Everyone Deserves Healthy Teeth Coalition

Members & Endorsers of Water Fluoridation

Coalition Partners

- Access Dental Plan
- African American Health Coalition
- African Partnership for Health
- African Women's Coalition
- Albina Head Start
- Asian Health & Service Center
- Asian Pacific American Network of Oregon (APANO)
- Capitol Dental Care
- Causa
- Center for Intercultural Organizing
- Central City Concern
- Children First for Oregon
- Coalition of Communities of Color
- Coalition of Community Health Clinics
- Component Dental Societies (17)
- Dental Foundation of Oregon
- Familias en Acción
- Friends of Creston Children's Dental Clinic
- Health Share of Oregon (Tri-County CCO)
- Kaiser Permanente Northwest
- Knowledge Universe
- Latino Network
- Legacy Health
- Lutheran Community Services Northwest
- Native American Youth Association (NAYA)
- Northwest Health Foundation
- Medical Teams International
- OEA Choice Trust
- OPAL Environmental Justice Oregon
- Oral Health Outreach
- Oregon Academy of Family Physicians
- Oregon Dental Association
- Oregon Dental Hygienists' Association
- Oregon Dental Services Companies
- Oregon Head Start
- Oregon Health & Science University
- Oregon Latino Health Coalition
- Oregon Latino Agenda for Action
- Oregon Medical Association
- Oregon Nurses Association
- Oregon Oral Health Coalition
- Oregon Pediatric Society
- Oregon Primary Care Association
- Oregon Public Health Association
- Oregon Public Health Institute
- Oregon School Nurses Association
- Oregon School-Based Health Care Network
- Pew Center on the States
- Philippine American Chamber of Commerce of Oregon
- Portland African American Leadership Forum
- Providence Health & Services - Oregon
- P:ear
- Regence BlueCross BlueShield of Oregon
- SEIU Local 49
- Urban League
- Upright Brewing Company
- Upstream Public Health
- Virginia Garcia Memorial Health Center
- Willamette Dental

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National & International Organizations Endorsing Water Fluoridation

- 100 Black Men Of America
- American Academy of Allergy, Asthma, and Immunology
- American Academy of Family Physicians
- American Academy of Pediatrics
- American Academy of Pediatric Dentistry
- American Association of Oral and Maxillofacial Surgeons
- American Association of Public Health Dentistry
- American Cancer Society
- American Council on Science and Health
- American Dental Association
- American Dental Education Association
- American Dental Hygienists' Association
- American Dietetic Association
- American Medical Association
- American Nurses Association
- American Osteopathic Association
- American Public Health Association
- American School Health Association
- American Society of Clinical Nutrition
- American Society of Dentistry for Children
- American Society for Nutritional Sciences
- Association of State and Territorial Health Officials
- Centers for Service in the Public Interest
- Centers for Disease Control and Prevention
- Children's Dental Health Project
- Head Start Bureau and Early Head Start
- Hispanic Dental Association
- Institute of Medicine
- International Association for Dental Research
- Indian Health Service
- National Academy of Sciences
- National Cancer Institute
- National Congress of Parents and Teachers
- National Consumers League
- National Council against Health Fraud
- National Down Syndrome Society
- National Institutes of Health
- National Health Council
- National Parent Teachers' Association
- Pew Center on the States
- The Institute for Science in Medicine
- The National Assembly on School-Based Health Care
- The Network for Public Health Law
- U.S. Public Health Service
- World Health Organization

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Contact: 971-258-1764

Benefits of Water Fluoridation

Public Health Benefits

Water fluoridation is the single most effective public health measure to prevent tooth decay. The Centers for Disease Control named the "fluoridation of drinking water" as one of "10 great public health achievements" of the 20th century[1].

What is Fluoride?

Fluoride is a mineral that exists naturally in nearly all water supplies. Fluoridation is the adjustment–either increasing or lowering–of the naturally occurring level of fluoride to the optimal level of 0.7 pmm[2].

How does fluoride work?

When fluoridated water is consumed while the bones and teeth are still growing, fluoride works in two ways:

- Fluoride mixes with saliva to reach the surface of the teeth, where acid from bacteria in the mouth can cause damage. Fluoride heals that damage and shields teeth from further decay.
- Fluoride is absorbed into the bloodstream through the stomach, and enters the teeth and bones. Fluoride combines with the phosphate and calcium to create a strong barrier to protect teeth from cavities. Fluoride makes teeth stronger and able to withstand the acid produced by bacteria found in the mouth[3].

What do the experts say?

American Academy of Family Physicians

"Fluoridation of public water supplies is a safe, economical, and effective measure to prevent dental caries." [4].

American Academy of Pediatrics

Water fluoridation is a cost-effective means of preventing dental caries, with the lifetime cost per person equaling less than the cost of 1 dental restoration. In short, fluoridated water is the cheapest and most effective way to deliver anti-caries benefits to communities[5].

