007
http://www.nhmrc.gov.au/_files_nhmrc/file/media/media/rel07/Fluoride_Flyer.pdf

Technical

20. How is water fluoridated? What is the process?

Water fluoridation is the adjustment of existing natural fluoride levels to the recommended levels for healthy teeth.

The fluoridation process occurs at the water treatment facility, under the careful supervision of water treatment personnel. Water plant personnel receive training on the management of the chemicals and additives in water plants, including fluoride (6). The fluoride control system is designed with numerous safeguards and controls for the precise control of fluoride dosage.

The fluoridation of a municipal drinking water supply is a decision made by local municipalities in collaboration with the appropriate provincial authority (37). The provincial government issues licenses to the municipalities in order to operate a fluoridation system (with the exception of Quebec). Under the regulations, continuous monitoring of the fluoridation process by the water treatment personnel is required, including meter readings, checking volumes and weights of the fluoride solution and conducting lab analyses of fluoride concentrations. Quality control of fluoride used for drinking water fluoridation in Quebec is currently overseen by the MSSS (Quebec department of health and social services), through the LSPQ (Quebec public health laboratory) (38).

The fluoride compounds used in the adjustment are obtained from the environment. The water treatment plant receives it in the form of a powder or liquid (containing fluoride, hydrogen, and silica – all of which are natural components of our water).

Media Response

Water fluoridation is the adjustment of the existing natural fluoride level to the recommended levels for healthy teeth. The fluoride compounds used in the adjustment are obtained from the environment. The water treatment plant receives it in the form of a powder or liquid (containing fluoride, hydrogen, and silica – all of which are natural components of our water). The fluoridation process occurs at the water treatment facility, under the careful supervision of the water treatment personnel.

21. Why do we need to fluoridate the water if there are other types of fluoride such as toothpaste, mouth rinses and professionally applied fluorides?

There are alternative fluoride modalities; however, community water fluoridation is most cost-effective and equitable. The decision to use community water fluoridation as a preventive measure for dental decay is based on a number of factors. Most importantly, community water fluoridation is

accessible to the entire community, regardless of socioeconomic status, education, income or race/ethnicity (39). This means that the preventive effects of fluoride are available to populations who may not be able to afford other types of fluoride. The benefits of fluoride can be obtained without individuals needing to change their behavior, it is effective throughout the life span and it is more cost effective than other forms of fluoride treatments or applications.

In addition, research shows that water fluoridation has an effect over and above that of fluoridated toothpaste (and other sources of fluoride) (20).

Media Response

There are alternative fluoride modalities; however, community water fluoridation is most cost effective and equitable. Community water fluoridation is accessible to the entire community, regardless of socioeconomic status, education, income or race/ethnicity. In addition, research shows that water fluoridation has an effect over and above that of fluoridated toothpaste (and other sources of fluoride).

22. What are the units of measurement for fluoride in water? What does ppm and mg/L stand for?

Fluoride levels in water can be measured in the following units:

ppm – parts per million
mg/L – milligrams per litre
µg/L – micrograms per litre

1 ppm is 1 part fluoride in 1 million parts water
1 mg/L is 1 milligram of fluoride in 1 litre of water

1 ppm is the same as 1 mg/L. This amount is extremely small. To appreciate how small, think of it compared with other units of measurement.

1 ppm is equivalent to:

- 1 inch in 16 miles
 - 1 minute in 2 years
 - 1 cent in \$10,000
-

23. What is the acceptable level of fluoride in drinking water supplies?

The Canadian guideline for fluoride in drinking water is a Maximum Acceptable Concentration (MAC) of 1.5 mg/L. Exposure to fluoride in drinking water at, or below, this level will not cause any adverse health effects (37).

The optimal level to promote public health benefits of fluoride for preventing tooth decay, while minimizing the chance for dental fluorosis, is called the optimal concentration, and is well below the MAC. For communities that choose to fluoridate their drinking water, the level of fluoride that is optimal in preventing tooth decay is 0.7 mg/L (40).

Media Response

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The optimal level to promote public health benefits of fluoride for preventing tooth decay, while minimizing the chance for dental fluorosis, is called the optimal concentration, and is well below the MAC. For communities that choose to fluoridate their drinking water, the level of fluoride that is optimal in preventing tooth decay is 0.7 mg/L.

24. What is the optimal level of fluoride in drinking water?

Health Canada's Chief Dental Officer has reviewed the available science and sought external expert advice from the scientific dental community and has determined the optimal concentration of fluoride in drinking water for dental health to be 0.7 mg/L (37). The scientific basis for this number is provided by a study from Heller *et al.*, which concluded that under modern conditions of exposure, 0.7 mg/L of fluoride in drinking water provides a suitable trade-off between the risk of dental fluorosis and the protective effect against dental caries (41). In other words, this concentration provides optimal dental health benefits with the least risk of dental fluorosis. At this level, it also prevents excessive intake of fluoride through multiple sources of exposure (40).

Scientific and government bodies continually monitor fluoride and the effects of fluoride use on the population. Health Canada periodically reviews all current scientific literature to ensure the optimal level of fluoride in water is in accordance with up-to-date science and to set drinking water guidelines in concert with the provinces and territories.

Media Response

Health Canada's Chief Dental Officer has reviewed the available science and sought external expert advice from the scientific dental community and has determined the optimal concentration of fluoride in drinking water for dental health to be 0.7 mg/L. Health Canada periodically reviews all current scientific literature to ensure the optimal level of fluoride in water is in accordance with up-to-date science and to set drinking water guidelines in concert with the provinces and territories.

25. Why has the recommended level of fluoride in drinking water changed from a range of 0.8 ppm to 1.2ppm to a level of 0.7 ppm?

When the optimal level for fluoridation was first determined more than 60 years ago, the recommended fluoride intake was based mainly on fluoridated water, the principal source of fluoride at the time. Since that time, there has been widespread use of fluoride in toothpastes, mouth rinses, and topical fluoride applications (42). In order to account for the availability of fluoride from various sources, over time, the guidelines for the concentration of fluoride in drinking water for optimal oral health have been lowered. Based on its review of the available science, Health Canada has determined that the optimal concentration of fluoride in drinking water should be lowered to 0.7 ppm from a range of 0.8 ppm to 1.0 ppm (37). At the recommended fluoride level, the maximum reduction in tooth decay occurs with the minimum risk of dental fluorosis.

Further studies refined the relationship of fluoride levels to decay prevention by also looking at the role of climate and water consumption. Such research led to the recommendation that fluoride levels in drinking water be established at 0.7 to 1.2 parts per million, depending on the average daily air temperature for each community (41). This recommendation is also in line with the results from a previous analysis by Eklund and Striffler, which indicated that the effectiveness of water fluoridation plateaued at concentrations higher than 0.6 ppm of fluoride in drinking water (43). Since then, findings from the Fluoride Expert Panel in 2007 showed that it is now not necessary to “determine a range for the optimal target concentration of fluoride, partly because seasonal variability in drinking water consumption appears to be less significant now than before, with more indoor temperature control and fewer people working outdoors” (40). Thus, a recommended level of 0.7ppm was established.

Media Response

When the optimal level for fluoridation was first determined more than 60 years ago, the recommended fluoride intake was based mainly on fluoridated water, the principal source of fluoride at the time. Since the time those studies were completed, there has been widespread use of fluoride in toothpastes, mouth rinses, and topical fluoride. In order to account for the availability of fluoride from various sources, over time, the guidelines for the concentration of fluoride in drinking water for optimal oral health have been lowered. Based on its review of the available science, Health Canada has determined that the optimal concentration of fluoride in drinking water should be lowered to 0.7 ppm from a range of 0.8 ppm to 1.0 ppm. This concentration provides optimal dental health benefits and is well below the MAC to protect against adverse health effects.

26. Will the addition of fluoride affect the quality of the drinking water?

No. Drinking water is treated to ensure it is safe for human consumption. The addition of fluoride will not change the properties of the water in the distribution system, as the water properties (such as pH level) must be adjusted prior to distribution to meet the Guidelines for Canadian Drinking Water Quality.

Media Response

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27. Will the addition of fluoride to my water affect its taste or odor?

No. Optimal levels of fluoride have no taste or smell, so the addition of fluoride to water supplies will not change the taste or smell of drinking water.

Taste, color and odor are not affected by the addition of fluoride at concentrations found in drinking water. This has been demonstrated in taste tests, with and without fluoride, at concentrations up to 133 ppm of fluoride (44).

Water supplies normally vary in their taste, colour, and odor. Dissolved solids such as calcium, magnesium, iron and organic materials such as decaying vegetation are primarily responsible for causing the tastes, colours, or odors in a water supply (45).

Media Response

Taste, color and odor are not affected by the addition of fluoride at concentrations found in drinking water. This has been demonstrated in taste tests, with and without fluoride, at concentrations up to 133 ppm of fluoride.

28. Does water fluoridation corrode the waterlines in water distribution systems?

No. The addition of fluoride will not change the properties of the water in the distribution system, as the water properties (such as pH) must be adjusted prior to distribution to meet the Guidelines for Canadian Drinking Water Quality.

The allegation that fluoridation will cause corrosion has been investigated and refuted by the U.S. Environmental Protection Agency and the National Association of Corrosion Engineers (46).

Media Response

Fluoridation does not cause corrosion of water lines since the addition of fluoride will not change the properties of the water in the distribution system, as the water properties (such as pH) must be adjusted prior to distribution to meet the Guidelines for Canadian Drinking Water Quality.

29. Is fluoride in drinking water classified as a drug under the *Food and Drugs Act*?

No. Fluoride used in drinking water fluoridation is not considered a drug by Health Canada as per the *Food and Drugs Act* and is not regulated by the federal government as a drug (47). Fluoride is considered a non-essential mineral nutrient and is beneficial for the prevention of dental disease. Fluoride added to water in the concentrations available in Canada is considered nutritive as opposed to therapeutic. Fluoride is added to drinking water as a public health measure to protect dental health and prevent or reduce tooth decay.

When a fluoride preparation, such as a dental rinse or toothpaste, includes a therapeutic claim and is represented for sale in Canada, it is considered to be a drug and is regulated accordingly by Health Canada. It is the responsibility of the product submission sponsor to demonstrate compliance with the applicable federal requirements.

Governments and health professionals have a responsibility to make decisions and implement public health strategies that balance community health outcomes with individual choices. Adjusting the level of fluoride in drinking water can be compared to practices such as adding iodine to salt for thyroid health and adding folic acid to cereals to reduce neural tube defects.

Media Response

Fluoride used in drinking water fluoridation is not considered a drug by Health Canada as per the *Food and Drugs Act* and is not regulated by the federal government as a drug. Fluoride is considered a non-essential mineral nutrient and is beneficial for the prevention of dental disease.

30. Can fluoride be removed from the water?

Yes. Fluoride can be removed at both the municipal and residential level through various approaches and technologies.

At the municipal level, approaches include combining fluoride-rich waters with waters of low fluoride content, the selection of low-fluoride sources and the removal of excess fluoride by treatment processes at the public water supply or household level. Technologies, such as activated alumina, reverse osmosis, lime softening and ion exchange, are capable of reducing excess fluoride levels from drinking water (37).

At the residential level, fluoride removal can be achieved by activated alumina filters, distillation or using a reverse osmosis system. Depending on the size and type of the system, it will remove between 90 to 99 percent of the fluoride in the water (48). Household Brita water pitchers and faucet mounts will not remove fluoride from the water.

Health Canada does not recommend specific brands of drinking water treatment devices, but it strongly recommends that consumers use devices that have been certified by an accredited certification body as meeting the appropriate NSF International/American National Standards Institute (ANSI) drinking water treatment unit standards (37). These standards have been designed

to safeguard drinking water by helping to ensure the material safety and performance of products that come into contact with drinking water. Certified devices for the reduction of fluoride from drinking water rely on reverse osmosis and distillation treatment processes.

Individuals who drink water processed by distillation or reverse osmosis units may not receive the optimal level of fluoride required for the dental decay preventive benefits.

Media Response

Fluoride can be removed at both the municipal and residential level through various approaches and technologies. At the residential level, fluoride removal can be achieved by activated alumina filters, distillation or using a reverse osmosis system. Individuals who drink water processed by distillation or reverse osmosis units may not receive the optimal level of fluoride required for the dental decay preventive benefits.

31. Will boiling fluoridated water change the amount of fluoride in the water?

No. A portion of the water will evaporate and decrease but the total amount of fluoride will remain the same. For example, one gallon of water at 1 ppm contains 4.5 mg of fluoride. If the water is boiled and evaporates, the fluoride concentration will increase but the total amount of fluoride present will still be 4.5 mg (6). Boiling water will not significantly change the amount of fluoride in the water (49) but will alter the concentration due to evaporation.

Media Response

Boiling water will not significantly change the amount of fluoride in the water. When drinking water is boiled, a portion of the water will evaporate and decrease but the total amount of fluoride will remain the same.

32. Is it wasteful to fluoridate the entire water system?

No. It is technically difficult and certainly more costly to fluoridate only the water used for drinking (50). Compared to alternative methods of preventing tooth decay, fluoridating the entire water supply is most cost effective (51).

Media Response

Compared to alternative methods of preventing tooth decay, fluoridating the entire water supply is most cost effective.

33. What is an individual's average daily fluoride intake?

Daily fluoride intake levels can vary depending on a number of factors including:

- Source of fluoride (air, soil, water, food/beverages, toothpaste)
- Fluoridated vs. non-fluoridated water supply
- Level of fluoride in the water/food
- Amount of fluoride in supplements consumed
- Amount of food/beverages consumed
- Individual variability
- Consumption of tea
- Dental products used

The risk assessment approach used by Health Canada to establish drinking water guidelines for fluoride in drinking water includes estimation of the total daily intake of fluoride from all sources of exposure for all age groups.

