



STAFF REPORT ACTION REQUIRED

Water Fluoridation in Toronto

Date:	March 21, 2011
To:	Toronto Board of Health
From:	Medical Officer of Health
Wards:	All
Reference Number:	

SUMMARY

Toronto's drinking water has been fluoridated since 1963. This report provides information on the regulatory framework for water fluoridation in Canada and Ontario, an overview of the effects of fluoride on reducing dental caries, a discussion about the safety and concerns with water fluoridation as well as an examination of the viability of alternate fluoride delivery methods.

Water fluoridation continues to be supported provincially, nationally and internationally as being the most cost-effective and equitable strategy for the prevention of dental caries. Discontinuing the fluoridation of Toronto water would reduce the oral health status of Torontonians and will result in increased costs for treatment of dental disease.

RECOMMENDATIONS

The Medical Officer of Health recommends that:

1. The Board of Health reaffirm its position to continue the fluoridation of Toronto water.

DECISION HISTORY

At its meeting on May 14, 2007, the Board of Health considered the report "Fluoridation of Toronto Tap Water", which contained information about the safety, effectiveness and economic benefits of fluoridation of Toronto's water supply. Based on the information provided, the BOH did not propose any changes to the status of Toronto community

water fluoridation. A communication from Councillor Frances Nunziata dated January 14, 2011 requested the Board of Health to invite The Toronto Coalition Against Fluoridation to a future meeting of the Board. This matter was referred to the Medical Officer of Health for a report.

ISSUE BACKGROUND

Fluorides are minerals found naturally in rocks, soil and water. In the early 1900s it was discovered that people in communities with naturally high fluoride content in their water, had low levels of tooth decay. Subsequently, studies were conducted that confirmed the effect of fluoridated water in preventing tooth decay. Community water fluoridation, the practice of adjusting the level of fluoride in potable drinking water to maximize its benefit to oral health, has been practiced for over 60 years in many jurisdictions around the world.

Water fluoridation has been studied extensively by major scientific and professional bodies and continues to be reviewed to this day. To date, the overwhelming body of evidence attests to the effectiveness and safety of this public health measure. The effectiveness of community water fluoridation in reducing the prevalence of dental decay has been endorsed by more than 100 national and international dental, allied health and other organizations. These include, but are not limited to:

Table 1. Organisations supporting water fluoridation to reduce occurrence of tooth decay

Canadian	International
Health Canada	World Health Organization (WHO)
Canadian Medical Association	Centers for Disease Control and Prevention, USA
Ontario Medical Association	Pan American Health Organization
Canadian Public Health Association	European Organization for Caries Research
Canadian Paediatric Society	American Dental Association
Association of Local Public Health Agencies, Ontario	British Medical Association
Ontario Dental Association	British Dental Association
Canadian Dental Hygienists Association	Australian Dental Association

Fluoride has been used internationally in many different ways to prevent tooth decay e.g. fluoridated milk and salt, fluoride tablets, fluoridated tooth paste, gels, mouth rinses.

Scientific and governmental bodies continually monitor the availability of fluoride in various forms and the effects of fluoride use on the population. In Canada, at the national level, Health Canada periodically reviews all current scientific literature to recommend the optimal level of fluoride in water and to set drinking water guidelines in concert with the provinces and territories.

According to the current guideline by Health Canada, the maximum acceptable concentration (MAC) for fluoride in drinking water is 1.5 mg/L. A new guideline document is at the final stages of approval and will be released in spring 2011; the current draft reaffirms this level (1). Current legislative standards in the Ontario Drinking Water Quality Standards regulation, under the Safe Drinking Water Act, also set out safety

standards for the maximum allowable concentration of fluoride in drinking water as 1.5mg/L (2).

In 2007, Health Canada's fluoride Expert Panel recommended the adoption of a level of 0.7 mg/L as the optimal target concentration for fluoride in drinking water. This concentration prevents excessive intake of fluoride through multiple sources of exposure (3). In Canada, 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. Following changes at the national level, the Ontario Ministry of the Environment (MOE) lowered the fluoride level standard in 2000, from 1.0–1.2 mg/L to 0.5–0.8 mg/L (4). The level of fluoride in Toronto water was reduced from 1.2 mg/L to 0.8 mg/L in 1999 and then to 0.6 mg/L in 2005. Therefore the City of Toronto is in compliance with the Federal and Provincial standards for safe drinking water, as presently defined. At 0.6 mg/L, the drinking water of Toronto actually has a lower level of fluoride than that which naturally occurs in some parts of Ontario, e.g. Stratford (1.4 to 2.1 mg/L), St. Pauls (1.59 mg/L), Mitchell (1.93 mg/L), Sebringville (2.76 mg/L), and St. Mary's (1 mg/L).