Over 73% of the U.S. population drink fluoridated water, totalling more than 204 million residents*

* Calculations are based on U.S. residents connected to a community water system [6]

1 Centers for Disease Control. Achievements in public health, 1900-1999: Fluoridation of drinking water to prevent dental caries. MMWR Morb Mortal Wkly Rep. 1999;48:933-40.
2 Pew Center on the States. Water Fluoridation: Frequently Asked Questions. http://www.pewstates.org/research/analysis/water-fluoridation-frequently-asked-questions-85899379776
3 Pew Center on the States. . How Fluoride Works. http://www.ilikemyteeth.org/wp-content/uploads/2010/11/How-Fluoride-Works.pdf
4 http://www.aafp.org/online/en/home/clinical/clinicalrecs/guidelines/fluoridation.html
5 "Preventive Oral Health Intervention for Pediatricians," Pediatrics, Vol. 122, No. 6, December 2008, pp. 1387-1394
6 Centers for Disease Control. 2010 Water Fluoridation Statistics http://www.cdc.gov/fluoridation/statistics/2010stats.htm

Photos courtesy of imagery majestic / digitalart

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Oregon's Dental Health Crisis
Tooth Decay in Children

Tooth Decay / Rampant Decay

Tooth decay is the process that results in a cavity. It occurs when bacteria in the mouth make acids that eat away at a tooth. If not prevented or treated, tooth decay can cause pain, infection, and tooth loss. Rampant decay is defined as seven or more decayed teeth.

Consequences

Tooth decay is the most common childhood disease, affecting five times more children than asthma. Tooth decay among children is a major concern, often causing severe pain and infection, which in turn can affect a child's school attendance and success, nutrition, speech development, self-esteem, and general health[1].

The Dental Health Crisis Among Oregon Children

Worst in the Region

Oregon children suffer from higher rates of untreated tooth decay than all neighboring states. Over 35% of Oregon children have untreated decay compared to only 14.9% in Washington, and Oregon ranks near the bottom among all states for childhood oral health[2,3,4].

School Children Suffer

Children experiencing dental pain are likely to be distracted and unable to focus in class or on their homework. Dental decay is a leading cause of student absenteeism[5].

Getting Worse

The latest statewide survey shows untreated tooth decay increased 49% in Oregon from 2002 to 2007. More than one in three children are living with untreated decay, and one in five children suffer from rampant decay[6].

Dental Decay is Costly

Nearly one in six 2nd graders in Oregon have already had cavities in their permanent, 'adult' teeth. Decay in a permanent tooth requires a lifetime of re-treatment[7].

Dental disease accounts for 30% of all healthcare costs for children[8].

Decay is Preventable

There is no reason to accept dental decay. Prevention (education, dental exams, fluoride) is the most cost-effective response to end the pain, suffering, and expensive costs associated with cavities.

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1 Oregon Department of Human Services, 2007. Oregon Smile Survey 2007.
2 Centers for Disease Control. State Oral Health Profile. http://apps.nccd.cdc.gov/nohss/ByState.asp?StateID=41
3 Centers for Disease Control. State Oral Health Profile. http://apps.nccd.cdc.gov/nohss/ByState.asp?StateID=53
4 National Oral Health Surveillance System. http://apps.nccd.cdc.gov/nohss/IndicatorV.asp?Indicator=3
5 S. Blumenshine et al., "Children's School Performance: Impact of General and Oral Health," Journal of Public Health Dentistry 68 (2008): 82–87
6 Oregon Department of Human Services, 2007. Oregon Smile Survey 2007.
7 Data and Analysis Center (DAC)
8 United States Department of Health and Human Services. (2000). Oral health in America: A report of the Surgeon General. Rockville, MD: NIH.

Photo Courtesy of capl@washjeff.edu at freedigitalphotos.net

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Oregon's Dental Health Crisis

Health Disparities Among Low-Income Communities

A Window to Overall Health

Dental health is intimately linked to overall health. Poor dental health contributes to heart disease and diabetes, and it adversely affects speech and self-esteem. Dental decay prevents educational success and future employment opportunities.

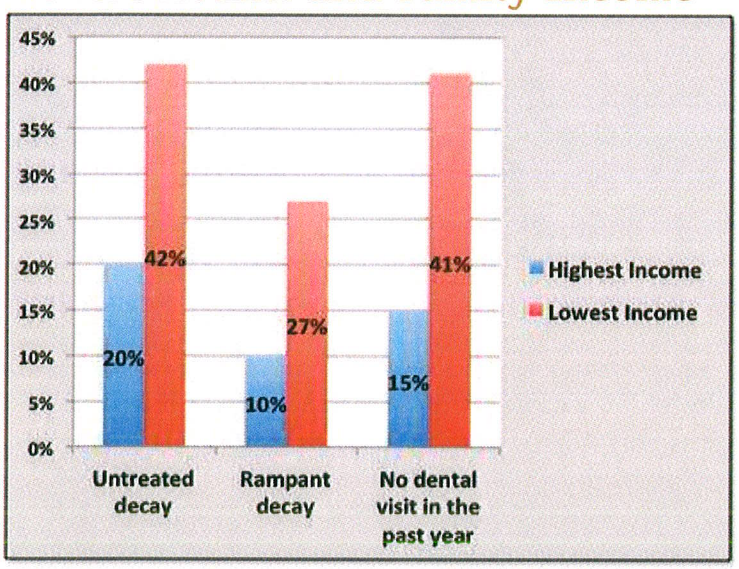
Dental decay disproportionately affects low-income populations

- Tooth decay is closely tied to socioeconomic levels, with children from low-income families more likely to develop cavities. Preschoolers in households with incomes less than 100% of the federal poverty level (FPL) are three to five times more likely to have cavities than children from families with incomes equal to or above 300% of the FPL[1].
- Low-income children miss 12 times more school days due to dental disease than children from higher income families[2].