Health Canada has estimated average intakes of fluoride, from all sources, in the Canadian general population by age group. See Table 2 below:

Table 2: Daily Intakes of Fluoride in the Canadian General Population Based on Age (37)

| Daily Intake of Fluoride From Various Sources (µg/kg body weight per day) | | | | | | | | | |
|---|-------------------|-----------------------------|------|-----------|---------|-----------|------------|---------------------|--|
| Age groups | Type of community | Drinking water ^a | Air | Soil | Food | Beverages | Toothpaste | Total (mean) | Proportion of fluoride intake from drinking water (mean) |
| 7-12 months Breast-fed infants | Non-fluoridated | 0.77-3.23 | 0.01 | 0.39-1.19 | 2.2-2.4 | 8.8-9.6 | 20.0-30.0 | 32.2-46.4 (39.3) | 0.24-0.33 (0.29) |
| | Fluoridated | 7.08-16.92 | 0.01 | 0.39-1.19 | 3.4-4.2 | 13.6-16.8 | 20.0-30.0 | 44.5-69.1 (56.8) | 0.36-0.59 (0.48) |
| 7-12 months Bottle fed infants | Non-fluoridated | 0.77-3.23 | 0.01 | 0.39-1.19 | 2.6-2.8 | 10.4-11.2 | 20.0-30.0 | 34.2-48.4 (41.3) | 0.27-0.35 (0.31) |
| | Fluoridated | 7.08-16.92 | 0.01 | 0.39-1.19 | 4.8-5.2 | 19.2-20.8 | 20.0-30.0 | 51.5-74.1 (62.8) | 0.42-0.60 (0.51) |
| 1-4 years | Non-fluoridated | 0.77-3.23 | 0.01 | 0.39-1.19 | 3.2 | 12.8 | 20.0-30.0 | 37.2-60.4 (48.8) | 0.28-0.33 (0.31) |
| | Fluoridated | 7.08-16.92 | 0.01 | 0.39-1.19 | 3.2 | 20.8 | 20.0-30.0 | 53.5-84.1 | 0.41-0.55 (0.48) |

| | | | | | | | | | |
|------------------|-----------------|-----------|------|-----------|---------|-----------|------|---------------------|---------------------|
| | | | | | | | | (68.8) | |
| 20+ years | Non-fluoridated | 0.29-1.20 | 0.01 | 0.03-0.09 | 4.8-6.6 | 19.2-26.4 | 1.14 | 25.5-35.4 (30.5) | 0.64-0.91 (0.78) |
| | Fluoridated | 2.63-6.29 | 0.01 | 0.03-0.09 | 7.6-9.6 | 30.4-38.4 | 1.14 | 41.8-55.5 (48.7) | 0.68-0.92 (0.80) |

Air: Estimated inhaled fluoride intake for Canadians (42)

Soil: Calculated from the mean fluoride concentration of soil of 100 µg/g (NRC, 2006) and upper bound of 309 µg/g (52)

Food and beverages: Ranges of mean intake data from the food basket survey for the 7- to 12-months, 1- to 4-year, and 20+-year age groups (53)

Toothpaste: Mean values are used in the range of fluoride intake from toothpaste, as recommended by the Expert Panel on Fluoride (40)

For in depth information on how the numbers above were derived, visit:
<http://hc-sc.gc.ca/ewh-semt/pubs/water-eau/2011-fluoride-fluorure/index-eng.php>

A total diet survey conducted in 2007 estimated the dietary intakes of fluoride in the Canadian population. The authors found that the average dietary intake of fluoride in the 1- to 4-year-old group is estimated to be 0.026 mg/kg bw/day and 0.016 mg/kg bw/day in fluoridated and non-fluoridated communities, respectively. The average dietary intakes of fluoride in the Canadian population aged 20 years and older are estimated to vary between 0.024 to 0.033 mg/kg bw/day in non-fluoridated communities and between 0.038 to 0.048 mg/kg bw/day in fluoridated communities (53).

Media Response

The risk assessment approach used by Health Canada to establish drinking water guidelines for fluoride in drinking water includes estimation of the total daily intake of fluoride from all sources of exposure for all age groups.

Health Canada has estimated average intakes of fluoride, from all sources, in the Canadian general population by age group. This can be found at: <http://hc-sc.gc.ca/ewh-semt/pubs/water-eau/2011-fluoride-fluorure/index-eng.php>.

34. Is my child getting an appropriate amount of fluoride from drinking water and tooth paste?

Yes. If you and your child are among the 13 million Canadians who receive their water from an optimally fluoridated community water system, and you follow guidelines in your child's tooth brushing, then it is highly unlikely that your child is receiving too much fluoride. The Canadian Dental Association (54) recommends that children from birth to 3 years of age should only use fluoridated toothpaste if the child is at higher risk for tooth decay. If such a risk exists, the child's teeth should be brushed by an adult using a minimal amount (a portion the size of a grain of rice) of fluoridated toothpaste. For children from 3 to 6 years of age, only a small amount (a portion the size of a green pea) of fluoridated toothpaste should be used. Children in this age group should be assisted by an adult in brushing their teeth and should spit out the excess paste.

Media Response

If you and your child are among the 13 million Canadians who receive their water from an optimally fluoridated community water system, and you follow the Canadian Dental Association's guidelines, then it is highly unlikely that your child is receiving too much fluoride.

35. Once fluoride is ingested, where does it go?

Approximately 75 to 90 percent of the fluoride we obtain from our diet is absorbed by the gastrointestinal tract. Once absorbed, fluoride is rapidly distributed throughout the body by the blood. As a general rule for healthy adults, approximately 40 percent of the fluoride ingested each day becomes associated with calcified tissues (bones and teeth) within 24 hours, while the remainder is excreted in the urine. Of the total amount of fluoride retained in your body, approximately 99 percent of the fluoride in the body is found in calcified tissues, such as the teeth and bones (25).

Fluoride is removed from the body fluids almost exclusively by calcified tissue uptake and renal excretion. Fluoride is excreted primarily by means of the urine, with perspiration, saliva, breast milk, and faeces making smaller contributions to daily body clearance (24; 25).

Media Response

Approximately 75 to 90 percent of the fluoride we obtain from our diet is absorbed by the gastrointestinal tract. Once absorbed, fluoride is rapidly distributed throughout the body by the blood. As a general rule for healthy adults, approximately 40 percent of the fluoride ingested each day becomes associated with calcified tissues (bones and teeth) within 24 hours, while the remainder is excreted in the urine.

36. Does bottled water contain optimal levels of fluoride?

No. The majority of bottled waters on the market do not contain optimal levels of fluoride.

Bottled waters can show substantial variation in their fluoride contents. Most bottled waters contain less than 0.3 mg fluoride/L; however, some artesian waters and certain imported mineral waters contain higher levels (55; 56; 57).

In 2000, a study examining the fluoride levels and bacterial content of commercial bottled waters and municipal tap water in the United States compared samples from 57 bottled waters and 4 water processing plants. Results showed that 51 (89 percent) contained less than 0.30 mg/L of fluoride, 1 (2 percent) contained 0.30 to 0.60mg/L, and only 5 (9 percent) contained 0.61 to 1.00mg/L. The tap water samples all contained fluoride levels between 0.4 mg/L and 1.00 mg/L (58).

Bottled water tested in this study had fluoride levels similar to bottled water in a study conducted in 1995, in which 78 brands of bottled water were tested. Eighty-three percent of products studied contained less than 0.3mg/L of fluoride (59). A similar study conducted in 1994 also showed that there were significant differences in fluoride concentration among 39 bottled water samples and that 34 of the 39 bottles had fluoride levels below 0.3 ppm (57).

Another study that examined fluoride concentration of commercially available bottled water products found that all products tested had fluoride concentrations that fell below the accepted national standards for optimally fluoridated water. Due to the significant variability in fluoride concentration among the products, the authors concluded that, “dental providers should advise their patients that bottled water might not contain optimal levels of fluoride (60)”.

Similar findings were found in a 2003 study that looked at the fluoride contents of 65 bottled waters, where only 12.3 percent of the brands tested contained an optimal level of fluoride. It was concluded that bottled water may not provide sufficient fluoride to maintain optimal dental health (61).

Over the years, consumption of bottled water has dramatically increased. The following table displays the consumption pattern of bottled water in the United States from the years 2000 to 2004:

Table 3: Consumption Pattern of Bottled Water in the United States from 2000 to 2004 (62)

| Per Capita Consumption from 2000 - 2004 | | |
|---|--------------------|-------------------|
| Year | Gallons Per Capita | Annual Change (%) |
| 2000 | 17.2 | -- |
| 2001 | 18.7 | 8.7 |
| 2002 | 20.7 | 10.8 |
| 2003 | 22.1 | 7.0 |
| 2004 | 23.8 | 7.6 |

All bottled water sold in Canada must comply with the *Food and Drugs Act* and its Regulations. In accordance with Canadian Food Inspection Agency's labelling and advertising legislation, all bottled water in Canada must declare the fluoride ion content on the bottle (63).

Individuals who drink bottled water as their primary source of water could potentially be missing the decay preventive effects of optimally fluoridated water in their community water supply.

Media Response

The majority of bottled waters on the market do not contain optimal levels (0.7 ppm) of fluoride. Bottled waters can show substantial variation in their fluoride contents. Most bottled waters contain less than 0.3 mg fluoride/L; however, some artesian waters and certain imported mineral waters contain higher levels. Individuals who drink bottled water as their primary source of water could potentially be missing the decay preventive effects of optimally fluoridated water in their community water supply.

37. I am feeding my baby formula. How do I know if my baby is getting too much fluoride?

In Canada, infant formula is regulated by the Canadian Food Inspection Agency and must meet requirements set out in the *Food and Drug Regulations* (FDR) for infant formula. Ready-to-serve, concentrated, and powdered formulas are generally not fortified with fluoride but parents are always advised to read manufacturers' guidelines as these can change from time to time. The water used in the ready-to-serve fluoride is defluoridated. The total fluoride content of powdered and concentrated formulas is determined by the amount of fluoride in the drinking water that is mixed by the consumer.

Based on Health Canada's review of the literature, fluoride is not a concern for infants that are exclusively breastfed or consuming ready-to-feed infant formula. Liquid or powdered infant formula can be reconstituted with fluoridated tap water. However, it is advised that individuals living in areas with naturally occurring high levels of fluoride (higher than the guideline of 1.5 mg/L), may want to use a different source of drinking water with a lower fluoride concentration (37).

Dabeka *et al.* estimated the dietary intakes of fluoride by infants as a function of the fluoride level in their community drinking water and the type of infant formula fed to them. According to data, the highest estimated dietary intake of fluoride in infants is from powdered infant formula reconstituted with fluoridated drinking water. Breast milk and ready-to-use infant formulas contain a low dietary intake of fluoride, even in communities with fluoridated drinking water. The following table shows the estimated dietary intake of fluoride by infants:

Table 4: Estimated Dietary Intake of Fluoride by Infants (53)

| Diet* | Status of Fluoride in Water | Dietary Intake (µg/kg body weight/day) | | | | |
|---------------------------------|-----------------------------|--|------------|------------|------------|--------------|
| | | 0-1 months | 2-3 months | 4-6 months | 7-9 months | 10-12 months |
| All Formulas | Fluoride in water | 33 | 37 | 21 | 26 | 24 |
| | No fluoride in water | 14 | 16 | 12 | 14 | 13 |
| Ready-to-use milk-based formula | Fluoride in water | 26 | 28 | 28 | 27 | 30 |
| | No fluoride in water | 21 | 23 | 22 | 22 | 21 |
| Powdered milk-based formula** | Fluoride in water | 119 | 120 | 115 | 97 | 85 |
| | No fluoride in water | 19 | 21 | 20 | 20 | 20 |
| Ready-to-use soy-based formula | Fluoride in water | 69 | 70 | 68 | 60 | 55 |
| | No fluoride in water | 64 | 65 | 63 | 54 | 46 |
| Powdered soy-based formula | Fluoride in water | 102 | 111 | 102 | 92 | 81 |
| | No fluoride in water | 15 | 17 | 17 | 18 | 18 |
| Breast milk | Fluoride in water | 12 | 14 | 15 | 17 | 21 |
| | No fluoride in water | 6 | 8 | 9 | 11 | 12 |

*All dietary intake estimates were calculated assuming that the only milk or formula type fed to the infant was that described in the table.

**For the powdered formula, a dilution of 8.5 g (water) + 1.5 g (powder) was used to estimate the concentration of fluoride in the formula as fed, assuming water contains fluoride at 1 mg/L or 0 mg/L.

According to Health Canada, current scientific literature does not support an association between consumption of infant formula reconstituted with drinking water containing fluoride at optimal fluoride levels, and the risk of moderate/severe fluorosis (37). The critical period for fluorosis of the anterior permanent teeth is well after the first twelve months of life by which time the majority of children have ceased exclusive infant formula consumption. In addition, increased fluorosis risk is associated with extended periods (e.g., multiple years) of exposure to fluoride. Therefore, slightly higher exposure in the first year of life may not be as much of a concern if it is subsequently followed by continuous low exposure (37).

Media Response

Current scientific literature does not support a link between consumption of infant formula reconstituted with drinking water containing fluoride and the risk of moderate/severe dental fluorosis. Based on Health Canada's review of the literature, fluoride is not a concern for infants that are exclusively breastfed or consuming ready-to-feed infant formula. Liquid or powdered infant

formula can be reconstituted with fluoridated tap water. However, it is advised that individuals living in areas with naturally occurring high levels of fluoride (higher than the guideline of 1.5 mg/L), may want to use a different source of drinking water with a lower fluoride concentration.

Efficacy

38. Is water fluoridation effective?

Yes. Water fluoridation is an effective intervention to prevent tooth decay. Since 1997, there have been 18 reviews (see Appendix) that have examined water fluoridation, including an expert panel convened by Health Canada in 2007. These reviews have consistently found that fluoridation is effective in reducing the risk of tooth decay, and is the most cost-effective way of providing the benefits of fluoride to communities.