According to Ontario's Fluoridation Act (5), the fluoridation or defluoridation of a municipal drinking water supply is a decision made by local municipalities in collaboration with the appropriate provincial authority. Under the Ontario Public Health Standards (OPHS)^a, the Protocol for the Monitoring of Community Water Fluoride Levels (6) requires specific action from boards of health if the water fluoride levels fluctuate above or below the range of 0.5 - 0.8 mg/L, for more than 90 days. This protocol includes provision of fluoride alternatives to segments of the population at high risk for dental caries when water fluoride levels fall below 0.5mg/L.

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 changing reasons. Concerns expressed have included: adverse health effects; cost; issues regarding the addition of substances to water without individual consent; effectiveness of fluoride in reducing dental decay; and necessity, when fluoride is available from other sources such as toothpaste and mouth rinses.

Several municipalities have revisited the practice of water fluoridation. Some jurisdictions decided to discontinue water fluoridation while others continued the practice. By referendum, Waterloo (November 2010) decided to discontinue water fluoridation by the very slim margin of 50.3% to 49.7%. Calgary City Council also voted to discontinue water fluoridation (February 2011). Ontario cities that have formally decided to maintain water fluoridation include Hamilton (2008, council decision) and London (February 2011, council decision).

^a The Ontario Public Health Standards are the minimum requirements for public health services, set by the Minister of Health and Long-Term Care under the Health Protection and Promotion Act.

In the United States, currently 70% of the population has access to fluoridated water. This percentage is increasing as the city of San Diego started water fluoridation in February 2011(7) and the state of Arkansas legislated water fluoridation effective March 4, 2011 (8).

COMMENTS

1. What is fluoride?

a. Fluoride occurs naturally in water

Fluoride salts are minerals found in rocks and soil. When water flows over rocks and soil, it dissolves the fluoride compounds. As a result, most water supplies (both fresh and salt) contain some naturally occurring fluoride. Sea water contains 1.2 to 1.5 mg/L of fluoride (9), while fresh water in Canada contains 0.01 to 11 mg/L (10, 11). According to routine tests conducted by Toronto Water, the level of fluoride in Lake Ontario is within the range of 0.12 to 0.17 mg/L. Testing and documentation over the past 25 years has indicated that this has remained constant. Lake Ontario is the principal source of water supply for Toronto. Water sources in several Ontario communities have naturally high fluoride levels, considerably above those of treated Toronto water.

b. Discovery of dental benefits

In the 1920s and 1930s it was discovered through observation, that there was a correlation between fluoride levels in the water and incidence of dental decay (12). In 1940, four community studies were conducted to examine the effect on dental health of adding sodium fluoride to fluoride deficient water supplies. The results of these studies confirmed that fluoridation is a practical and safe public health measure for the prevention of tooth decay. Since that time, fluoridation has been the subject of numerous additional studies.

c. Mode of action of fluoride

Fluoride works both topically and systemically to prevent tooth decay by increasing the resistance of tooth enamel to decay.

Systemic

The systemic effect of fluoride occurs when fluoride is ingested during the formation of teeth. The fluoride becomes incorporated into the structures throughout the tooth surface and provides long lasting protection against tooth decay (13). The major source of systemic fluoride is fluoridated water. As a substitute for water fluoridation, fluoride can be given systemically by adding it to salt (e.g. jurisdictions in Germany, France, Mexico, Jamaica), milk (jurisdictions in Chile, UK, Thailand) or as a supplement.

Topical

Topical fluorides are applied after the teeth are already present in the mouth. The fluoride is incorporated into the surface of the teeth making them more resistant to tooth decay. The major source of topical fluoride is toothpaste, professionally applied

fluoride foams, gels and varnishes. It should be noted that systemic fluoride also provides protection topically, as low levels of fluoride present in saliva and in plaque (a film covering the teeth) can also prevent and reverse the process of dental decay.

The maximum protection from tooth decay is realised when fluoride is available both systemically and topically. Water fluoridation provides both a systemic and topical source of fluoride for protection against tooth decay.