True Cost of a Cavity

A ten-year old child who develops cavities will pay more than $2,000 over a lifetime to take care of the decayed tooth[3].

Dental Health and Family Income



Graph data courtesy of Oregon Department of Human Services, 2007. Oregon Smile Survey 2007.

Less Access, Higher Decay

- Children living in low-income families have twice the untreated decay as their more affluent peers[4].
- Nearly 1 in 3 children living in low-income families in Oregon currently suffer from rampant decay (seven or more teeth with past or present decay)[5].
- Children living in low-income families are significantly less likely to visit a dentist, resulting in higher rates of untreated and rampant decay[6].

1 Vargas C, Crall J, Schneider D. Sociodemographic distribution of pediatric dental caries: NHANES III, 1988- 1994. J Am Dent Assoc. 1998; 129:1229-1238.
2 Department of Health and Human Services. Oral Health in America: A Report of the Surgeon General – Executive Summary. (2000).
3 Data and Analysis Center (DAC)- cited by Northeast Delta Dental
4 Eberhardt MS, Ingram DD, Makuc DM, et al. Urban and Rural Health Chartbook. Health, United States, 2001. Hyattsville, Maryland
5 Oregon Department of Human Services (DHS) Oregon Smile Survey 2007
6 Ibid.

Photo Courtesy of healingdream at freedigitalphotos.net

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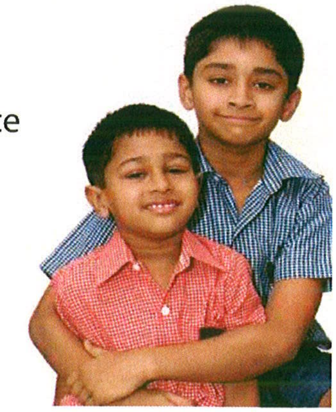
Oregon's Dental Health Crisis
Health Disparities among Communities of Color

A Window to Overall Health

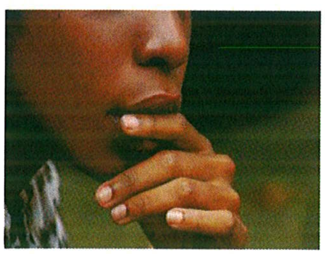
Dental health is intimately linked to overall health. Poor dental health contributes to heart disease and diabetes, and it adversely affects speech and self-esteem. Dental decay prevents educational success and limits future employment opportunities.

Latino Community



- A national survey found that employed Hispanic adults were twice as likely to have untreated dental cavities as Whites[1].
- 46% of Oregon Latino children have untreated dental decay, as compared to 34% of their Whites counterparts[2].
- Mexican American toddlers are more likely to have experienced dental cavities in their primary teeth, more decay and fillings, and more untreated decay than White children[3].

African American/ Black Community



- African Americans of all ages have substantially higher rates of untreated decay than Whites[4].
- African Americans ages 35-44 have almost double the rate of tooth decay as Whites[5].
- African American males have the highest incidence rate of cavities in the U.S., compared with women and other racial/ethnic groups[6].

Native American Community

- The odds of Native American preschoolers having tooth decay is five times greater than other ethnic/racial groups[7].
- Native American teens have more than double the amount of permanent-tooth decay as their peers (68% compared to 24%)[8].
- 72% of six to eight year old Native Americans have untreated cavities[9].

1 U.S Department of Health and Human Services, Office of Minority Health. Based on Healthy People 2010 baseline data
2 Ibid.
3 U.S Department of Health and Human Services, Office of Minority Health. Based on Healthy People 2010 baseline data
4 Ibid.
5 Ibid
6 Ibid.
7 Ibid.
8 Children's Dental Health Project.CDHP Feact Sheet: Native American Child Oral Health
9 The Pew Center on the States 2010 report: The Cost of Delay: State Dental Policies Fail One in Five Children. http://www.pewtrusts.org/our_work_report_detail.aspx?id=57447

Photos Courtesy of Arvind Balaraman/africa/Sujin Jetkasettakorn

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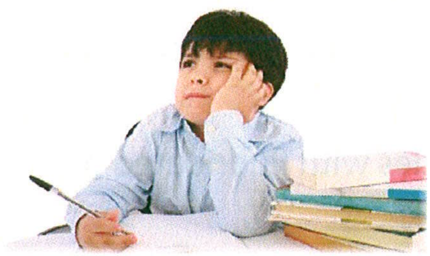
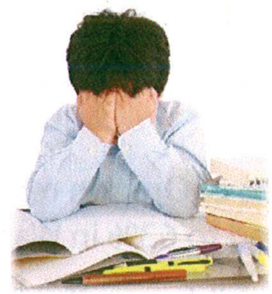
Oregon Children Dental Crisis

Dental Health & Student Achievement





Problem

Tooth decay is the number one chronic disease in childhood and is a leading cause of absenteeism[1,2].

Impact

- An estimated 51 million school hours are lost each year due to dental-related illness. Disparities in dental health contribute to higher absenteeism among low-income children[3].
- One study found that California children missed 874,000 schools days in 2007 due to toothaches or other dental problems[4].
- A 2008 study in North Carolina found that children with both poor oral and general health were 2.3 times more likely to perform poorly in school than their healthier peers[5].

Disparities among low-income and communities of color

Pain and suffering due to untreated diseases can lead to problems in eating, speaking, and learning. Poor children suffer nearly 12 times more school days than children from higher-income families[6].

Dental decay causes school absenteeism

In a school survey of Native American school children, one-third of children reported missing school because of dental pain[7].