In addition to the direct benefits, water fluoridation has several indirect advantages as well. These include reductions in pain from dental infections, fewer missing teeth, fewer abscessed teeth, reduced need for dentures, and fewer working days lost due to dental problems or visits to the dentist (4).

Canadian data continue to confirm lower decay rates in fluoridated communities compared to non-fluoridated areas. To illustrate, a British Columbia study, involving 6 to 14 year old children who lived in the fluoridated city of Kelowna, British Columbia had 35 percent fewer decayed or filled tooth surfaces than similar children in a non-fluoridated city Vernon (64).

Similarly, in an analysis conducted by Statistics Canada for the Office of the Chief Dental Officer (65), decay rates for children aged 6 to 19 in Ontario (mostly fluoridated) were compared to those for 6 to 19 year olds in Quebec (mostly non-fluoridated) using data from the CHMS. Results showed that the prevalence of dental caries in primary and permanent teeth among 6 year olds was 10 percent higher in Quebec, while the severity of decay was 27.4 percent higher. Similar trends were seen in children aged 6 to 11 and adolescents aged 12 to 19. Most notably, the severity of decay among 12 to 19 year olds in Quebec was shown to be 19.5 percent higher than the same age group in Ontario.

In May 2010, an assessment of dental decay rates among adults from the British Columbia Adult Dental Health Survey (ADHS) was compared to CHMS data. British Columbia is primarily non-fluoridated compared to other fluoridated communities represented in the national CHMS survey and results from the analysis showed that adults aged 20 to 79 in British Columbia experienced decay rates 28 to 44 percent higher than adults in the Canadian population (66).

These observations have also been confirmed by the national supporting documentation of the Guidelines for Canadian Drinking Water Quality and also by international research, such as the 2007 report on fluoridation from the Australian National Health and Medical Research Council and a comprehensive systematic review conducted in 2000 (20; 37; 67).

Media Response

Water fluoridation is an effective intervention to prevent tooth decay. Since 1997, there have been 18 reviews that have examined water fluoridation, including an expert panel convened by Health Canada in 2007. These reviews have consistently found that fluoridation is effective in reducing the risk of tooth decay, and is the most cost-effective way of providing the benefits of fluoride to communities.

39. How does fluoride work to reduce tooth decay?

Fluoride works to reduce tooth decay in two ways—systemically and topically. The systemic effect of fluoride occurs pre-eruptively (i.e. during tooth formation). Fluoride has to be ingested in order for it to reach the teeth that are developing before they appear in your mouth. Systemic fluoride (i.e. fluoridated drinking water) is incorporated into the developing tooth enamel to strengthen the tooth structure and create a surface which is more resistant to decay (10; 11; 12; 13). In essence, the fluoride enters into the crystal structure of the enamel whereby hydroxyapatite becomes fluorapatite (13; 14).

The major source of systemic fluoride is fluoridated water. As a substitute for water fluoridation, fluoride can also be given systemically by adding it to salt (e.g. jurisdictions in Germany, France, Mexico, Jamaica), milk (e.g. jurisdictions in Chile, United Kingdom, Thailand) or as a supplement.

The second, and predominant way, fluoride acts to reduce dental decay is topically, or post-eruptive (i.e. after the tooth erupts). Topical fluorides include toothpastes, mouth rinses and professionally applied fluoride gels, foams and varnishes. Fluoride makes the tooth more resistant to decay and helps reinforce the tooth when acid attacks the enamel. Fluoridated water, although it contains a much lower concentration of fluoride, also provides significant topical benefits when it flows over the teeth (13). Systemic fluorides also provide topical benefits by way of the saliva. In addition, fluoride also becomes incorporated into dental plaque to facilitate further remineralization of the tooth enamel (17).

Media Response

Maximum reduction in dental decay is achieved when fluoride is available both pre-eruptively (systemically) for incorporation during all stages of tooth formation and post-eruptively (topically) at the tooth surface. Water fluoridation provides both types of exposure.

40. Is water fluoridation effective in preventing root caries?

Yes. Research has shown that water fluoridation can reduce root surface decay up to 35 percent in individuals aged 60 years and older with a history of long-term residence (at least 31 years) in optimally fluoridated areas (68). In addition, a 2007 meta-analysis examining the effectiveness of water fluoridation among adults over 40, found that, out of the 7 studies, all studies showed caries rates were higher in non-fluoride groups than in fluoride groups (22).

Root caries, otherwise known as root surface decay, is found on the exposed root surface of the tooth near the gum tissue. Root surface decay is increasing as a result of longer retention of teeth and the aging population. Older adults experience more gum recession than other age groups and these exposed roots are at a high risk for decay. This is a good reminder that tooth decay is not just a disease of childhood and that fluoride can provide lifelong benefits.

Media Response

Research has shown that water fluoridation can reduce root surface decay up to 35 percent in individuals aged 60 years and older with a history of long-term residence (at least 31 years) in optimally fluoridated areas. A 2007 meta-analysis examining the effectiveness of water fluoridation among adults over 40, found that caries rates were higher in non-fluoride groups than in fluoride groups. Fluoride provides lifelong benefits.

41. Does water fluoridation reduce tooth decay in both children and adults?

Yes. Individuals of all ages benefit from fluoridated water. Tooth decay remains one of the most common diseases affecting substantial numbers of children and adults of all ages. The consequences of tooth decay include pain, infection, premature tooth loss and misaligned teeth. This results in the need for costly dental treatment and possibly braces. Water fluoridation is the most effective and least expensive way to prevent tooth decay (69).

Tooth decay is reduced when fluoride is incorporated into developing teeth during childhood years and this provides resistance to cavities into adulthood. Water fluoridation also benefits adult's teeth that have already formed and appear in the mouth. The fluoride from the water is incorporated in the outer tooth surface during the continual "bathing" effect when drinking. This provides an ongoing protection against tooth decay.

Maximum benefit of fluoride is achieved if fluoridation is available from birth and during all stages of tooth formation. When fluoride is incorporated in the developing tooth, it produces shallower grooves in the anatomy, which makes the tooth more resistant to decay. After the tooth erupts into the mouth, the fluoride from the drinking water is also incorporated into the outer tooth surface. The combination of these 2 actions (pre-eruptive and post-eruptive) by water fluoridation provides maximum reduction in tooth decay (70).

A review of past research has shown that water fluoridation can reduce tooth decay in children's primary teeth up to 60 percent (30 to 60 percent) and in their permanent teeth up to 35 percent (15 to 35 percent) (70; 71). Most recently, a systematic review on water fluoridation found that fluoride in drinking water was associated with an increased proportion of children without caries and a reduction in the number of teeth affected by caries. The range of the proportion of children without caries was -5.0 percent to 64 percent, indicating a mean reduction of 14.6 percent. The mean change in decayed, missing, and filled primary/permanent teeth was 2.25 teeth (20).

Although the benefits of water fluoridation have been generally associated with children, a review of past research has shown that adults can have up to 35 percent (15 to 35 percent) reduction in tooth decay from lifelong exposure to water fluoridation (72). A systematic review conducted in 2007 assessed the effectiveness of water fluoridation among adults and found the preventive fraction of community water fluoridation to be 27 percent. These findings suggest that fluoride prevents caries among adults of all ages (22). This has important public health implications since, with the exception of water fluoridation; virtually all primary preventive programs target children and youth.

Media Response

Individuals of all ages benefit from the effects of water fluoridation. Tooth decay remains one of the most common diseases affecting substantial numbers of children and adults of all ages and water fluoridation is the most effective and least expensive way to prevent it.

42. What happens if water fluoridation is discontinued?

Over time, it can be expected that dental decay rates will increase if water fluoridation is discontinued, unless other fluoride interventions are introduced.

Since the 1960s, numerous studies have been conducted to evaluate the impact on dental rates as a result of the discontinuation of water fluoridation. One of the first studies took place in Antigo, Wisconsin. In Antigo, fluoridation was implemented in 1949 and then discontinued in 1960. After five years of discontinued fluoridation, second grade children experienced over 200 percent more decay, fourth graders 70 percent more and sixth graders 91 percent more than those of the same ages. As a result, in 1965, fluoridation was re-instituted on the basis of the deterioration of the children's oral health (73).

In Anglesey, North Wales, fluoridation began in 1955 and the residents received the benefits of reduced tooth decay until 1991 when fluoridation was ceased. In 1987, the average number of decayed, missing, and filled teeth (dmft) in 5 year old Anglesey children was 0.8. After fluoridation was discontinued, in 1993, the average decayed, missing, and filled teeth (dmft) in 5 year old children increased to 2.01, indicating a 151 percent increase. As a result of this increase in decay rate, 30 percent of 5 year olds in the Holyhead area of Anglesey in 1993 suffered from a toothache and as many as 17 percent had dental extractions under general anesthetic (74; 75).

In 2002, an independent task force convened by the Centers for Disease Control and Prevention examined the 'before and after' measurements of caries at the tooth level. They found that initiating, or continuing, fluoridation decreased dental caries experience among children aged 4 to 17 years by a median of 29.1 percent during 3 to 12 years of follow-up. They also discovered that discontinuation of fluoridation was associated with a median increase of 17.9 percent in dental caries during 6 to 10 years of follow-up (76).

A recent Canadian analysis looked at dental decay trends in Dryden, Ontario. Prior to the discontinuation of fluoridation, decay rates for 4 to 5 year old children had shown a continual decline from the time of inception. However, after fluoridation was discontinued in 2001, children within the community's schools showed an increase in decay rates of approximately 26 percent.

Media Response

Over time, it can be expected that dental decay rates will increase if water fluoridation is discontinued. Since the 1960s, numerous studies have demonstrated the negative impact on dental rates as a result of the discontinuation of water fluoridation.

43. With other forms of fluoride available, is water fluoridation still an effective method for preventing tooth decay?

Yes. Water fluoridation is still considered a very effective method for preventing tooth decay in children, adolescents, adults, and seniors.

Although elucidated over 60 years ago, the caries preventative effects of fluoridated drinking water are still evident in modern studies of fluoridated versus non-fluoridated communities. After adjustment for potential confounding variables, McDonagh *et al* showed in their systematic review that the introduction of water fluoridation into a community significantly increased the proportion of caries-free children, and decreased the mean dmft/DMFT scores compared with areas which were non-fluoridated over the same time period (20).

Since 1997, there have been 18 reviews (see Appendix) examining fluoridation, including an expert panel convened by Health Canada in 2007. These reviews have consistently found that fluoridation is effective in reducing the risk of tooth decay, and is the most cost-effective way of providing the benefits of fluoride to communities.

Even in a period with the widespread availability of fluoride from other sources, water fluoridation continues to be effective in reducing dental decay by 30 to 60 percent for children and 15 to 35 percent for adults (6; 69). An extensive body of research suggests that water fluoridation has an effect over and above that of fluoridated toothpaste (and other sources of fluoride) (6; 20).

Several recent and authoritative reviews conducted in the US, Australia, the UK, and Ireland provide evidence of the effectiveness of water fluoridation under modern conditions (67; 76; 77). Additionally, an independent task force on fluoride convened by the Centers for Disease Control and Prevention found strong evidence that water fluoridation is effective in reducing the cumulative caries experience (76).

Presently, water fluoridation is just as effective as it ever was in being able to prevent tooth decay in populations at high risk to tooth decay and who do not have ready access to other sources of fluoride (78).

Media Response

Water fluoridation is still considered a very effective method for preventing tooth decay in children, adolescents, adults, and seniors. Even in an era with the widespread availability of fluoride from other sources, water fluoridation continues to be effective in reducing dental decay by 30 to 60 percent for children and 15 to 35 percent for adults.

44. What is the “halo” or “diffusion” effect of water fluoridation?

The “halo” or “diffusion” effect occurs when foods and beverages processed in a fluoridated community are consumed in a community without fluoridation. This “diffusion” effect results in an increased fluoride intake, among people in non-fluoridated communities, which provides them increased protection against dental decay (79).

The diffusion effect has been quantified in studies by measurement of the differences in mean DMFS between, and among, communities with different diffusion exposures to fluoride (80). Analyses show that a direct comparison of mean DMFS between fluoridated and non-fluoridated regions underestimate the effectiveness of water fluoridation (69; 81). The diffusion effect also has important implications in terms of discontinuing community water fluoridation, since decay levels would be expected to rise not only in fluoridated areas, but also in non-fluoridated communities if the fluoride levels were not maintained (82).

Media Response

The “halo” or “diffusion” effect occurs when foods and beverages processed in a fluoridated community are consumed in a community without fluoridation. This “diffusion” effect results in an increased fluoride intake, among people in non-fluoridated communities, which provides them increased protection against dental decay.

45. Is fluoridated milk an effective alternative to water fluoridation?

While studies among small sample sizes of children have demonstrated a decrease in dental decay levels as a result of fluoridated milk consumption, these results have not been demonstrated in large-scale surveys (83; 84). More research is needed before milk fluoridation can be recommended as an alternative to water fluoridation.

The WHO has supported milk fluoridation projects in the UK, China, Peru and Thailand (85); yet there are a number of concerns (83) raised about the widespread benefits of milk fluoridation including:

- Variability of consumption
- There are a considerable number of children and adults who cannot drink milk due to sensitivities or lactose intolerance

- Monitoring of fluoride content in milk is more difficult than drinking water due to the large number of dairies
- Regulation becomes difficult and marketing patterns would be disrupted since fluoridated milk should not be sold in areas having optimal levels of fluoride in the water supply
- Studies have shown that fluoride in milk is absorbed by the body at a slower rate than from water

Media Response

While studies among small sample sizes of children have demonstrated a decrease in dental decay levels as a result of fluoridated milk consumption, these results have not been demonstrated in large-scale surveys. More research is needed before milk fluoridation can be recommended as an alternative to water fluoridation.