2. Effectiveness of fluoridation in reducing dental caries

The effectiveness of fluoride in reducing caries has been studied for many years, in many jurisdictions internationally. These studies have shown that fluoride is an effective preventive agent to reduce the incidence of dental caries in various populations. Opponents of water fluoridation often question the evidence that confirms the effectiveness of water fluoridation.

a. Scientific evidence for determining the effectiveness of water fluoridation

Dental health and the impact of water fluoridation on it may vary between communities for a number of reasons, including underlying dental health, naturally occurring fluoride levels in local water sources, socioeconomic status, access to dental care, and nutrition. For this reason, the results of individual studies of the impact of water fluoridation can be challenging to interpret.

The situation is further complicated by the fact that fluoridating the water in one community can benefit neighbouring communities in what is called the "halo" or "diffusion" effect. This happens through the use of fluoridated water in food/drink processing or by patterns of commuting or change of residence. Therefore comparisons between the oral health of residents of neighbouring communities when one community is fluoridated and one is not, may underestimate the effect of water fluoridation. One study which quantified this effect found that children residing in non-fluoridated areas with minimum halo effect had higher decay rates than children living in fluoridated communities or children living in non fluoridated areas with a high halo effect (20).

One consequence of this halo effect is that since Toronto is the major economic hub and food and beverage processing centre for Southern Ontario, people from neighbouring municipalities also benefit from fluoridation of its water.

For all of these reasons, the most appropriate way to assess the population health impacts of water fluoridation is to examine multiple studies conducted in different populations over time using standardized scientific. This methodology of assessing health interventions for populations is called a systematic review.

In order to arrive at conclusions from a systematic review, results from many studies for the same health measure are analyzed by an expert group using rigorous scientific

methods and criteria. The effectiveness and safety of water fluoridation have been confirmed by many large systematic reviews (11, 14, 15, 16, 17,18,19) including those by the Australian National Health and Medical Research Council, 2007; UK University of York, 2000; and US Centers for Disease Control and Prevention, 2002.

b. Caries reducing benefit

The existing body of evidence confirms that water fluoridation continues to be beneficial for reducing dental caries. Systematic reviews show that the introduction of water fluoridation into an area significantly increases the proportion of caries-free children. Mean decay rates also decrease compared with areas which were non-fluoridated over the same time period. Overall, these comparisons show a reduced prevalence of dental caries in the range of 18-40 % when water fluoridation is implemented (21).

The findings of systematic reviews also suggest that tooth decay increases in a population after fluoridation is discontinued. Several studies published since 1999 have shown that stopping water fluoridation in a community generally results in an increased prevalence of dental caries (15, 21, 22).

c. Population level impacts

Although the occurrence of tooth decay is decreasing among children in industrialised countries as a result of many factors, the World Health Organisation states that water fluoridation is the safest, most economical and most effective means of preventing and controlling tooth decay on a population level (23). While the majority of studies examined the effect of water fluoridation on the dental health of children, a small body of reliable, high quality scientific studies have also established that adults and seniors benefit from this measure (15, 21, 24).

Most people who reside in industrialized countries for most of their lifetime, age with all or most of their teeth due to increased access to preventive dental care and better information on the deleterious effects of refined sugars. Fluoridation, in all its methods of application, has contributed to this.

Research also shows that the benefits of water fluoridation are greater for disadvantaged sectors of the population who are most difficult to reach with conventional preventive health services (25, 26, 27, 28). Low income residents and recent immigrants are often the least likely to receive the benefits of fluoride through other delivery mechanisms, such as attending a dental care provider's office for topical application of fluoride. It should be recognized that seniors, who often do not have third party dental insurance, also benefit from water fluoridation. Seniors are vulnerable to tooth decay, in particular root decay. Given that all population groups benefit, water fluoridation is an equitable prevention strategy.

d. Canadian impact

Before water fluoridation in Toronto, children used to get on average 5-7 decayed teeth. Today, Toronto children on average get 1-2 decayed teeth. In fact, in most

upper and middle income families many children do not have cavities for most of their childhood. This improvement in dental health cannot be solely attributed to water fluoridation, but it has been a contributing factor.

Surveillance of dental decay rates in Ontario and other areas of Canada indicate that tooth decay rates are generally higher in non-fluoridated communities and that decay rates increase after the cessation of fluoridation. The following are examples of recent studies.