1 Healthy People: 2010. Html version hosted on Healthy People.gov website.
2 S. Blumenshine et al., "Children's School Performance: Impact of General and Oral Health," Journal of Public Health Dentistry 68 (2008): 82–87
3 Gift, H.C. 1997. Oral health outcomes research: Challenges and opportunities. In Measuring Oral Health and Quality of Life, ed. G.D. Slade, 25–46. Chapel Hill, NC: Department of Dental Ecology, University of North Carolina.
4 Pew Center on the State
5 S. Blumenshine et al., "Children's School Performance: Impact of General and Oral Health," Journal of Public Health Dentistry 68 (2008): 82–87
6 Department of Health and Human Services. Oral Health in America: A Report of the Surgeon General -- Executive Summary. (2000).
7 Chen, M., R.M. Andersen, D.E. Barnes, M.H. Leclercq and C.S. Lyttle. 1997. Comparing Oral Health Care Systems: A Second International Collaborative Study. Geneva, Switzerland: World Health Organization.

Photo Courtesy of David Castillo Dominici / digitalart at freedigitalphotos.net

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Dental Crisis Policy Solution
Water Fluoridation

The need for policy change in Oregon

- Oregon is 48th of 50 states for percent of the population with access to fluoridated water[1].
- Only 27% of Oregon residents live in communities with fluoridated water, compared to 63% in Washington[2].
- Oregon children suffer from higher rates of untreated tooth decay than children in all neighboring states. Over 35% of Oregon children have untreated decay compared to only 14.9% in Washington[3,4].

Solution: Water fluoridation reduces cavities by 30%

- Today, studies prove water fluoridation continues to be effective in reducing tooth decay by 30%, even in an era with widespread availability of fluoride from other sources, such as fluoride toothpaste[5].
- Water fluoridation is the most cost-effective way to prevent tooth decay and reduce medical costs among all residents, young and old. Cities save an estimated $38 in dental costs for every $1 invested in fluoridation[6].
- A Texas study confirmed that the state saved $24 per child, per year in Medicaid expenditures due to cavities that were prevented by drinking fluoridated water[7].

National youth & student focused organizations that publicly endorse water fluoridation

- National Parent Teachers' Association
- Head Start Bureau and Early Head Start
- American School Health Association
- National Congress of Parents and Teachers
- American Academy of Pediatrics
- American Academy of Pediatric Dentistry
- American Society of Dentistry for Children

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Oregon's Dental Health Crisis

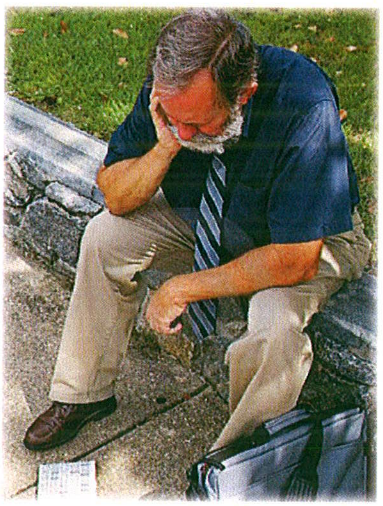
The Economic Impact of Dental Decay

True Cost of a Cavity

A ten-year old child who develops cavities will pay more than $2,000 over a lifetime to take care of the decayed tooth[1].

Missed School Days = Missed Opportunities to Learn

One study found that California children missed 874,000 schools days in 2007 due to toothaches or other dental problems. The goal of creating an educated workforce is undermined when health issues interfere with schooling[2].



Decreased Employment Opportunities

- Adults who had poor dental health as kids find it harder to find a good job. Research confirms that people who are missing front teeth are viewed as less intelligent, less trustworthy, and less desirable than people without a gap in their smile[3].
- Adults who received inadequate dental care as kids often miss work dealing with the consequences of dental decay[4].
- Nationally, an estimated 164 million hours of work are missed each year because of dental problems[5].

Economic Impact on Women

- According to a 2008 study by Columbia University, women who resided in communities with fluoridated water during childhood earn 4.5% more than women who did not[6].
- Consumer and employer discrimination are the likely driving factors through which oral health affects earnings[7].

"Since I didn't have a smile, I couldn't even work at a checkout counter".

– Ms. Abbott, 51 year old women who lost her teeth[8]

1 Data and Analysis Center (DAC)- cited by Northeast Delta Dental
2 N. Pourat and G. Nicholson, Unaffordable Dental Care is Linked to Frequent School Absences (Los Angeles, CA: UCLA Center for Health Policy Research, 2009) 1–6, http://www.healthpolicy.ucla.edu/pubs/publication.aspx?pubID=387
3 M. Willis, C. Esqueda, and R. Schact, "Social Perceptions of Individuals Missing Upper Front Teeth," Perceptual and Motor Skills, Vol. 106 (2008): 423–435.
4 Centers for Disease Control and Prevention, Division of Oral Health, "Oral Health for Adults," December 2006, http://www.cdc.gov/OralHealth/publications/factsheets/adult.htm
5 Ibid
6 Glied S, Neidell M. The Economic Value of Teeth. J. Human Resources 2010
7 Ibid
8 Eckholm, Erik. America's 'Near Poor' Are Increasingly at Economic Risk, Experts Say. NY Times May 8, 2006

Photo Courtesy of: David Castillo Dominici / Photostock

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The Economic Case for Water Fluoridation

The Problem: Oregon falls behind most of the country in dental health.