46. Is fluoridated salt an effective alternative to water fluoridation?

Yes. Salt fluoridation was initiated in Switzerland in 1955. Presently, there are 12 countries in the Americas and 8 countries in Europe (estimate 250 million population) that use salt fluoridation as a means to prevent dental decay (86). The use of fluoridated salt is widespread in many other Central and South American countries including Costa Rica, Guatemala, Nicaragua, Jamaica, Uruguay, Ecuador and Mexico. Salt fluoridation is distinct in its ability to deliver oral health benefits to remote locations where no potable municipal water supplies exist.

The Pan American Health Organization (PAHO), a regional division of the World Health Organization (WHO), has been active in developing strategies to implement caries prevention programmes in the regions of the Americas using both water and salt fluoridation (87).

There are a couple of concerns with the implementation of salt fluoridation. First, the natural fluoride level of each source of drinking water must be determined prior to implementation of a salt fluoridation program in order to prevent over-exposure. The second concern relates to the issue of mixed public health messages, whereby the promotion of dental benefits of fluoridated salt can be contradictory to public health messages that encourage the reduction of consumption of salt for management of hypertension. Thus, populations of countries where fluoridated salt is available are not encouraged to consume more salt to improve their dental health; rather, the passive effect of fluoridated salt is accepted. In other words, people are not encouraged to change their usual behaviour to obtain the benefits (88).

Media Response

Salt fluoridation has been shown to be an effective alternative to water fluoridation. The Pan American Health Organization (PAHO), a regional division of the World Health Organization (WHO), has been active in developing strategies to implement caries prevention programmes in the regions

of the Americas using both water and salt fluoridation. One concern about using salt as a means to prevent dental decay relates to the issue of mixed public health messages, whereby the promotion of dental benefits of fluoridated salt can be contradictory to public health messages that encourage the reduction of consumption of salt for management of hypertension.

Safety

47. Is water fluoridation safe at the recommended level?

Yes. Throughout more than 60 years of research and practical experience, the overwhelming weight of scientific evidence has continuously, and consistently, showed that fluoridation of community water supplies is safe. Studies showing the safety and effectiveness of water fluoridation have been confirmed, time and time again, by independent scientific studies conducted by national and internationally recognized investigators (6; 89).

There has also been continual monitoring of this scientific literature by the world's major national and international health organizations, committees of experts and special councils of governments. Examples of just a few are: the World Health Organization (WHO Expert Committee on Oral Health Status and Fluoride Use), U.S. Public Health Service (Department of Health and Human Services – Committee on Fluoride), the National Health and Medical Research Council of Australia and Health Canada's Federal-Provincial-Territorial Committee on Drinking Water in Canada. To date, the results of these reviews reaffirm that water fluoridation, at the recommended level, is safe and does not pose a risk for health problems.

Media Response

Throughout more than 60 years of research and practical experience, the overwhelming weight of scientific evidence has continuously, and consistently, showed that fluoridation of community water supplies is safe.

48. Should I be worried about fluoride in my drinking water?

No. Provided the levels in your drinking water are at, or below, the maximum acceptable concentration of 1.5 mg/L, fluoride in drinking water is safe. Fluoride is a beneficial mineral nutrient that occurs naturally in most sources of drinking water. At low levels in drinking water, fluoride prevents the formation of dental cavities and improves dental health.

Some municipalities adjust the level of fluoride in their drinking water to provide maximum dental benefits. At levels up to the maximum acceptable concentration of 1.5 mg/L, there are no adverse health effects from fluoride.

Media Response

Provided the levels in your drinking water are at, or below, the maximum acceptable concentration of 1.5 mg/L, fluoride in drinking water is safe. Fluoride is a beneficial mineral nutrient that occurs naturally in most sources of drinking water. At low levels in drinking water, fluoride prevents the formation of dental cavities and improves dental health. At levels up to the maximum acceptable concentration of 1.5 mg/L, there are no adverse health effects from fluoride.

49. Is fluoride in my drinking water a toxic substance?

No. At levels up to the maximum acceptable concentration, fluoride in drinking water is not toxic.

There is a difference in the effect of a massive dose of fluoride and the effect of taking small amounts of fluoride daily to reduce tooth decay. Like many essential substances needed for good health (i.e. salt, iron, vitamins and oxygen) fluoride can be toxic in excessive quantities (90). However, acute toxicity from the ingestion of optimally fluoridated water is impossible since at 0.7 ppm, an average adult weighing 70 kilograms would need to drink up to 15,000 litres of water in one sitting to consume an acute, lethal toxic dose (6; 30).

The possibility of adverse health effects from continuous low level consumption of fluoride over long periods has been studied extensively. Essentially, the average adult would need to drink up to 15 litres of water a day, every day for 10 years to show the effects of chronic toxicity (6; 30). After more than 60 years of research, scientific evidence indicates that fluoridation of community water supplies is both safe and effective (37).

According to Health Canada, the weight of evidence from all currently available studies does not support a link between exposure to fluoride in drinking water at the maximum acceptable level of 1.5 mg/L and any adverse health effects, including those related to cancer, immune system defects, reproductive and developmental defects, or defects of brain and nervous system development (37).

Media Response

At levels up to the maximum acceptable concentration, fluoride in drinking water is not toxic. The possibility of adverse health effects from continuous low level consumption of fluoride over long periods has been studied extensively. After more than 60 years of research, scientific evidence indicates that fluoridation of community water supplies is both safe and effective.

50. Does fluoridated water, at the recommended optimal level, leach out large amounts of aluminum in aluminum cook ware?

No. Evidence from available scientific evidence suggests fluoride at optimal levels does not leach out aluminum from cook ware. Research shows that leaching of aluminum occurs at extreme (acidic or alkaline) pH levels, levels considered unacceptable for drinking water (91; 92) .

For further information regarding the aluminum content and pH of your drinking water, please contact your local water treatment plant.

Media Response

Water fluoridation, at the recommended optimal levels, does not leach out large amounts of the aluminum in aluminum cook ware. Leaching of aluminum occurs at extreme (acidic or alkaline) pH levels, levels considered unacceptable for drinking water.

51. Will the long term effects of drinking fluoridated water at optimal levels be harmful to my health?

No. Drinking fluoridated water at the recommended level of 0.7 ppm is not harmful to human health.

Since its inception over 60 years ago, there have been many studies that provide evidence supporting the safety and efficacy of water fluoridation. There have been 18 reviews (see Appendix) of water fluoridation since 1997, and these reviews, which comprise critical appraisal of research by experts, have found no evidence that fluoridation is associated with cancer, bone disease, kidney disease, birth defects, or other adverse health effects (37; 67).

The reviews of the US Public Health Service and the National Research Council, both in 1993 and most recently in 2006, report no toxic health effects associated with fluoride concentrations recommended to prevent tooth decay (93; 94) . Two other systematic reviews of the scientific literature, one published in Australia and the other in the United Kingdom in 2000, arrived at the same conclusions (95; 96) .

Health Canada recognizes that exposure to high levels of fluoride may lead to dental fluorosis, and at very high levels, skeletal fluorosis, however, Health Canada confirms that the weight of evidence does not support other adverse health effects (37). Health Canada's Guideline Technical Document for fluoride in drinking water, prepared by the Federal-Provincial-Territorial Committee on Drinking Water in 2010, states "Based on a comprehensive review of available data, the weight of evidence does not support a link between exposure to fluoride in drinking water at 1.5 mg/L and any adverse health effects, including those related to cancer, immunotoxicity, reproductive/developmental toxicity, genotoxicity and/or neurotoxicity. In addition, the weight of evidence does not support a link between fluoride and intelligence quotient deficit, as there are significant concerns regarding the available studies, including quality, credibility, and methodological weaknesses. These conclusions are in agreement with the findings and recommendations of the 2007 Fluoride Expert Panel meeting on fluoride held in Canada" (37).

Media Response

Since its inception over 60 years ago, there have been thousands of studies that provide evidence supporting the safety and efficacy of water fluoridation. There have been 18 reviews of water fluoridation since 1997, and these reviews, which comprise critical appraisal of research by experts, have found no evidence that fluoridation is associated with cancer, bone disease, kidney disease, birth defects, or other adverse health effects.

52. Is there an association between water fluoridation and heart disease?

No. There is no evidence of any relationship between the intake of fluoridated water and heart disease.

A number of studies have examined mortality in relation to water fluoridation and found that there is no relationship between fluoridation and heart disease death rates (6). In one U.S study, 20 years of mortality trends in 473 cities were studied and found that there was no link between fluoridation and heart disease (97). In another large study, mortality rates for approximately 30 million people in 24 fluoridated cities were compared with those of 22 non-fluoridated cities over a 2 year time period. The authors found no evidence of any harmful health effects, including heart disease, attributable to fluoridation. As in other studies, crude differences in the mortality experience of the cities with fluoridated and non-fluoridated water supplies were attributed to differences in the age, sex, and race composition of the population studied (98).

These results support earlier conclusions made by the National Heart and Lung and Blood Institute of the National Institutes of Health in the United States. After collecting and analyzing data from both non-fluoridated and fluoridated communities, their final report concluded, “[...] from medical and pathological examination of persons exposed to a lifetime of naturally occurring fluorides or persons with high industrial exposures, and from broad national experience with fluoridation all consistently indicate no adverse effect on cardiovascular health” (99).

Media Response

There is no evidence of any relationship between the intake of fluoridated water and heart disease. A number of studies have examined mortality in relation to water fluoridation and found that there is no relationship between fluoridation and heart disease death rates.

53. Does water fluoridation cause Acquired Immune Deficiency Syndrome (AIDS)?

No. There is absolutely no correlation between fluoridation and AIDS.

The infectious agent responsible for AIDS has been identified as a retrovirus and designated as the Human Immunodeficiency Virus (HIV). Several studies have identified the routes of transmission as unprotected homosexual or heterosexual activity, exposure to blood or blood products, sharing of contaminated injection equipment by intravenous drug users and perinatal transmission from an

infected mother to a fetus or newborn **(100)**. Thus, there is definitive evidence of the association between HIV and AIDS and no evidence for an association with community water fluoridation.

The Centers for Disease Control and Prevention have stated, “The allegation that fluoride is a cause or co-factor in the development of AIDS or HIV infection lacks scientific verification. Based on the epidemiologic and laboratory data acquired since 1981, further studies documenting the alleged association between fluoride and HIV infection appear unnecessary and unwarranted. The allegation that fluoride is a cause of AIDS is unfounded” **(101)**.

Media Response

There is absolutely no correlation between fluoridation and AIDS. The infectious agent responsible for AIDS has been identified as a retrovirus and designated as the Human Immunodeficiency Virus.

54. Does water fluoridation cause allergic reactions or harm my immune function?

No. Water fluoridation, at optimal levels, does not cause allergic reactions or interfere with immune function.

A review of the scientific literature on fluoride and immune function was performed by Challacombe (1996) and found there were no confirmed cases of allergy to fluoride or of any positive skin testing in humans or animal models. In addition, there was no increased reporting of allergy of any type with increased fluoride consumption and no reports of reactions of an allergic nature to fluoride in other situations such as in tea, in tinned fish or salt water, where concentrations can be much higher than in fluoridated water (102).

Health Canada’s Guideline Technical Document for fluoride in drinking water, prepared by the Federal-Provincial-Territorial Committee on Drinking Water in 2010, states “Based on a comprehensive review of available data, the weight of evidence does not support a link between exposure to fluoride in drinking water at 1.5 mg/L and any adverse health effects, including those related to cancer, immunotoxicity, reproductive/developmental toxicity, genotoxicity and/or neurotoxicity[...] These conclusions are in agreement with the findings and recommendations of the 2007 expert panel meeting on fluoride held in Canada” (37).

Media Response

Water fluoridation, at optimal levels, does not cause allergic reactions or interfere with immune function. Comprehensive reviews of the literature confirm that fluoride is not associated with immunotoxicity or reactions of an allergic nature.

55. Does water fluoridation cause Alzheimer’s disease?

No. There is no generally accepted scientific knowledge that demonstrates fluoridated drinking water is a risk factor for Alzheimer’s disease.

At this time, scientific evidence does not support a link between fluoridated water and Alzheimer’s disease (103). Health Canada’s review of the health risks associated with fluoride in drinking water, assessing all identified human health risks found that the weight of evidence from all currently available studies does not support a link between exposure to fluoride in drinking water at 1.5 mg/L and any adverse health effects (37).

Media Response

At this time, scientific evidence does not support a link between fluoridated water and Alzheimer’s disease.

56. Is there an association between water fluoridation and birth defects?

No. There is no known association between birth defects and fluoridated drinking water.

In 1991, the U.S. Public Health Service, after an extensive review of the literature, concluded that chronic low-level fluoride is not associated with birth defects (104).

The York review in 2000 concluded that there were not enough quality studies to reach a conclusion and that “the outcomes related to infant mortality, congenital defects and IQ indicate a need further high quality research, using appropriate analytical methods to control for confounding factors” (20).

Based on Health Canada’s review of available science, as supported by the Fluoride Expert Panel meeting, the weight of evidence does not support a link between exposure to fluoride in drinking water at 1.5 mg/L and any adverse health effects including cancer, immunotoxicity, reproductive and/or developmental toxicity, genotoxicity, and/or neurotoxicity (37).

Media Response

Results from comprehensive systematic reviews, including the recent review by Health Canada, have demonstrated that there is no association between fluoridated drinking water and birth abnormalities.

57. Is there an association between water fluoridation and hip fractures?

No. Current scientific literature does not support a link between exposure to fluoridated drinking water and hip fractures.

An extensive literature review was conducted in 2000 to assess the efficacy and safety of water fluoridation. After dental fluorosis, bone effects were the most studied potential adverse effect of fluoride. Using a qualitative method of analysis, the authors did not find a clear association between hip fracture and water fluoridation, and the evidence for other fractures was similar. They concluded that the overall findings of the studies on bone fracture showed small variations around the “no effect” mark (20).