As presented in the Saskatchewan Dental Health Screening Program 2008-2009 Report, dental health disparities were noted between children attending schools in communities with water fluoridation and those in schools without access to community water fluoridation (29). The average 'deft/DMFT'^b per child attending schools in communities with water fluoridation was 1.61 compared to 2.48 per child attending schools in non water fluoridated communities. The caries-free proportion of children attending schools in communities with water fluoridation was 58.1% as compared to 43.9% for children attending schools in communities without water fluoridation. The differences in oral health between children living in Saskatoon and Regina are noteworthy. The average decay rate in Saskatoon which is fluoridated was 2.36 (teeth) compared to 3.24 in Regina which is non-fluoridated. Regina also had a higher percentage of children with cavities (33.5%) as compared to Saskatoon (19.2%). The occurrence of early childhood tooth decay, a severe form of tooth decay in children under the age of 5, was higher (10.3%) among Regina's school children than in Saskatoon (5.9%).

However, a 2007 Greater Toronto Area study did not show any significant difference in the oral health of neighbouring communities, one which was fluoridated and one which was not. In Brampton, Ontario which has fluoridated water, 64% of children were caries free compared to 61% caries free children in neighbouring Caledon, which is not fluoridated (30). Possible explanations for these findings include the halo effect from neighbouring fluoridated communities, and the higher socioeconomic status of Caledon residents compared with Brampton. This is an example of the complexity of interpreting the findings of individual studies.

At a national level, using the Canadian Health Measures Survey (CHMS) 2007-2009, comparisons were made between the caries rates among school children in Ontario and Quebec. About 7% of the population in Quebec receives fluoridated water as compared to Ontario's 70%. Six year-olds in Quebec had 27% more tooth decay than six year olds in Ontario. In the 12-19 years age group, the Quebec children had 20 % more caries than in Ontario, even though Quebec has a dental program for children.

Using data obtained from the British Columbia (BC) Adult Dental Health Survey (ADHS) in 2010, adults showed between 29% to 44% higher tooth decay than adults

^b Deft and DMFT are names of indexes used to measure tooth decay: "deft" is for baby teeth and represents decayed, exfoliated/extracted, filled teeth. The "DMFT" stands for adult teeth and the "M" is for missing teeth. Adult teeth are not expected to exfoliate. +

in Ontario. About 4% of the population in BC has access to fluoridated water compared to 70% in Ontario (31).

The Ontario municipality of Dryden discontinued fluoridation in 2001. The provincially mandated dental survey of elementary school children showed that, in Dryden, the caries level of 5 year olds increased by 26% from 2001 to 2008 (32).

3. Safety of fluoridation

a. General Health Effects

One of the concerns frequently raised about water fluoridation is whether the chemical used to fluoridate water is toxic. Toxicity of any substance is typically related to the level of exposure or dose (the amount ingested over a period of time). Even substances essential for life like water, oxygen, and salt can be toxic in excess amounts. In concentrations used for water fluoridation (0.6mg/L, for Toronto), fluoride is not toxic or harmful. 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 cavities in teeth. It is widely recognized that the ingestion of fluoride in low concentrations is good for teeth, but the regular ingestion of excessive amounts of fluoride can lead to debilitating skeletal fluorosis. The World Health Organization has studied certain areas in China, Central Asia and Africa with very high levels of naturally occurring fluoride in the water, and documented elevated levels of skeletal fluorosis (33). For example, a study conducted in 16 large farms, villages and towns in the Ethiopian Rift Valley between 1977 and 1985 found that the fluoride level of drinking-water collected from wells there ranged from 1.2 to 36.0 mg/L.

The following table shows the amount of optimally fluoridate water that would have to be ingested on a regular basis to produce toxic effects.

Table 2. Exposure to fluoride and associated toxic effects with examples

Exposure	Example for intake of quantity of optimally fluoridated water (0.6mg/L)	Impact
=2 mg/L	Child (under the age of 8 years) consumes 17 ^c glasses of water daily for a prolonged period	Mild dental fluorosis
=8 mg/L	Child or adult consumes 67 glasses daily for a prolonged period	Skeletal fluorosis
=16 mg oral/kg body weight	A 20 kg child will have to drink 2666 glasses of water (about 140 jugs of orange juice of 128 Ounces each) at one sitting	Acute lethal dose (child)
2,500-10,000 mg oral	An adult male would need to consume at least 4167 litres of water (about 28 bath tubs) that is fluoridated at optimum levels continuously in one sitting	Acute lethal dose (adult)

Adapted from UK Medical Research Council Report, 2002

^c According to the UK Medical Research Council 2002 report, daily intake of water containing 2ppm fluoride or greater can cause mild dental fluorosis. One litre of water makes five glasses with 200 ml each. At 0.6mg fluoride/L, it would take 16.6 glasses or more per day to ingest 2mg/L fluoride per day.