- Dental disease accounts for 30% of all healthcare costs for children[1].
- Untreated dental decay is the most common childhood disease and has increased 50% in a five-year period[2].
- Between 2008 and 2010, the number of dental-related emergency room visits by Oregon's Medicaid enrollees jumped 31%[3].

Solution: Water fluoridation is the most cost-effective way to prevent tooth decay and reduce medical costs among all residents, young and old. Cities save an estimated $38 in dental costs for every $1 invested in fluoridation[4].

Fluoridation Saves Money

A Colorado study showed that fluoridation saved the state nearly $149 million by avoiding unnecessary treatment costs. The study found that the average savings were $61 per person[5].

In New York, Medicaid recipients in less fluoridated counties required 33% more treatments for tooth decay than those in counties where fluoridated water was prevalent[6].

A Texas study confirmed that the state saved $24 per child, per year in Medicaid expenditures by preventing cavities through fluoridated drinking water[7].

"Dental disease accounts for a growing and significant proportion of medical costs; and yet all dental disease is preventable. Water fluoridation can stop 1/3 of all cavities for less than the cost of a toothbrush per person, per year." **- Bill Zepp**

Executive Director Oregon Dental Association

1 United States Department of Health and Human Services. (2000). Oral health in America: A report of the Surgeon General. Rockville, MD: NIH.
2 Oregon Department of Human Services. Oregon smiles survey, 2007.
3 Pew Center On the States. The Cost of Delay: State Dental Policies Fail One in Five Children, 2010. Pew Charitable Trusts, Washington, DC
4 Griffin, S., Jones, K., & Tomar, S. L. (2001). An economic evaluation of community water fluoridation. Journal of Public Health Dentistry, 61(2), 78-86.
5 O'Connell J.M. et al., "Costs and savings associated with community water fluoridation programs in Colorado," Preventing Chronic Disease (November 2005)
6 Kumar, J. —Geographic Variation in Medicaid Claims for Dental Procedures in New York State: Role of Fluoridation Under Contemporary Conditions‖. Public Health Reports. Vol. 125, 2010.
7 Texas Department of Health. (2000, May). Water fluoridation costs in Texas: Texas health steps (EPSDT-MEDICAID).

Photo Courtesy of nixxphotography / Ambro at freedigitalphotos.net

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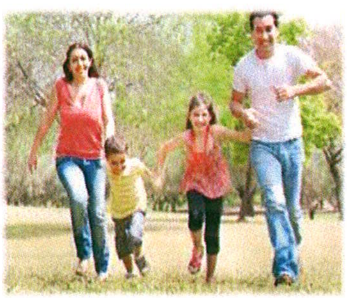
Water Fluoridation: An Environmentally Safe Solution to the Dental Health Crisis

Public Health Benefits

Water fluoridation is the single most effective public health measure to prevent tooth decay. Fluoride is a natural mineral that is found in almost every water source on earth. Fluoridation is the adjustment of the naturally occurring level of fluoride to the optimal level of 0.7 ppm.

Safe for the Environment

No credible studies have shown any adverse effects on any living organism at the optimal fluoride level, including salmon. In fact, salmon spend most of their lives in the ocean, which naturally contains 1.2 -1.5 ppm of fluoride (double the concentration of fluoridated municipal water)[1]. The average concentration of fluoride in the Columbia is 0.12 ppm[2]. If all of the added fluoride in the Bull Run water supply somehow ended up in the Columbia River, it would only increase the river's fluoride concentration by 0.00047 ppm of fluoride, far below the rivers natural variability[3].



Healthy and Safe

Pew Charitable Trusts has identified more than 3,000 studies that have been completed on fluoridation. The overwhelming weight of the evidence–plus more than 65 years of experience–supports the safety and effectiveness of this public health practice. Every respected health authority that has taken a position on the issue endorses fluoridation as a policy that benefits the public's health.

Fluoride Compounds are Extremely Pure

Additional contaminants in fluoride are nearly undectable and far below any level to justify a health concern. Products used for drinking water treatment are evaluated to the criteria specified in the National Science Foundation's (NSF) Standard 60. Verification testing by independent certification entities documents that the actual purity of fluoride additives far exceeds the NSF Standard 60 requirements[4]. This guarantees that fluoridated water is extremely safe and pure. For example, you would receive more than 290 times the amount of arsenic by drinking a cup of tea as you would by drinking a glass of fluoridated water[5].

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1 World Health Organization, 2004. Fluoride in Drinking-water: Background document for development of WHO Guidelines for Drinking-water Quality. http://www.who.int/water_sanitation_health/dwq/chemicals/fluoride.pdf

2 United States Geological Survey. http://pubs.usgs.gov/wri/wri014255/results/stat/warren.htm

3 The change in the fluoride concentration of the Columbia River was calculated with the formula described in the paper Osterman, AJPH 1980. This formula uses a very conservative assumption that all the fluoride added to the water supply would end up in the river. The average value for the flow rate of the municipal water (101 mgd) was obtained from the Portland Water Bureau. The median flow rate of the Columbia (127,971) and the median fluoride concentration in the Columbia (0.12 ppm) were obtained from the United States Geological Survey: http://pubs.usgs.gov/wri/wri014255/results/stat/warren.htm . The data was collected at Warrendale, Oregon, slightly up river from Portland and before the Willamette River flow is added to the Columbia. This provides a conservative (i.e. lowest) estimate for the flow rate and fluoride concentration. The current fluoride concentration of the Bull Run water supply was assumed to be 0.1 ppm based on Water Bureau tests, and the optimal fluoridation rate was assumed to 0.7 ppm. Using this data and equation, the change in fluoride concentration in the Columbia due to fluoridation of the Bull Run water supply was estimated as 0.00047 ppm.