In 2006, the United States National Research Council assembled the Committee on Fluoride in Drinking Water to review the health effects of fluoridated water. The committee examined long-term exposure to fluoride in the range of 2 to 4 mg/L or above in drinking water. Their review of scientific literature revealed there were too few studies to adequately assess fracture risk in populations exposed to fluoride at 2 mg/L or less in drinking water; therefore, no conclusions could be drawn about the fracture risk or safety of fluoride in drinking water at that level (94).

Subsequently, a systematic review conducted in Australia in 2007 analyzed results from three existing systematic reviews on the safety of water fluoridation and concluded that fluoridation at levels aimed at preventing dental caries has little effect on fracture risk. They also did not uncover any association between water fluoridation and hip fractures (67).

After a review of the available science, the Fluoride Expert Panel convened by Health Canada concluded that “the current Maximum Acceptable Concentration (MAC) of 1.5 mg/L of fluoride in drinking water is unlikely to cause adverse health effects, including cancer, bone fracture [...]” (40).

Media Response

Current scientific literature does not support a link between exposure to fluoridated drinking water and hip fractures. After dental fluorosis, bone effects are the most studied potential adverse effect of fluoride. Multiple systematic reviews of the scientific literature have validated that there is no association between fluoride in drinking water and hip fractures.

58. Does water fluoridation, at optimal levels cause, or worsen, osteoporosis?

No. Actually, high doses (up to 50mg) of fluoride, primarily in the form of sodium fluoride, have been used in the treatment of osteoporosis (94).

Comprehensive reviews of the literature have concluded fluoride at up to 1 ppm does not have an adverse effect on bone strength, bone mineral density or fracture incidence (67; 77).

Health Canada’s review of the scientific literature found that exposure to fluoride at concentrations of 1.0–1.5 mg/L was occasionally associated with a positive effect on bone mineral density (37).

Media Response

There is no accepted scientific evidence establishing a causal relationship between optimal fluoride consumption and osteoporosis. Exposure to fluoride at concentrations between 1.0-1.5 mg/L have been associated with a positive effect on bone mineral density and high doses, primarily in the form of sodium fluoride, have been used in the treatment of osteoporosis.

59. Is there an association between water fluoridation and skeletal fluorosis?

No. Reviews of the scientific literature have determined that skeletal fluorosis is extremely rare in North America (40; 94). Skeletal fluorosis, the most serious adverse health effect associated with prolonged exposure to high levels of fluoride in drinking water, occurs at very high exposure levels, and has rarely been documented in Canada.

After a comprehensive review of the scientific literature, the Fluoride Expert Panel convened by Health Canada in 2007, concluded that skeletal fluorosis is likely to occur at about 10 mg/day after 10 or more years of exposure (40). In addition, the UK Medical Research Council found that skeletal fluorosis occurs after prolonged ingestion of water containing 8mg/L or more of fluoride (105).

Crippling skeletal fluorosis has been reported in India, Tanzania, South Africa and China where natural fluoride levels in the drinking water contain up to 20 mg/L of fluoride. This amount of fluoride is much higher than the Canadian maximum acceptable concentration (MAC) of 1.5 mg/L.

Media Response

Skeletal fluorosis is extremely rare in North America and is associated with prolonged exposure to high levels of fluoride in drinking water. It has rarely been documented in Canada. Crippling skeletal fluorosis has been reported in India, Tanzania, South Africa and China where natural fluoride levels in the drinking water contain up to 20 mg/L of fluoride. This amount of fluoride is much higher than the Canadian maximum acceptable concentration (MAC) of 1.5 mg/L.

60. Does water fluoridation cause cancer?

No. Since community water fluoridation was first introduced in 1945, more than 50 epidemiological studies have been conducted to evaluate the relationship between fluoride concentrations in drinking water and cancer. A number of expert committees, including an expert panel for Health Canada in 2007, have examined the link between fluoride and cancer and have concluded that there is no clear association between water fluoridation and overall cancer incidence or mortality (20; 40; 106). According to the leading authority, the International Agency for Research on Cancer (IARC), fluorides used in drinking water are not classified as carcinogens (107).

The fluoridation/cancer controversy began in the 1970s with a publication by well-known fluoride opponents Yiamouyiannis and Burk. Their report analyzed cancer deaths in 20 American cities and

concluded that cancer mortality in fluoridated cities was greater compared to cities without fluoridated drinking water (108). The National Cancer Institute reviewed this report and found the investigations had failed to take into account widely accepted risk factors known to affect the death rate for specific types of cancers. Ethnic composition of the population, geographic location, socioeconomic status, ages and sex differences had all been disregarded (109). In addition, when Yiamouyiannis and Burk's data were reanalyzed using standard procedures to account for these factors, the differences in cancer death rates were found to be due entirely to the age and racial makeup of the respective populations (110).

Concern was again fueled in 1990 by a finding of "equivocal evidence" (uncertain findings) in a rodent study conducted by the National Toxicology Program that fed rats doses of sodium fluoride up to 79 ppm. Osteosarcoma (bone tumors) were detected in 3 of the 50 male rats in the highest dose category of 79 ppm and one of the 50 in the 45 ppm group, while no osteosarcomas were found in female rats in the lower-dose groups (111).

Several studies were initiated in response to these results. In Alberta, rates of osteosarcoma from 1970 to 1988 in Calgary (non-fluoridated) were compared with Edmonton (fluoridated). There were no differences observed in the cancer rates (112). Similar studies were also conducted in New York State, New Jersey counties and Wisconsin, and all studies concluded that there was no association between osteosarcoma, or any other cancer risk, and water fluoridation (113; 114; 115; 116).

Controversy began again in 2006 after preliminary data from a research study conducted by Bassin *et al.* was released. The authors investigated age-specific and sex-specific effects of fluoride in drinking water and the incidence of osteosarcoma based on data from a matched case-control study. This exploratory analysis found an association between fluoride exposure in drinking water during childhood and the incidence of osteosarcoma among males but not consistently among females (117). Following the release of these results, a letter to the editor was published by Douglass (Bassin's thesis director) and Joshipura to warn readers not to generalize or over-interpret the results paper and to await publication from the full study before making any conclusions, particularly before influencing any related policy decision. According to the authors, Bassin *et al.* presented only the first of two sets of cases with their own control group (118). In 2011, the *Journal of Dental Research* published the results of the complete data set. In the study led by Douglass, bone fluoride levels in 137 individuals with osteosarcoma were compared to 51 tumour controls. Results showed that there was no significant association between bone fluoride levels and osteosarcoma risk (106). In response to these findings, the International Association for Dental Research vice-president, Helen Whelton, states "The controversy over whether there is an association between fluoride and risk for osteosarcoma has existed since an inconclusive animal study 20 years ago. Numerous human descriptive and case-control studies have attempted to address the controversy, but this study of using actual bone fluoride concentrations as a direct indicator of fluoride exposure represents our best science to date and shows no association between fluoride in bone and osteosarcoma risk" (119).

Previous to the study conducted by Bassin *et al.*, a systematic review conducted by McDonagh *et al.* in 2000 (20) found no association between water fluoridation and overall cancer incidence or mortality. In addition, a number of expert committees have examined the link between fluoride and cancer and have come to the same conclusions. For example, in 1993, the National Research Council (NRC) presented a review of fifty epidemiological studies on the relationship between drinking water fluoridation and cancer, including osteosarcoma, and found that there was no proven link between cancer and the natural or artificial presence of fluoride in water (93). These findings are confirmed by the World Health Organization's International Agency for Research on Cancer. Three other expert committees in the United Kingdom (95), Australia (67), and most recently, Health Canada (37), thoroughly examined the link between fluoridation and cancer, including osteosarcoma, and concluded that the scientific knowledge on this subject does not establish a link between water fluoridation and cancer of any kind. Lastly, Levy and Leclerc (120) assessed cumulative osteosarcoma incidence rate data in the United States and found that water fluoridation in the United States had no influence on osteosarcoma incidence rates during childhood and adolescence.

Media Response

Since community water fluoridation was first introduced in 1945, more than 50 epidemiological studies have been conducted to evaluate the relationship between fluoride concentrations in drinking water and cancer. A number of expert committees, including an expert panel for Health Canada in 2007, have examined the link between fluoride and cancer and have concluded that there is no clear association between water fluoridation and overall cancer incidence or mortality.

61. Does the ingestion of optimally fluoridated water affect thyroid gland function?

No. To date, scientific reviews have agreed that the science is insufficient to support an association between exposure to fluoride in drinking water and adverse thyroid effects.

A systematic review conducted by McDonagh *et al.* in 2000 included two studies that investigated the impact of water fluoridation upon thyroid cancer and neither found a statistically significant association with water fluoridation (20).

Health Canada's review of the evidence in 2010 demonstrated that there were some data to suggest that fluoride does adversely affect some endocrine glands, such as the thyroid; however, the available studies on the effects of fluoride on endocrine function displayed several design limitations which prevents their use in a risk assessment context (37). For example, many studies did not control for diet, specifically iodine intake or selenium levels. In the available studies, more severe effects on thyroid function were seen in populations with low-iodine intake. Low-iodine situations are unlikely to occur in the Canadian population since iodized salt is mandatory and iodine intakes for Canadians are above the adequate intake recommended by the Institute of Medicine to avoid iodine deficiency (37).

Media Response

Scientific reviews have agreed that the science is insufficient to support an association between exposure to fluoride in drinking water and adverse thyroid effects.

62. Does consumption of fluoridated water harm the kidneys?

No. Optimally fluoridated drinking water does not harm the kidneys.

Experimental rodent studies have shown that the threshold dose of fluoride in water which causes kidney effects in animals is approximately 50 ppm—more than 30 times the maximum acceptable concentration level allowed in Canadian drinking water (93). Large scale, human epidemiological studies have not observed increased kidney problems in populations with long-term exposure to fluoride concentrations in the drinking water up to 8 mg/L (121; 122).

Centers for Disease Control and Prevention, Division of Oral Health has stated, “To date, there is no scientific evidence that exposure to fluoride at the levels found in optimally fluoridated water present any risk for the development of any disease processes. Neither is there any evidence that certain individuals or subgroups of individuals such as the elderly or those with renal disease, suffer any adverse effects from drinking fluoridated water. The preponderance of scientific evidence indicates that fluoridation of community water supplies is both safe and effective” (123).

Individuals with kidney failure undergo hemo-dialysis for their survival. Water utilized during dialysis treatments must be de-ionized, and does not contain fluoride. This is because the individual’s blood is exposed to very large amounts of water each week during these treatments (280 to 560 quarts). The de-ionizing process removes excess minerals such as iron, magnesium, aluminum, calcium and other minerals as well as fluoride from the water (104; 124).

The 2010 Technical Guideline Document on Fluoride prepared by Health Canada in 2010 states that, “some sub-groups in the population could potentially be more susceptible to the toxic effects of fluoride, for example people with kidney problems [...] however, there are very limited data to support or refute an increased susceptibility to fluoride, and there are no data to suggest that exposure to fluoride at typical levels found in Canadian drinking water (e.g. at the maximum acceptable concentration of 1.5 mg/L) would result in adverse effects in these potentially susceptible populations” (37).

Media Response

Optimally fluoridated drinking water does not harm the kidneys. The Technical Guideline Document on Fluoride prepared by Health Canada in 2010, has recognized that individuals with kidney problems could potentially be more susceptible to the toxic effects of fluoride, however there are no data to suggest that exposure to fluoride at levels found in Canadian drinking water would result in adverse effects in these potentially susceptible individuals.

63. Does fluoridated drinking water, at optimal levels, adversely affect people with severe kidney dysfunction?

No. There is limited scientific data that suggests exposure to fluoride, at levels below the maximum acceptable concentration of 1.5 mg/L, would result in adverse health effects in individuals with kidney problems.

Individuals with kidney failure undergo hemo-dialysis for their survival. Water utilized during dialysis treatments must be de-ionized, and does not contain fluoride. This is because the individual's blood is exposed to very large amounts of water each week during these treatments (280 to 560 quarts). The de-ionizing process removes excess minerals such as iron, magnesium, aluminum, calcium and other minerals as well as fluoride from the water (104; 124).

Centers for Disease Control and Prevention, Division of Oral Health has stated, "To date, there is no scientific evidence that exposure to fluoride at the levels found in optimally fluoridated water present any risk for the development of any disease processes. Neither is there any evidence that certain individuals or subgroups of individuals such as the elderly or those with renal disease, suffer any adverse effects from drinking fluoridated water. The preponderance of scientific evidence indicates that fluoridation of community water supplies is both safe and effective" (123).

The Technical Guideline Document on Fluoride prepared by Health Canada in 2010 recognizes some sub-groups in the population could potentially be more susceptible to the toxic effects of fluoride, for example people with kidney problems. However, for most of these sub-populations there are very limited data to support or refute an increased susceptibility to fluoride, and there are no data to suggest that exposure to fluoride at levels below the maximum acceptable concentration of 1.5 mg/L would result in adverse effects in these potentially susceptible populations (37).

Media Response

While some sub-populations, such as individuals with kidney problems, may be potentially be more susceptible to the toxic effects of fluoride, there are very limited data to support or refute an increased susceptibility to fluoride, and there are no data to suggest that exposure to fluoride at levels below the maximum acceptable concentration of 1.5 mg/L would result in adverse effects in these potentially susceptible populations.

64. Does water fluoridation cause an increase in the incidence of Down syndrome?

No. There is no evidence of any relationship between the incidence of Down syndrome and water fluoridation.

This question originally arose from studies published between 1956 and 1959 by Ionel Rapaport, a psychiatrist without experience in epidemiology or dental research. Experienced epidemiologists and dental researchers for the National Institute of Dental Research and staff from the National

Institute of Mental Health found serious shortcomings in the statistical procedures and design of the study. Since 1950, Rapaport's conclusions have been refuted by researchers in England, Sweden and the United States (125; 126; 127).

In 1991, the U.S. Public Health Service, after reviewing the literature, concluded that current scientific literature failed to establish an association between water fluoridation and Down syndrome (104).