The scientific community continues to gather evidence to determine safe levels of fluoride in water and other sources that provide effective prevention against tooth decay with minimum health risks. In addition studies have been done to examine the total effect of fluoride from many sources so that appropriate adjustments can be made to the concentration of fluoride in drinking water.

Other effects of water fluoridation on health have been studied. These studies include impacts on blood, bone, kidney, liver, lungs, reproduction, and on prevalence and causal relationship to cancer (11, 12, 15, 17, 18, 19, 34). The results of Canadian and international studies confirm that water fluoridated at optimum levels does not cause adverse health effects.

The reviews of the US Public Health Service (1991) and the National Research Council (NRC, 1993 and 2006), report no toxic health effects associated with fluoride concentrations recommended to prevent tooth decay (18, 35, 36). Two other systematic reviews of the scientific literature, one published in Australia in 1999 (22), the other in the United Kingdom in 2000, came to the same conclusions (15).

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. This level is significantly higher than the current level of fluoride in Toronto water, 0.6mg/L. Research also does not support a link between fluoride exposure and intelligence quotient (IQ) deficit. Fluoride does not disrupt endocrine or human biological enzyme activity (37). Specifically fluoride is not associated with senile dementia, age of menarche, anemia of pregnancy, Sudden Infant Death Syndrome (SIDS), birth defects, Down's Syndrome, or effects on the pineal gland. The scientific literature does not support links between fluoride and problems with the male or female reproductive system even in naturally high fluoride areas. It does not affect fertility or birth rates. There were no changes in mortality rates from heart disease, intracranial lesions, nephritis, or cirrhosis of liver that have been associated with water fluoridation (30).

b. Dental and skeletal fluorosis

Of all the potential adverse effects of fluoride, dental and skeletal fluorosis – impact on teeth and bone structure – are the best documented. These effects are most common in areas where natural levels of fluoride in water are very high and considerably more than the concentration of fluoride in drinking water which is adjusted for preventing tooth decay.

Dental fluorosis

Prolonged ingestion of fluoride during tooth formation can lead to tooth discoloration, which in most cases occurs in the mild form. The mild form of dental fluorosis manifests as slight, whitish spots that are barely visible and tend to fade over time.

The risk of developing dental fluorosis is greatest up to the age of 6-8 years depending on the stage of tooth formation. Other causes, such as exposure to amoxicillin^d at an early age, can have a similar effect on tooth appearance (17). Mild or very mild fluorosis is hard to detect by the untrained eye, but moderate fluorosis, caused by the ingestion of even larger quantities of fluoride during tooth formation, does affect tooth appearance (18). Children aged 8 years and younger exposed to excessive amounts of fluoride have an increased chance of developing moderate or severe fluorosis in the form of pits in the tooth enamel, along with brown stains on teeth. In Canada, very few cases of moderate or severe fluorosis have been diagnosed. However, these cases were primarily found in individuals who migrated from other areas of the world where there are high fluoride levels occurring naturally in the water.

Skeletal fluorosis

Recent scientific literature indicates that skeletal fluorosis is extremely rare in North America (18). According to the UK Medical Research Council skeletal fluorosis can occur after prolonged ingestion of water containing 8mg/L or more of fluoride. A recent US report states that studies currently available provide no evidence that long-term exposure, to water fluoride concentrations of 4 mg/L, carries a risk of skeletal fluorosis. This fluoride level of 4mg/L is the current maximum allowable concentration (MAC) of fluoride in drinking water in the US, compared to the much lower MAC of 1.5mg/L in Canada.

c. Bone fracture

The systematic review conducted in Australia in 2007 (11) analyzed results from three existing systematic reviews (15, 16, 38) and concluded that water fluoridation at levels aimed at preventing dental caries has little effect on fracture risk. They also did not uncover any association between hip fractures and water fluoridation.