4 Division of Oral Health, National Center for Chronic Disease Prevention and Health Promotion. http://www.cdc.gov/fluoridation/fact_sheets/engineering/wfadditives.htm

5 NSF Fact Sheet on Fluoridation Chemicals. http://www.nsf.org/business/water_distribution/pdf/NSF_Fact_Sheet.pdf, National Academy Press. http://books.nap.edu/openbook.php?isbn=0309063337&page=50

Photos Courtesy of photostock / Baxter

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Water Fluoridation: Sources and Quality Assurance

Introduction

Fluoridation is the safest, most effective, and most cost-effective way for a community to improve its dental health[1]. That is why it is used by over 73% of the public water systems in the United States and by over 60 countries around the world. Fluoridation is promoted by the World Health Organization and is supported by every national health organization in the U.S., including the U.S. Surgeon General, CDC, American Academy of Pediatrics, and the American Dental Association. Over 70 community organizations support water fluoridation for Portland, OR.

Sources of Fluoride

Fluoride is a mineral found naturally in nearly all water sources. Water fluoridation is the practice of adjusting the concentration of fluoride up or down to the optimal level (0.7 ppm) shown to prevent tooth decay.

In water, fluoride exists as ions. The fluoride ions are identical whether they are acquired by water as it seeps through the earth or they are added to the water supply. Two recent studies documented that there is no difference between naturally occurring fluoride ion and additives[2]. The studies observed no intermediates or other products at pH levels as low as 3.5.

Fluoride is extracted from phosphorite rock. Phosphorite rock is also a source for phosphoric acid, a common ingredient in soda pop, and phosphate, which is later used in fertilizers. When phosphorite rock is heated, fluoride is released and then captured in water. Fluoride does not come from fertilizer[3]. The three fluoride additives approved for water fluoridation in the United States are: Sodium fluoride, Sodium fluorosilicate, and Fluorosilicic acid[4]. Each additive dissolves immediately into fluoride ions that are identical to each other, as well as sodium and silicates.

Quality Assurance

The U.S. Environmental Protection Agency (EPA) regulates fluoride and other additives in public drinking water under a Memorandum of Understanding with the U.S. Food and Drug Administration (FDA) signed in 1979[5]. Currently, the EPA sets a maximum fluoride concentration of 4ppm, more than 5.7 times greater than the optimal level recommended by CDC for preventing tooth decay (0.7ppm).

Fluoride additives must meet strict quality standards that assure the public's safety. Fluoride additives are subject to a stringent system of standards, testing, and certificates by the American Water Works Association (AWWA) and the National Sanitation Foundation/American National Standards Institute (NSF/ANSI)[6]. The annual NSF/ANSI Standard 60 review for fluoride additives considers all ingredients in the product, as well as the manufacturing process, processing aids, shipping containers, and other factors to ensure that there are no contaminants that may pose a health hazard[7]. Standard 60 uses on-site inspections and surprise "spot checks" to confirm that the additives meet the highest standards of quality, safety, and purity.

All fluoride additives are certified as meeting NSF/ANSI Standard 60. There has not been a single fluoride product tested since the initiation of the program in 1988 with a contaminant concentration in excess of its single product allowable concentrations (SPAC). The SPAC is a conservative, protective limit, and is set at ten percent of the maximum concentration allowed by the EPA to account for the possibility of multiple exposure sources.

Summary

Over 200 million Americans consume optimally fluoridated water. More than 60 countries use water fluoridation to prevent tooth decay. The safety and purity of fluoride additives are well-documented and highly regulated.

Everyone Deserves
Healthy Teeth Coalition
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1) http://www.cdc.gov/fluoridation/benefits.htm

2) http://www.cdc.gov/fluoridation/fact_sheets/engineering/wfadditives.htm#10

3) http://www.cdc.gov/fluoridation/fact_sheets/engineering/wfadditives.htm#2

4) http://www.cdc.gov/fluoridation/fact_sheets/engineering/wfadditives.htm#2

5) http://www.fda.gov/AboutFDA/PartnershipsCollaborations/MemorandaofUnderstandingMOUs/DomesticMOUs/ucm116216.htm