In 2001, a systematic review was commissioned by the UK Department of Health to investigate whether water fluoridation had any impact upon the incidence of Down syndrome. From the six ecological studies included in the review, the authors established that the evidence for an association between water fluoride level and the incidence of Down syndrome is weak, and that the identified studies were of poor quality. It was concluded that the evidence of an association between water fluoride level and Down syndrome is inconclusive (128).

Media Response

The scientific evidence is insufficient to support an association between exposure to fluoride in drinking water and the incidence of Down syndrome. Reviews conducted by international agencies have concluded that the evidence for an association between water fluoride level and the incidence of Down syndrome is weak and of poor quality.

65. Does fluoride at optimal levels in drinking water irritate, or damage, the stomach lining?

No. Based on a review of the available scientific literature, the U.S. Public Health Service and the National Research Council both concluded that there is no indication that low level fluoride exposure from drinking water presents a problem or adverse effects in the gastrointestinal system (93; 104).

Experimental studies in rodents, given extremely high fluoride doses of sodium fluoride (1900 mg/L) demonstrated erosive injury to the gastric mucosa.

Industrial workers with chronic exposure to high concentrations of fluoride dusts have reported chronic gastritis occasionally accompanied by ulcers (93). However, there have been no reports of gastrointestinal problems in populations exposed to low levels of fluoride found in either naturally occurring or adjusted drinking water.

Media Response

Current scientific evidence does not support a link between stomach lining damage and fluoride at levels found in water fluoridation. There have been no reports of gastrointestinal problems in populations exposed to low levels of fluoride found in either naturally occurring or adjusted drinking water.

66. Does water fluoridation cause genetic damage?

No. Drinking optimally fluoridated water does not alter chromosome structure and does not cause genetic damage.

Fluoride has been tested extensively for its genotoxicity. To resolve questions about the possible chromosome-damaging ability of fluoride, a study by the National Institute of Environmental Health Sciences found that mice that were administered doses of 0, 100, 200, and 400 ppm of fluoride in drinking water for six weeks, did not experience genetic alterations (129).

Since then, additional studies have been conducted using mice to investigate the genotoxicity of fluoride. These studies have shown no evidence that fluoride damages chromosomes, even at fluoride levels 100 times higher than that of fluoridated water. The lowest dose of fluoride reported to cause DNA alterations in mammalian cells was approximately 170 times that found in human cells of individuals living in areas of fluoridated water supplies (93).

Based on Health Canada's review of available science, as supported by the Expert Panel on fluoride, "the weight of evidence does not support a link between exposure to fluoride in drinking water at 1.5 mg/L and any adverse health effects including cancer, immunotoxicity, reproductive and/or developmental toxicity, genotoxicity, and/or neurotoxicity" (40).

Media Response

Based on the scientific literature, including Health Canada's review of available science, as supported by the Expert Panel on fluoride, the weight of evidence does not support a link between exposure to fluoride in drinking water at 1.5 mg/L and any adverse health effects, including genotoxicity.

67. Does water fluoridation, at optimal levels, affect brain function or intelligence quotient (IQ) levels?

No. There is no accepted scientific evidence establishing a causal relationship between optimal fluoride consumption and brain function or IQ.

The impact of fluoride exposure on children's IQ has been measured in several studies conducted in China. A popularly quoted study by Zhao *et al.* in 1996 compared the IQs of 160 children (ages 7 through 14) living in a village with naturally occurring fluoride (4.12 mg/L) with those of children living in a non-fluoridated community (0.91 mg/L). The results showed that the average IQ of children living in a high-fluoride area was significantly lower than those in the low-fluoride area (97.69 vs. 105.21) (130).

The problem with this study and other similar studies (131; 132; 133) looking at the relationship between fluoride and neurological function, lies in the fact that the methodology and design of the

studies are heavily flawed and lack appropriate controls. They were also conducted in a very different environmental context compared to Canada. These studies were recently reviewed by the Expert Panel on fluoride convened by Health Canada in 2007, and despite the consistency in the results from the studies, the panel agreed that there were significant concerns regarding the quality, credibility, and methodological weaknesses, such as the lack of control for confounding variables, small sample sizes, and the dose of exposure (40). The studies conducted in China were also reviewed by other organizations and external committees, which also concluded that the significance of these studies remains uncertain (94; 134; 135).

Based on a comprehensive review of available data, the Federal-Provincial-Territorial Committee on Drinking Water have determined that “the weight of evidence does not support a link between exposure to fluoride in drinking water at 1.5 mg/L and any adverse health effects, including those related to cancer, immunotoxicity, reproductive/developmental toxicity, genotoxicity and/or neurotoxicity. In addition, the weight of evidence does not support a link between fluoride and intelligence quotient deficit, as there are significant concerns regarding the available studies, including quality, credibility, and methodological weaknesses” (37).

Media Response

There is no accepted scientific evidence establishing a causal relationship between optimal fluoride consumption and neurological disorders. Studies originating from China that report an association between fluoride and neurological function are heavily flawed in methodology and design and lack appropriate controls. Based on a comprehensive review of available data, the Federal-Provincial-Territorial Committee on Drinking Water have determined that the weight of evidence does not support a link between exposure to fluoride in drinking water at 1.5 mg/L and any adverse health effects, including neurotoxicity and intelligence quotient deficit, as there are significant concerns regarding the available studies, including quality, credibility, and methodological weaknesses.

68. Is there an association between water fluoridation and adverse effects on reproduction, fertility or birth rates?

No. There is no credible evidence of an association between water fluoridation and human reproduction, fertility or birth rates.

While ingestion of very high levels of fluoride (100 to 200 ppm) has been associated with adverse effects on reproduction in animal species, there is not sufficient scientific evidence that ingestion of fluoride at levels found in water fluoridation would have adverse effects on human reproduction (104).

A review of the scientific literature by the National Research Council of the National Academy of Sciences in the United States concluded that ingestion of fluoride, at recommended concentrations in the drinking water, has no adverse effects on human reproduction (93). Subsequently, the U.S National Committee on Fluoride in Drinking Water declared that the number of available studies on

the link between human developmental or reproductive effects and fluoride in drinking water are few and have significant shortcomings in design and power, limiting their impact (94).

According to the Findings and Recommendations of the Expert Panel on Fluoride convened by Health Canada in 2007: “ [the] weight of evidence does not support a link between exposure to fluoride in drinking water at 1.5 mg/L and any adverse health effects regarding immunotoxicity, reproductive/developmental toxicity, genotoxicity and/or neurotoxicity” (37).

Media Response

There is no credible evidence that indicates an association between water fluoridation and human reproduction, fertility or birth rates. Scientific reviews conducted by international agencies, including Health Canada, have examined the link between fluoride and fertility and have concluded that there is no association between water fluoridation and adverse effects on human reproduction.

69. Are certain sub-populations, such as the elderly, individuals with cardiovascular and kidney problems, and certain ethnicities, more susceptible to fluoride levels in drinking water?

No. There is little evidence of value that these sub-populations are more susceptible to fluoride at typical levels found in Canadian drinking water.

The Centers for Disease Control and Prevention, Division of Oral Health has responded to this issue by stating, “[...] there is no scientific evidence that exposure to fluoride at the levels found in optimally fluoridated water present any risk for the development of any disease processes. Neither is there any evidence that certain individuals or subgroups of individuals such as the elderly or those with renal disease, suffer any adverse effects from drinking fluoridated water. The preponderance of scientific evidence indicates that fluoridation of community water supplies is both safe and effective” (123).

In the 2010 Technical Guideline Document on Fluoride prepared by Health Canada, it was found that some sub-groups could potentially be more susceptible to the toxic effects of fluoride. However, there are very limited data to support or refute an increased susceptibility to fluoride, and there are no data to suggest that exposure to fluoride at typical levels found in Canadian drinking water (e.g. at the maximum acceptable concentration of 1.5 mg/L) would result in adverse effects in these potentially susceptible populations (37).

Media Response

There is little evidence of value that certain sub-populations are more susceptible to fluoride at typical levels found in Canadian drinking water. Reviews of the evidence, conducted by the Centers for Disease Control and Prevention, in addition to Health Canada, have concluded that exposure to

fluoride at typical levels found in drinking water (e.g. at the maximum acceptable concentration of 1.5 mg/L) do not result in adverse effects in any population.

70. Is it safe to drink fluoridated water while pregnant or breastfeeding?

Yes. It is safe to drink optimally fluoridated water while pregnant or breastfeeding.

No credible scientific study has linked drinking optimally fluoridated water with birth defects or other reproductive effects (67; 134; 136).

Infants daily dietary intake of fluoride from breast milk depends on their age (amount of milk ingested) and whether the mother herself drinks fluoridated water or not. Research conducted by Health Canada in 2007 estimated the dietary intake of fluoride by breast-fed infants as a function of the fluoride level in their community drinking water. Results showed that while fluoride intake levels were higher for infants in fluoridated communities, overall, human milk contains a low dietary intake of fluoride (37) .

Breast milk is relatively low in fluoride but the fluoride will still benefit the infant's teeth. Infants who receive all or some of their feedings with commercial formula will also benefit from the fluoridated drinking water that is mixed with the formula. In Canada, the amount of fluoride in formula (ready-to-use, concentrated, and powdered) is regulated by Health Canada to help ensure that infants do not receive too much fluoride in their diet.

Media Response

It is safe to drink optimally fluoridated water while pregnant or breastfeeding. No credible scientific study has linked drinking optimally fluoridated water with birth defects or other reproductive effects. In Canada, the amount of fluoride in formula (ready-to-use, concentrated, and powdered) is regulated by Health Canada to help ensure that infants do not receive too much fluoride in their diet.

71. Is there an association between Sudden Infant Death Syndrome (SIDS) and water fluoridation?

No. There is no relationship between water fluoridation and SIDS.

In their review of the scientific literature, Health Canada identified one study that assessed the relationship between fluoride in drinking water and SIDS. In 1999, Dick *et al.* (137) reported that infants exposed to fluoridated water supplies in utero were not at increased risk for SIDS. For breast-fed infants at the time of death, the association between fluoridated water exposure and an increased risk for SIDS was not statistically significant. Likewise, fluoridated formula, when compared with non-fluoridated formula, did not show a statistically significant increased risk of

SIDS. The authors concluded that exposure to fluoridated water supplies prenatally or postnatally did not affect the relative risk for SIDS.

Media Response

Scientific evidence has demonstrated that exposure to fluoridated water supplies prenatally or postnatally does not affect the risk for Sudden Infant Death Syndrome.

72. What is dental fluorosis? Should I be concerned about it?

Dental fluorosis is an alteration in the appearance of the teeth and is caused by a change in enamel formation, which occurs during tooth development related to the ingestion of higher than optimal levels of fluoride (138). Enamel formation of the permanent teeth occurs from around the time of birth until approximately 5 years of age. After the enamel is completely formed, dental fluorosis cannot occur. It is for this reason that older children and adults are not at risk for dental fluorosis (139).

The development of dental fluorosis is dependent on two things: dose and timing. This means that sufficient fluoride during the time of tooth development is required to produce fluorosis at the level of cosmetic concern (11).

The most universally accepted classification of dental fluorosis is the one developed by H.T Dean in 1942 called the Dean’s Fluorosis Index (140). A dental fluorosis score is based on the severest form of fluorosis recorded for two or more teeth:

Table 5: Dean’s Fluorosis Index

| Classification | Criteria/Description of Enamel |
|----------------|--|
| Normal | Smooth, glossy, creamy-white translucent surface |
| Questionable | A few white specks or white spots |
| Very Mild | Small opaque, paper-white areas covering less than 25% of the tooth surface |
| Mild | Opaque white areas covering less than 50% of the tooth surface |
| Moderate | All tooth surfaces affected; marked wear on biting surfaces; brown stains may be present |
| Severe | All tooth surfaces affected; discrete or confluent pitting; brown stain present |

Questionable, very mild, mild and moderate dental fluorosis have no effect on tooth function. In fact, questionable, very mild and mild fluorosis may actually make the tooth more resistant to decay. These types of fluorosis are not readily noticeable to the affected individual or the casual observer and often require a trained dental professional to detect. The moderate and severe types of fluorosis are easier to detect.

Dental fluorosis is not considered a concern in Canada since the actual prevalence of moderate and severe fluorosis is extremely low. Additionally, evidence suggests that since 1996 there has been an overall decreasing trend of moderate dental fluorosis in Canada. Results from the national Canadian Health Measures Survey (CHMS) in 2009 show that 59.8 percent of children aged 6 through 12 have teeth that, according to Dean's Index, are normal and another 23.5 percent that are identified as questionable. Questionable means there were spots in the enamel of the teeth that could have been caused by any number of childhood illnesses. 12 percent have 1 or more teeth with fluorosis classified as very mild and 4.4 percent as mild. The 2007-09 report on the findings of the oral health component of the CHMS states, "So few Canadian children had moderate or severe fluorosis that, even combined, the prevalence is too low to allow reporting however it can be seen that this number is less than 0.3%" (19).

Media Response

Dental fluorosis is an alteration in the appearance of the teeth caused by a change in enamel formation, which occurs during tooth development related to the ingestion of higher than optimal levels of fluoride. The most universally accepted classification of dental fluorosis is the one developed by H.T Dean in 1942 that classifies fluorosis severity from questionable to severe. Questionable, very mild, mild and moderate dental fluorosis have no effect on tooth function. In fact, questionable, very mild and mild fluorosis may actually make the tooth more resistant to decay. These types of fluorosis are not readily noticeable to the affected individual or the casual observer and often require a trained dental professional to detect. The moderate and severe types of fluorosis are easier to detect.

The actual prevalence of moderate dental fluorosis in Canada is low, and all evidence suggests that since 1996 there has been an overall decreasing trend of moderate dental fluorosis in Canada. Findings from the Canadian Health Measures Survey demonstrated that so few Canadian children experience moderate or severe dental fluorosis, that the prevalence was too low to allow reporting.