d. Cancer

The existing systematic review by McDonagh et al (2000a) in the UK (15) concluded that there is no clear association between water fluoridation and overall cancer incidence or mortality (for 'all cause' cancer, and specifically for bone cancer and osteosarcoma). A number of expert committees have examined the link between fluoride and cancer. In 1991, the National Cancer Institute (NCI) conducted an exhaustive review of the US tumour registries and found no cancer risk attributable to fluoride in humans (39). In 1993, the National Research Council (NRC) presented a review of some fifty epidemiological studies on the relationship between drinking water fluoridation and cancer, including osteosarcoma. The NRC concluded that there was no proven link between cancer and the natural or artificial presence of fluoride in water (36). These findings are confirmed by the World Health Organization's International Agency for Research on Cancer (40). Two other expert committees in the United Kingdom (2000) and Australia (2007) examined, in considerable depth,

^d Amoxicillin is one of the most common antibiotic medications prescribed for children to treat common illnesses such as ear infections.

the link between fluoridation and cancer, including osteosarcoma. According to the reports of these committees, the current scientific knowledge on this subject does not establish a link between water fluoridation and cancer of any kind (11, 15).

4. Other issues and concerns

A number of other concerns have been raised with respect to water fluoridation.

a. Consent

Water fluoridation is one of several examples of public health measures where additives are used to achieve health benefits in a population. It is not feasible to obtain explicit individual informed consent for a population wide preventive intervention. The decision is usually made by appropriate policy makers (elected representatives or designates) who rely on best available evidence.

Other examples of additives used to achieve population wide health benefits include the following:

- Iodine is added to table salt to prevent thyroid disease
- Vitamin D is added to milk and juice to prevent rickets
- Folic acid is added to flour to prevent birth defects

Another example of a population wide health strategy is the chlorination of drinking water to prevent the spread of water borne diseases such as E.coli, cholera, and typhoid. The benefits of these population- wide prevention strategies are well known and recognised in today's society and have contributed to improved health and quality of life.

Adding vitamin C to foods to prevent scurvy has origins similar to those of water fluoridation. It was through observation of the effect of citrus foods on soldiers suffering from scurvy that the health benefit of vitamin C was ultimately discovered. Currently, vitamin C is also artificially manufactured and used for its health and other benefits.

b. Fluoridation in Europe

Fluoridation practices in Europe are sometimes contrasted with those in North America. There is no directive or legislation banning water fluoridation in Europe, and fluoridation practices are not consistent across the continent. Some countries have fluoridated water (i.e., parts of UK and Spain) while others use alternate delivery methods for fluoride such as salt fluoridation (e.g., Germany, France and Switzerland). In the summer of 2010, the European Union undertook a critical review of new evidence on the hazard profile, health effects, and human exposure to fluoride and the fluoridating agents of drinking water. The Scientific Committee on Health and Environmental Risks (EU) concluded that one advantage to water fluoridation is that caries prevention will reach disadvantaged children from lower socioeconomic groups (43).

They also concluded that the exposure of environmental organisms to levels of fluoride as used in the fluoridation of drinking water is not expected to lead to unacceptable risks for the environment.

c. Hydrofluorosilicic acid is an industrial waste product

Hydrofluorosilicic acid, the substance added to drinking water, is a by-product of the phosphate industry. It is not uncommon for by products of one industry to be used in other products of a different industry. For example there are numerous by products of the oil industry that are widely used in society e.g capsules for vitamins, food preservatives, antihistamines, toothpaste, to name a few.

The important issue is the safety of the product for its intended use. To this end, all treatment chemicals added to Toronto water are stringently controlled and rigorously monitored. Toronto Water uses only those chemicals that are certified by the National Sanitation Foundation (NSF) and the American National Standards Institute (ANSI) STANDARD 60 which deal with Health Effects of Drinking Water Treatment Chemicals. This standard applies to all chemicals added to drinking water by treatment plants. In order to meet the requirements of ANSI/NSF Standard 60, the chemicals must be tested in a recognized laboratory. Finally, according to a critical review done by the European Union, these compounds are rapidly and completely hydrolyzed to fluoride ion. No residual fluorosilicate intermediates have been reported (43).

d. Fluoride as a non-essential nutrient

In a recent report (2005), the WHO lists fluoride as one of the 14 minerals considered essential to good health (44). Prevention of chronic disease may be considered to be a factor in deciding nutrients essential for the body. Using this rationale, the Linus Pauling Institute for Micronutrient Research states that fluoride can be considered an essential trace element (45, 46). Due to its health benefits, the Institute of Medicine of the National Academies of Sciences also declared that fluoride was an important nutrient (47). A report by the U.S. Surgeon General in 2004 states that fluoride is a nutrient that is potentially beneficial for bones (48).