6) http://www.cdc.gov/fluoridation/fact_sheets/engineering/wfadditives.htm#4

7) http://www.nsf.org/business/water_distribution/pdf/NSF_Fact_Sheet.pdf

MYTHS & FACTS

Responses to common anti-fluoride claims

For more information, go to ILikeMyTeeth.org

THE TRUTH	OPPONENT'S CLAIM	THE FACTS
Fluoride occurs naturally in water, though rarely at the optimal level to protect teeth.	*"Fluoride doesn't belong in drinking water."*	• It's already there. Fluoride exists naturally in virtually all water supplies and even in various brands of bottled water. If the people making this statement truly believed it, they would no longer drink water or grape juice — or eat shellfish, meat, cheese or other foods that contain trace levels of fluoride. • What's at issue is the amount of fluoride in water. There are proven benefits for public health that come from having the optimal level of fluoride in the water — just enough to protect our teeth. In 2011, federal health officials offered a new recommended optimal level for water fluoridation: 0.7 parts per million. That's our goal: getting just enough to help all of us keep our teeth longer.
Numerous scientific studies and reviews have recognized fluoride as an important nutrient for strong healthy teeth.	*"Adding fluoride is like forcing people to take medication"*	• Fluoride is not a medication. It is a mineral, and when present at the right level, fluoride in drinking water has two beneficial effects: preventing tooth decay and contributing to healthy bones. • U.S. court decisions have rejected the argument that fluoride is a "medication" that should not be allowed in water. The American Journal of Public Health summarized one of these rulings, noting that "fluoride is not a medication, but rather a nutrient found naturally in some areas but deficient in others." • There are several examples of how everyday products are fortified to enhance the health of Americans — iodine is added to salt, folic acid is added to breads and cereals, and Vitamin D is added to milk.
Fluoridation is one of the most cost-effective health strategies ever devised.	*"Our city council can save money by ending fluoridation of our water system."*	• A community that stops fluoridating or never starts this process will find that local residents end up spending *more* money on decay-related dental problems. Evidence shows that for most cities, every $1 invested in fluoridation saves $38 in unnecessary treatment costs. • A Texas study confirmed that the state saved $24 per child, per year in Medicaid expenditures because of the cavities that were prevented by drinking fluoridated water. • A Colorado study showed that water fluoridation saved the state nearly $149 million by avoiding unnecessary treatment costs. The study found that the average savings were roughly $61 per person.

THE TRUTH	OPPONENT'S CLAIM	THE FACTS
Fluoridation is a public health measure where a modest community-wide investment benefits everyone.	*"Fluoridation is a 'freedom of choice' issue. People should choose when or if they have fluoride in their water."*	• Fluoride exists naturally in virtually all water supplies, so it isn't a question of choosing to get fluoride. The only question is whether people receive the optimal level that's documented to prevent tooth decay. • It is completely unrealistic to make water fluoridation a person-by-person or household-by-household choice. The cost efficiency comes from a public water system fluoridating its entire supply. • Maintaining an optimal amount of fluoride in water is based on the principle that decisions about public health should be based on what is healthy for the entire community, not based on a handful of individuals whose extreme fears are not backed by the scientific evidence. • Fluoridation is not a local issue. Every taxpayer in a state pays the price for the dental problems that result from tooth decay. A New York study found that Medicaid enrollees in counties where fluoridation was rare needed 33% more fillings, root canals, and extractions than those in counties where fluoridated water was much more prevalent.
Fluoridated water is the best way to protect everyone's teeth from decay.	*"We already can get fluoride in toothpaste, so we don't need it in our drinking water."*	• The benefits from water fluoridation build on those from fluoride in toothpaste. Studies conducted in communities that fluoridated water in the years after fluoride toothpastes were common have shown a lower rate of tooth decay than communities without fluoridated water. • The CDC reviewed this question in January 2011. After looking at all the ways we might get fluoride — including fluoride toothpaste — the CDC recommended that communities fluoridate water at 0.7 parts per million. Any less than that puts the health of our teeth at risk. • Fluoride toothpaste alone is insufficient, which is why pediatricians and dentists often prescribe fluoride tablets to children living in non-fluoridated areas.
Very high fluoride concentrations can lead to a condition called fluorosis. Nearly all fluorosis in the U.S. is mild. This condition does not cause pain, and does not affect the health or function of the teeth.	*"Fluoridation causes fluorosis, and fluorosis can make teeth brown and pitted."* and *"One-third of all children now have dental fluorosis."*	• Nearly all cases of fluorosis are mild — faint, white specks on teeth — that are usually so subtle that only a dentist will notice this condition. Mild fluorosis does not cause pain, and it does not affect the health or function of the teeth. • The pictures of dark pitted teeth that anti-fluoride opponents circulate show *severe* cases of fluorosis, a condition that is almost unheard of in the U.S. Many of these photos are from India, and the reason is *natural* fluoride levels over there that are dramatically higher than the level used in the U.S. to fluoridate public water systems. Common sense shows how misleading these photos are. Think about it: Do one-third of the children's teeth you see look brown and pitted? No, they don't. • In 2011, the CDC proposed a new level for fluoridation — 0.7 parts per million — that is expected to reduce the likelihood of fluorosis while continuing to protect teeth from decay.