Public Health

73. Is tooth decay a public health problem?

Yes. Dental decay is the most common chronic disease in children, affecting 5 to 8 times as many children as asthma (18). According to recent data from the Canadian Health Measures Survey (CHMS), 56.8 percent of children in Canada aged 6 to 11 years are affected by dental caries and 58.8 percent of adolescents aged 12 to 19 have experienced decay in 1 or more permanent teeth. By adulthood, nearly 96 percent of dentate Canadians have experienced coronal decay, with a mean count of 10.7 DMFT (decayed, missing and filled teeth) (19).

The consequences of tooth decay include pain, infection, premature tooth loss and misaligned teeth. Complications interfere with children's development and the quality of life of those affected. Importantly, tooth decay is a costly disease. In 2009, dental services in Canada cost over \$12 billion, an average of \$360 per Canadian (141).

Media Response

Tooth decay remains one of the most common diseases affecting substantial numbers of children and adults of all ages. The consequences of tooth decay include pain, infection, premature tooth loss and misaligned teeth. Complications interfere with children's development and the quality of life of those affected. Importantly, tooth decay is a costly disease. In 2009, dental services in Canada cost over \$12 billion, an average of \$360 per Canadian.

74. Is community water fluoridation a valuable public health intervention?

Yes. Community water fluoridation serves as an example of an excellent public health initiative. The benefits are readily provided to everyone served by a fluoridated public water system and large groups of people can benefit in a manner that does not discriminate against any group, regardless of age, race, gender, ethnicity, religion, education, and socioeconomic status.

Fluoridation does not require individuals to gather in a central location to receive the protection, as do immunization programs, nor does it require the services of health professionals to deliver the preventive measure directly. There are no daily dosage schedules to remember or pills to take. People benefit continuously in a way that requires no special effort. The protection of fluoridation reaches community members in their homes, at work and at school – simply by drinking the water.

Community water fluoridation is a valuable public health initiative for the following reasons:

- It is accessible to the entire community regardless of socioeconomic status, educational attainment, income or other social variables
- Individuals do not need to change their behavior to obtain the benefits
- Frequent exposure to small amounts of fluoride over the life span makes it effective in preventing dental decay
- It is more cost effective, on a per person basis, compared to other forms of fluoride treatments

The effectiveness of community water fluoridation has been established by several national and international health agencies (6; 20; 37; 67; 142). Water fluoridation continues to be both effective and socially equitable, benefiting children across a wide range of socioeconomic backgrounds, where children with the greatest dental need, benefit the most.

In 1994, the U.S Centers for Disease Control and Prevention named community water fluoridation as one of the most economical preventive interventions (143). Further, in 1999, the Centers for Disease Control and Prevention named water fluoridation one of ten great public health achievements of the 20th century (144). In 2010, the Canadian Public Health Association named water fluoridation in its list of the 12 greatest public health achievements of the past 100 years (145).

Media Response

Community water fluoridation serves as an example of an excellent public health initiative. The benefits are readily provided to everyone served by a fluoridated public water system and large groups of people can benefit in a manner that does not discriminate against any group, regardless of age, race, gender, ethnicity, religion, education, and socioeconomic status. In 1999, the Centers for Disease Control and Prevention named water fluoridation one of ten great public health achievements of the 20th century and in 2010, the Canadian Public Health Association named water fluoridation in its list of the 12 greatest public health achievements of the past 100 years.

75. What is a plebiscite? Have any occurred in Canada regarding community water fluoridation?

A plebiscite is a vote by a group of people about a political issue. Typically, voters are asked to answer yes or no to a particular question.

Although the decision to implement fluoridation rests with municipalities, the outcome of municipal plebiscites will depend, in part, on guidelines set in place at the provincial level. Typically, the decision is left to municipal electorates or the community at large, by way of a vote (7).

The first community water fluoridation plebiscite held in Canada occurred in Thorold, Ontario in 1957. In the end, the community of Thorold voted in favor of continued fluoridation with a vote of

1,359 to 756. The most important contribution to the outcome was the letter of endorsement signed by all physicians and dentists in the community. Since then, over 30 plebiscites or council votes have taken place in Canada for the introduction or continuance of fluoridation across various municipalities (7). The most recent include votes in Toronto, Halton region, Peel region, Hamilton, Toronto, London, Waterloo, Lethbridge and Calgary. All except Calgary and Waterloo voted to maintain community water fluoridation.

Although the outcomes of plebiscites reflect unique local and provincial circumstances, anti-fluoridation groups are well organized and often well-funded, and therefore it is important to organize those in favor of fluoridation as early as possible, including engaging local decision-makers and securing the support of the local media (146).

Media Response

A plebiscite is a vote by a group of people about a political issue. Typically, voters are asked to answer yes or no to a particular question. The decision to implement fluoridation rests with municipalities; however, the outcome of municipal plebiscites will depend, in part, on guidelines set in place at the provincial level. Typically, the decision is left to municipal electorates or the community at large, by way of a vote. Over 30 plebiscites or council votes have taken place for the introduction or continuance of fluoridation across various municipalities. The most recent include votes in Toronto, Halton region, Peel region, Hamilton, Toronto, London, Waterloo, Lethbridge and Calgary. All except Calgary and Waterloo voted to maintain community water fluoridation.

Ethics

76. Does water fluoridation interfere with my freedom of choice?

No. Water fluoridation is one of several examples of public health measures where additives are used to achieve health benefits in a population. The decision to implement fluoridation rests with municipalities; however, the outcome of municipal plebiscites will depend, in part, on guidelines set in place at the provincial level. Typically, the decision is left to municipality electorates or the community at large, by way of a vote (7).

Infringement upon personal freedom is often justified when the well-being of vulnerable groups is at stake. For example, community water fluoridation is argued to be a practical and effective means of ensuring access to fluoride among vulnerable populations, such as those with limited socioeconomic resources who may not otherwise have access to preventive dental care and treatment. In countries such as Canada, there is a core set of values which allows for infringement of individual rights in certain instances such as mandatory vaccination, fortification of foods with essential nutrients, and routine testing for certain genetic diseases at birth and water fluoridation (147).

In 2007, the Nuffield Council on Bioethics reviewed the case of community water fluoridation and the issue of consent (148). It was identified that the requirements for individual consent can, at times, be over-emphasized in the public health context, and this can be problematic in situations where there is very low risk of harm and where refusal to give consent would restrict others from receiving important health benefits. In their report, it was determined that the decision to fluoridate a community's water supply should be made using democratic decision-making procedures at the municipal level (148), which is the approach used in Canada.

In the past, the courts have rejected the contention that fluoridation ordinances are a deprivation of religious or individual rights. Individuals are not forced to drink fluoridated water, as fluoride-free sources are available (6; 149; 150).

Media Response

Water fluoridation is one of several examples of public health measures where additives are used to achieve health benefits in a population. The decision to implement fluoridation rests with municipalities; however, the outcome of municipal plebiscites will depend, in part, on guidelines set in place at the provincial level. Typically, the decision is left to municipality electorates or the community at large, by way of a vote.

In countries such as Canada, there is a core set of values which allows for infringement of individual rights in certain instances such as mandatory vaccination, fortification of foods with essential nutrients, routine testing for certain genetic diseases at birth and water fluoridation.

77. Is water fluoridation a form of mass medication?

No. Fluoride used in drinking water fluoridation is not considered a drug by Health Canada as per the *Food and Drugs Act* and is not regulated by the federal government as a drug.

Fluoride is considered a beneficial nutrient based on its proven effects on dental health. Fluoride is added to drinking water as a public health measure to protect dental health and prevent or reduce tooth decay.

When a fluoride preparation, such as a dental rinse or toothpaste, includes a therapeutic claim and is represented for sale in Canada, it is considered to be a drug and is regulated accordingly by Health Canada. It is the responsibility of the product submission sponsor to demonstrate compliance with the applicable federal requirements.

Governments and health professionals have a responsibility to make decisions and implement public health strategies that balance community health outcomes with individual choices. Adjusting the level of fluoride in drinking water can be compared to practices such as adding iodine to salt for thyroid health and adding folic acid to cereals to reduce neural tube defects.

Media Response

Fluoride used in drinking water fluoridation is not considered a drug by Health Canada as per the *Food and Drugs Act* and is not regulated by the federal government as a drug. Fluoride is added to drinking water as a public health measure to protect dental health and prevent or reduce tooth decay.

78. Does the public support water fluoridation?

Yes. Contrary to the belief of opponents, the majority of the Canadian population is supportive of water fluoridation.

In 1998, a telephone survey of a random sample of residents living in fluoridated and non-fluoridated municipalities in the Quebec City region demonstrated that while the overall, knowledge of the main benefits of fluoride was relatively low, over 80 percent of respondents supported water fluoridation (151).

Furthermore, Quiñonez and Locker conducted a telephone survey of a random sample of Canadians concerning public opinions about community water fluoridation. They found that approximately

one in two adults surveyed knew about community water fluoridation. Of those who knew about it, 60 percent believed that it was both safe and effective, and 62 percent supported the idea of having fluoride added to their local drinking water (152).

Most recently, a survey conducted in Quebec in 2010 revealed that 62 per cent of the population supports water fluoridation (153).

Media Response

According to recent studies, the majority of the Canadian population is supportive of water fluoridation. A poll in Quebec showed over 80 percent of respondents support water fluoridation and another demonstrated over 60 percent of Canadians support the idea of having fluoride added to their local drinking water.

Environment

79. Is water fluoridation, at optimal levels, harmful to the environment?

No. Fluoride, at levels found in drinking water, is not harmful to the environment. Fluoridation of drinking water is not a major source of inorganic fluorides in the environment. Inorganic fluorides found into the Canadian environment come from both anthropogenic (caused by humans) and natural sources. The main anthropogenic sources in Canada include phosphate fertilizer production, aluminum smelting, and chemical production (154).

Controversy surrounding the impact of fluoride on the environment have stemmed from incidents related to industrial pollution or accidents involving large amounts of fluoride. Historically, in Canada, concerns were bolstered by an event in 1967 in Dunnville, Ontario, in which fluoride pollution from a fertilizer plant damaged crops and animals (146). A comprehensive review of the literature evaluating the impact of water fluoridation on the environment in 1990 concluded that there were absolutely no negative environmental effects as a result of water fluoridation (155).

Media Response

Comprehensive reviews of the literature evaluating the impact of water fluoridation on the environment have concluded that there are absolutely no negative environmental effects as a result of water fluoridation.

80. Is fluoride, at optimal levels, harmful to fresh water aquatic life?

No. At optimal levels of fluoride, fluoride is not harmful to fresh water or marine aquatic life. Although fluoridated drinking water is eventually released into surface waters, treatment processes and/or dilution of the effluent reduces the concentrations of fluorides to the source water level, typically less than the freshwater aquatic life guideline of 0.12 mg/L. It is therefore unlikely that there would be any impact on aquatic organisms due to fluoridation practices (154; 156).

Several studies have shown that fluoride is toxic to fish species at levels much higher than those found in drinking water (157; 158; 159). Concern over fluoride levels and the effect on fish, particularly salmon species, have derived from a study conducted in 1989 by Damkaer and Dey. This is the only study that purports to link environmental impacts with fluoride levels less than 1 mg/L. In their study, the authors attempted to investigate the effects of high fluoride levels from an adjacent aluminum plant on the fish. They concluded that fluoride concentrations of about 0.5 mg/L adversely affect the migration of adult salmon and that 0.2 mg F/L may be near or below the threshold for fluoride sensitivity in Chinook and Coho salmon (160).

As a result of these conclusions, the British Columbia Ministry of the Environment have suggested a raw water guideline for aquatic life where in fresh water, the total fluoride level should not exceed 0.2 mg/L to 0.3 mg/L depending on the hardness of the water. This is a guideline only, and the document states that it holds no legal standing (161).

The article by Damkaer and Dey contains several internal inconsistencies and limitations. For example, the authors fail to describe how they measured salmon mortality or spawning success and the amount of time the fish spent below the dam. In addition, they did not control for factors such as concentrations of other chemicals as reasons for the observed behaviours of the salmon. They show in their results section that it was not the fluoride concentrations from the aluminum plant, yet their discussion states there was “empirical and theoretical evidence” of its influence (160). Discrepancies within their study make it difficult to draw any conclusions on the influence of fluoride on fish species at levels below 1 mg/L.

By memorandum of understanding between the Minister of the Department of Fisheries and Oceans and the Minister of the Environment, the Minister of the Environment administers the pollution prevention provisions of the *Fisheries Act* in relation to the disposal or the deposit of a toxic substance in waters frequented by fish. To date, monitoring data from Environment Canada suggest fluoride levels are highly unlikely to be affecting fish and fish habitat (162). In addition, current monitoring data do not suggest fluoride is influencing the migration patterns or affecting some marine species such as Pacific Salmon (162).

Media Response

At optimal levels of fluoride, fluoride is not harmful to fresh water or marine aquatic life. Although fluoridated drinking water is eventually released into surface waters, treatment processes and/or dilution of the effluent reduces the concentrations of fluorides to the source water level, typically less than the freshwater aquatic life guideline of 0.12 mg/L. To date, monitoring data from Environment Canada suggest fluoride levels are highly unlikely to be affecting fish and fish habitat. In addition, current monitoring data do not suggest fluoride is influencing the migration patterns or affecting some marine species such as Pacific Salmon.

Cost

81. What is the cost to fluoridate a community's water supply?

The cost of water fluoridation varies in each community depending on a number of factors, which include:

- Size of the community
- Number of fluoride injection points
- Amount and type of equipment used
- Amount and type of fluoride used, its price and cost for transportation/storage
- Expertise and number of personnel at water treatment plant

In the small city of Dryden in northwestern Ontario, the cost to fluoridate the drinking water is approximately \$4 per person per year. In a mid-size city, such as Hamilton Ontario, the cost of water fluoridation is less than \$1 per person per year (51). According to an exhaustive analysis of the costs related to the Quebec fluoridation program, the average cost of fluoridation in Quebec is \$2.13 per person per year (163).