e. Reconstituting infant formula with fluoridated water

According to Health Canada, current scientific literature does not support a link between consumption of infant formula reconstituted with drinking water containing fluoride at the concentration in the drinking water in Toronto, and the risk of moderate/severe fluorosis (37). The critical period for fluorosis of the anterior permanent teeth is after the first twelve months of life (41, 42), by which time the majority of children have ceased exclusive infant formula consumption (13). In addition, the free fluoride available for absorption by the body in reconstituted infant formula is likely less than that available from drinking water (3). Moreover, 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.

5. Viability of providing fluoride through alternate delivery systems

The impact of discontinuing water fluoridation in a city with a population as diverse in so many ways as Toronto is unknown. In areas where water fluoridation was discontinued and there was no significant oral health impact, the population was generally homogeneous and access to dental care was not an issue or dental programs were introduced after the discontinuation of water fluoridation. In addition, other fluoride delivery methods e.g. salt/milk fluoridation, fluoride mouth rinsing in schools etc. were introduced.

If Toronto were to discontinue water fluoridation, then it would be incumbent on City Council to ensure that proper alternative measures are introduced to maintain the current oral health status of its residents. If this was not done then the consequences could be a gradual decline in the oral health status of Toronto population resulting in costly treatment for dental disease. The people who would be most negatively affected by removal of fluoride from Toronto water, without the availability of replacement preventive measures, are those at the low end of the socio economic scale. These are the people who can least afford to be further disadvantaged given the deleterious effect of untreated dental disease on nutrition, self esteem, employability and on general health and well being.

The cost and viability of alternate mechanisms for providing fluoride to populations need to be considered when examining the issue of defluoridation of Toronto water. The City of Hamilton (49) 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 results of this analysis are presented in the table below.

Table 3. Annual costs of alternate fluoride delivery approaches for City of Hamilton, 2008

Preventive measure	Annual Cost/person
Topical fluoride application twice per year to all high risk individuals by Public Health Services	\$44.5
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	\$8.5

The cost for these alternative approaches may be somewhat different for Toronto but data from Hamilton, a neighbouring municipality, can be used as a benchmark for planning purposes. The current cost of fluoridating Toronto water supply is \$0.77 per person as shown in Table 4 below.

Table 4. Current annual cost of fluoridating Toronto water

Total Estimated Chemical Cost	\$1.2 M per year
Estimated maintenance cost (Fluoridation systems, all costs)	\$0.7 M (approx.) per year
Total cost	\$1.9 M (approx.) per year
Cost per person	\$0.77

Water fluoridation is the most economical method to apply this preventive measure to reduce the burden of dental disease in the population.

Apart from the direct operational and capital costs of these alternate fluoride delivery mechanisms, the potential added cost for increased waste management needs to be considered. For instance, additional paper or plastic cups, gloves, masks, Styrofoam trays and applicator tips, used for these 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.

If water fluoridation is discontinued, public health and private dental practitioners would likely increase the frequency of topical fluoride application. The use of fluoridated tooth paste, supplements and rinses may also increase. Commonly available fluoride toothpastes contain about 1000-1455 ppm fluoride; mouth rinses contain about 225 ppm; and topical fluoride gels contain about 1000-5000 ppm of fluoride. This combined increase in fluoride use from both the private and public sectors would likely increase the fluoride concentration of water in Toronto sewer systems. Consequently, additional costs may be incurred to correct the presumably raised fluoride levels.

Based on this preliminary analysis it is reasonable to conclude that if the City of Toronto were to discontinue water fluoridation, costly investments would be required to maintain current levels of dental health and to mitigate the environmental impact of other fluoride delivery methods.

Conclusion

Based on the weight of credible scientific evidence for the safety and effectiveness of water fluoridation and the estimated increase in financial costs to maintain current levels of oral health in Toronto residents in the absence of water fluoridation, the Medical Officer of Health recommends that the Toronto Board Of Health reaffirm its position to continue fluoridating Toronto water at current levels.

CONTACT

Dr. Hazel Stewart
Director, Dental & Oral Health Services
Toronto Public Health
Tel: 416-392-0442
Fax: 416-392-0713
Email: hstewart@toronto.ca

SIGNATURE

Dr. David McKeown
Medical Officer of Health

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