The following table displays the break down in annual costs of fluoridation in Toronto Ontario:

Table 6: Annual Costs of Water Fluoridation in Toronto (90)

| | |
|-------------------------------|-----------------|
| Total Estimated Chemical Cost | \$1.2M per year |
| Estimated Maintenance Cost | \$0.7M per year |
| Total Cost | \$1.9M per year |
| COST PER PERSON | \$0.77 per year |

It can be estimated from this data that the annual cost to fluoridate a Canadian community ranges from approximately \$0.77 to \$4 per person per year.

Media Response

The cost of community water fluoridation varies in each community depending on a number of factors, which include the size of the community, number of fluoride injection points, amount and type of equipment used, its price and cost for transportation/storage and expertise of personnel at the water plant. It can be estimated from current cost analyses data that the annual cost to fluoridate a Canadian community ranges from approximately \$0.77 to \$4 per person per year.

82. Is water fluoridation the most cost-effective means of preventing tooth decay?

Yes. Water fluoridation is the most economical method to reduce the burden of dental disease in the population.

Given that the annual cost to fluoridate a Canadian community ranges from approximately \$0.77 to \$4 per person per year, the average lifetime cost per person to fluoridate a water system is less than the cost of one dental filling (6). For most cities, every \$1 invested in water fluoridation saves \$38 in dental treatment costs (164).

A 2005 article for the Centers of Disease Control and Prevention estimated the cost savings associated with community water fluoridation programs in Colorado. An economic model compared the costs associated with community water fluoridation implementation and maintenance with treatment savings achieved through averted tooth decay. Results revealed an annual savings of \$148.9 million in 2003, or an average of \$60.78 per person per year (165).

School-based dental prevention activities, professionally applied topical fluorides and dental health education are not as cost-effective in preventing dental decay as water fluoridation. The City of Hamilton conducted an analysis of the cost of delivering fluoride through four methods: water fluoridation, topical fluoride application twice per year by public health services, topical fluoride application twice per year by private dentists and, distribution of tooth pastes and tooth brushes. The annual costs of alternate fluoride delivery approaches in 2008 are presented in the table below.

Table 7: Annual Cost of Various Fluoride Delivery Approaches (51; 90)

| Preventive measure | Annual Cost/person |
|--|--------------------|
| Topical fluoride application twice per year to all high risk individuals by Public Health Services | \$44.50 |
| Topical fluoride application twice per year to all high risk individuals by Private Dentists | \$96.12 |
| Distribution of tooth pastes and tooth brushes to all members of the population | \$8.50 |
| Water Fluoridation | \$.77 - \$4.00 |

Apart from the direct operational and capital costs of these alternate fluoride delivery methods, the potential added cost for increased waste management is also a factor to be considered. For example, additional paper or plastic cups, gloves, masks, trays and applicator tips used for the application of topically applied fluorides will have to be disposed. The environmental impact of the increased production of these products, as well as the cost of disposal of the generated waste, must be considered.

The economic importance of fluoridation is emphasized by the fact that the cost of treating dental decay is paid not only by the individual, but also by the general public, through health insurance premiums, health departments and community health clinics. With the escalating cost for health

care, fluoridation remains a preventive measure that benefits all members of the community, regardless of socioeconomic status, at a minimal cost.

Media Response

Water fluoridation is the most economical method to reduce the burden of dental disease in the population. Given that the annual cost to fluoridate a Canadian community ranges from approximately \$0.77 to \$4 per person per year, the average lifetime cost per person to fluoridate a water system is less than the cost of one dental filling.

Opposition

83. Is there opposition to water fluoridation?

Yes. Even though water fluoridation is supported locally, nationally and internationally by the major medical, dental and health organizations for the prevention of tooth decay, there is still a small vocal minority who opposes fluoridation.

Opposition to fluoridation has existed as long as fluoridation itself. Since the discovery of the protective effects of fluoride against tooth decay in the 1930s and 1940s, there has been opposition to water fluoridation for many shifting reasons. Some of these reasons are philosophical, such as the argument for freedom of choice, or environmental, economic and some are because opponents are simply misinformed.

It should be noted that opposition towards the views of public health practitioners by minority groups is not restricted to the debate over water fluoridation. Parallels can be drawn with some other public health controversies such as child immunizations, dental amalgam or the use of genetically modified foods. Typically, individuals who oppose water fluoridation are the same individuals who oppose vaccinations, dental amalgam and other health- and food-related interventions.

Opponents of water fluoridation are often highly mobilized, highly funded, organised and rely heavily on disseminating their opinion via popular media, which is often eager to publish their sensationalist claims. Propagating the idea of an ongoing scientific debate gives the illusion of scientific uncertainty and is a favoured tactic of water fluoridation opponents.

Because internet resources are increasingly being used by the public as a source for health information, the uncontrolled spread of information has led to concern over its appropriateness and quality. Water fluoridation information on the World Wide Web is presented to the public indiscriminately and has been found to range from factual, to unsubstantiated opinion, to absolute deception. Although the overwhelming majority of scientific evidence supports the benefits of water fluoridation, members of the public who enter the term "water fluoridation" into any major search engine would immediately be presented with a disproportionate percentage of anti-fluoridation websites. Data derived from questionable scientific techniques also play a role in provoking opposition to fluoridation. It is important that the public, and particularly policy makers, are able to distinguish poor, unsubstantiated science from legitimate scientific research.

Some of the common tactics used by opponents of fluoridation are found in the table below:

Table 8: Tactics Used by Opponents of Fluoridation (6; 166)

| Tactic | Example |
|---|---|
| Targeting politicians, community leaders and editorial boards | Leaders are advised to remain neutral on the subject to relieve them of any responsibility in the matter while conducting public referendums that inundate the public with misinformation |
| Unproven claims | Fluoridation causes AIDS, Down Syndrome, cancer, heart disease, lowered intelligence, bone fractures, kidney disease, etc. |
| Denying the benefits of water fluoridation | Claims that fluoridation is either not effective or, at best, only minimally effective or that fluoride actually harms teeth, making them more susceptible to caries |
| Selective reporting of studies | Handpick studies; findings that do not support their viewpoint are disregarded |
| Selective reporting of results | Specific results within specific studies are reported while any disconfirming results are ignored |
| Downplaying or ignoring the scientific evidence | Dismissing differences in decay experience between fluoridated and non-fluoridated areas by inappropriately reporting effectiveness at the individual level rather than the effect at the population level |
| Innuendos | Subtly implying, in expression, fluoride as derogatory by linking water fluoridation to other medical and government sanctioned practices that have led to aversive and unexpected consequences (i.e. compare fluoride to lead and arsenic rather than other nutrients such as vitamins and minerals) |
| Paranoia, conspiracy theories and extremism | Claim that fluoridation is a communist plot to alter society, mass medication, part of a plot of the Illuminati, etc. |

Water fluoridation has endured over 60 years of scientific research. There has been continual monitoring of this scientific literature by the world's major national and international health organizations, committees of experts and special councils of governments. To date the results of these reviews reaffirm that water fluoridation, at the recommended level, is a safe and effective means of reducing dental decay and does not pose a risk for health problems.

Media Response

Even though water fluoridation is supported locally, nationally and internationally by the major medical, dental and health organizations for the prevention of tooth decay, there is still a small vocal minority who opposes fluoridation.

Opposition to water fluoridation exists for many shifting reasons. Some of these reasons are philosophical, such as the argument for freedom of choice, or environmental, economic and some are because opponents are simply misinformed.

Opposition towards the views of public health practitioners by minority groups is not restricted to the debate over water fluoridation. Parallels can be drawn with other public health controversies such as child immunizations or the use of genetically modified foods.

84. Is fluoridation a conspiracy?

No. Fluoridation is not a conspiracy, it is a recognized public health intervention implemented to reduce dental decay.

Opposition to fluoridation has existed since its inception in the 1940s. Arguments against fluoridation have remained relatively constant over the years however; opponents have used various approaches that play upon popular public concerns, including drawing on the distrust of experts and unease about medicine and science. A popular approach portrays fluoridation as a conspiracy among certain industries and the government. The following are common fluoride conspiracy theories:

Fluoride is a communist plot:

This argument holds that fluoridation was a plot to impose a socialist or communist regime. Those opposed to fluoridation claim that fluoride was instigated to make people docile and therefore amenable to defeat. This particular argument took place during the time of the initial fluoridation trials amidst an atmosphere of uncertainty. Following World War II, there was an overwhelming concern about security and the possibility of Communist subversion and water fluoridation was thought to be the channel by which the subversion would occur (7).

Carstairs and Elder wrote that opponents to fluoridation eventually stepped away from this argument because they realized that it was far-fetched and endorsement could harm their credibility (146).

Fluoridation is an aluminum company conspiracy:

This argument is based on the idea that aluminum companies use fluoridation as a way to get rid of sodium fluoride, a by-product of aluminum processing that is expensive to dispose of properly (146).

There is no evidence that aluminum companies have ever promoted fluoridation or that they have made money from producing fluorides to be used for water fluoridation.

Fluoridation is implemented by governments and scientists, and they cannot be trusted:

Another argument, related to others above, is that fluoridation is scheme devised by “elite” groups such as governments, scientists, and health professionals, and that these groups have ulterior motives and cannot be trusted to make appropriate decisions. This position is rooted in suspicion of large organizations, including medical and dental professions, as well as large corporations.

A vast body of scientific evidence endorses water fluoridation as safe and effective for the purpose of reducing the incidence of dental decay. Support for fluoridation among scientists and health professionals continue, with over 60 years of practical experience. Claims to the contrary are misleading because they evade the systematic reviews and the most important evidence.

Media Response

Fluoridation is not a conspiracy but rather a recognized public health intervention implemented to reduce dental decay. A vast body of scientific evidence endorses water fluoridation as safe and effective for the purpose of reducing the incidence of dental decay. Support for fluoridation among scientists and health professionals continue, with over 60 years of practical experience. Claims to the contrary are misleading because they evade the systematic reviews and the most important evidence.

Appendix

The following is a list of 18 reviews concerning water fluoridation since 1997:

1. **Health Canada.** *Findings and Recommendations of the Fluoride Expert Panel (January 2007).* 2008.
2. **McDonagh, M S, et al.** *Systematic review of water fluoridation.* Br Med J 2000, 321: 855-859.
3. **Government of Ireland.** *Forum on Fluoridation.* Dublin, Ireland: Stationery Office, Government Publications, 2002.
4. **National Health and Medical Research Council.** *Review of Water Fluoridation and Fluoride Intake from Discretionary Fluoride Supplements.* Melbourne, Australia: NHMRC, 1999.
5. **National Health and Medical Research Council.** *A Systematic Review of the Efficacy and Safety of Fluoridation, Part A: Review Methodology and Results.* Australian Government, 2007.
6. **Health Canada.** *Guidelines for Canadian Drinking Water Quality: Fluoride Guideline Technical Document.* Environmental and Workplace Health, Prepared by the Federal-Provincial-Territorial Committee on Health and the Environment. December 2010.
7. **Whiting, P, McDonagh, M and Kleijnen, J.** *Association of Down's syndrome and water fluoride level: a systematic review of the evidence.* BMC Public Health 2001, 1(1): 6.
8. **Truman, B I, et al.** *Reviews of evidence on interventions to prevent dental caries, oral and pharyngeal cancers, and sports-related craniofacial injuries.* Am J Prev Med 2002, 23(Suppl 1): 21S-54S.
9. **National Research Council.** *Fluoride in Drinking Water: A Scientific Review of EPA's Standards Committee on Fluoride in Drinking Water, Board on Environmental Studies and Toxicology.* Washington, D.C.: National Academy Press, 2006.
10. **Locker D.** *Benefits and Risks of Water Fluoridation: An Update of the 1996 Federal-Provincial Sub-committee Report.* Community Dental Health Services Research Unit Faculty of Dentistry, University of Toronto, November 1999.
11. **Scientific Panel on Dietetic Products, Nutrition and Allergies.** *Opinion of the Scientific Panel on Dietetic Products, Nutrition and Allergies on a request from the commission related to the tolerable upper intake level of fluoride (request no. EFSA-Q-2003-018).* Scientific Panel on Dietetic Products, Nutrition and Allergies, 2005.

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- 15. Centers for Disease Control and Prevention.** *Recommendations for using fluoride to prevent and control dental caries in the United States.* MMWR 2001; 50(RR14):1-42.
- 16. Calgary Regional Health Authority Expert Panel for Water Fluoridation Review.** *Report of the Expert Panel for Water Fluoridation Review.* Calgary Regional Health Authority, 1998.
- 17. Fort Collins Fluoride Technical Study Group.** *Report of the Fort Collins Fluoride Technical Study Group.* Fort Collins, Colorado, April 2003. [Cited: November 6, 2011.]
<http://www.healthdistrict.org/fluoridereport/FTSG.htm>
- 18. Levy M and Corbeil, F.** (2007) *Water Fluoridation: An Analysis of the Heath Benefits and Risks.* Institut National de Sante Publique Du Quebec, 2007. [Cited: November 6, 2011.]
<http://www.inspq.qc.ca/pdf/publications/705-WaterFluoration.pdf>

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2. **Health Canada.** Fluoride in Drinking Water. *Environmental and Workplace Health.* [Online] 06 24, 2011. [Cited: July 22, 2011.] http://www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/health-sante/faq_fluoride-fluorure-eng.php.
3. **Centers for Disease Control and Prevention.** Fluoridation Additives: FAQs. *Community Water Fluoridation.* [Online] November 17, 2010. [Cited: June 24, 2011.] <http://www.cdc.gov/fluoridation/engineering/faqs.htm#1>.
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22. **Griffin, SO, et al.** *Effectiveness of fluoride in preventing caries in adults.* J Dent Res 2007; 86(5): 410-5.
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