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Getting enough fluoride in childhood will determine the strength of our teeth over our entire lifetime.	*"Fluoride is especially toxic for small children."*	• According to the American Academy of Pediatricians optimal exposure to fluoride is important to infants and children. The use of fluoride for the prevention and control of cavities is documented to be both safe and effective. • Medical experts disagree with opponents' "toxic" claim. In fact, the American Academy of Family Physicians recommends that parents consider using dietary fluoride supplements for children at risk of tooth decay from ages 6 months through age 16 if their water isn't fluoridated. • Children who drink fluoridated water as their teeth grow will have stronger, more decay resistant teeth over their lifetime. A 2010 study confirmed that the fluoridated water consumed as a young child makes the loss of teeth (due to decay) less likely 40 or 50 years later when that child is a middle-aged adult.
Children who swallow toothpaste are at increased risk of mild fluorosis.	*"There's a warning label on fluoride toothpaste that tells you to 'keep out of reach of children', so fluoride in water must also be a danger."*	• The warning label simply reflects the fact that toothpaste contains roughly 1,000 times as much fluoride per milligram as fluoridated water. Even so, the American Dental Association (ADA) believes the warning label on toothpaste exaggerates the potential for negative health effects from swallowing toothpaste. The ADA has stated that "a child could not absorb enough fluoride from toothpaste to cause a serious problem" and noted that fluoride toothpaste has an "excellent safety record." • Many vitamin labels have similar statements: "Keep out of reach of children." That's because almost anything has the potential for negative health effects if it's left in the hands of unsupervised, young children.
Fluoridated water is safe for babies and young children.	*"Fluoridated water isn't safe to use for babies."*	• The evidence does not support what anti-fluoride groups say. The American Dental Association concludes that "it is safe to use fluoridated water to mix infant formula" and encourages parents to discuss any questions they may have with their dentists and pediatricians. • Although using fluoridated water to prepare infant formula might increase the chance that a child develops dental fluorosis, nearly all instances of fluorosis are a mild, cosmetic condition. Fluorosis nearly always appears as very faint white streaks on teeth. The effect is usually so subtle that only a dentist would notice it during an examination. Mild fluorosis does not cause pain, nor does it affect the function or health of the teeth. • A 2010 study examined the issue of fluorosis and infant formula, and reached the conclusion that "no general recommendations to avoid use of fluoridated water in reconstituting infant formula are warranted." The researchers examined the condition's impact on children and concluded that "the effect of mild fluorosis was not adverse and could even be favorable."

THE TRUTH	OPPONENT'S CLAIM	THE FACTS
Although Americans' teeth are healthier than they were several decades ago, many people still suffer from decay — and the overall impact it has on their lives.	*"Tooth decay is no longer a problem in the United States."*	• Tooth decay is the most common chronic health problem affecting children in the U.S. It is five times more common than asthma. Tooth decay causes problems that often last long into adulthood — affecting kids' ability to sleep, speak, learn and grow into happy and healthy adults. • California children missed 874,000 school days in 2007 due to toothaches or other dental problems. A study of seven Minneapolis-St. Paul hospitals showed that patients made over 10,000 trips to the emergency room because of dental health issues, costing more than $4.7 million. • Poor dental health worsens a person's future job prospects. A 2008 study showed that people who are missing front teeth are viewed as less intelligent and less desirable by employers. • In a 2008 study of the armed forces, 52% of new recruits were categorized as Class 3 in "dental readiness" — meaning they had oral health problems that needed urgent attention and would delay overseas deployment.
Leading health and medical organizations agree: fluoridated water is both safe and effective.	*"Fluoridation causes cancer and other serious health problems."*	• The American Academy of Family Physicians, the Institute of Medicine and many other respected authorities endorse water fluoridation as safe. The Centers for Disease Control and Prevention reports that "panels of experts from different health and scientific fields have provided strong evidence that water fluoridation is safe and effective." • More than 3,200 studies or reports had been published on the subject of fluoridation. Even after all of this research, the best that anti-fluoride groups can do is to claim that fluoride *could* cause or *may* cause one harm or another. They can't go beyond speculating because the evidence simply doesn't back up their fears. • The cancer claim is part of a pattern. According to the American Council on Science and Health, "Historically, anti-fluoride activists have claimed, with no evidence, that fluoridation causes everything from cancer to mental disease." • A 2011 Harvard study found no link between fluoride and bone cancer. This study reviewed hundreds of bone samples, and the study's design was approved by the National Cancer Institute. The study is significant because the National Research Council reported that ***if*** there were any type of cancer that fluoride might possibly be linked to, it would probably be bone cancer (because fluoride is drawn to bones). The fact that this Harvard study found no link to bone cancer strengthens confidence that fluoride is unlikely to cause any form of cancer. • Opponents usually cite a 2006 study when they raise the cancer issue, but they omit the fact that the author of this study called it "an exploratory analysis." Instead of measuring the actual fluoride level in bone, this 2006 study relied on estimates of fluoride exposures that could not be confirmed, which undermines the reliability of the data.

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Dozens of studies and more than 60 years of experience have repeatedly shown that fluoridation reduces tooth decay.	*"Fluoridation doesn't reduce tooth decay."*	• An independent panel of 15 experts from the fields of science and public health reviewed numerous studies and concluded that fluoridation reduces tooth decay by 29%. • An analysis of two similarly sized, adjacent communities in Arkansas showed that residents without access to fluoridated water had twice as many cavities as those with access to fluoridated water. • In New York, Medicaid recipients in less fluoridated counties required 33% more treatments for tooth decay than those in counties where fluoridated water was prevalent. • The benefits of fluoridation are long-lasting. A recent study found young children who consumed fluoridated water were still benefiting from this as adults in their 40s or 50s. • The Centers for Disease Control and Prevention recognizes fluoridation's effectiveness in preventing tooth decay and cited fluoridated drinking water as one of the "10 great public health achievements of the 20th century." • The European Archives of Pediatric Dentistry published an analysis of 59 studies that concluded that "water fluoridation is effective at reducing [decay] in children and adults."
Millions of people living in Europe are receiving the benefits of fluoride.	*"European countries have rejected fluoridation, so why should we fluoridate water?"*	• Europe has used a variety of programs to provide fluoride's benefits to the public. Water fluoridation is one of these programs. Fluoridated water reaches 12 million Europeans, mostly residents of Great Britain, Ireland and Spain. Fluoridated milk programs reach millions of additional Europeans, mostly in Eastern Europe. • Salt fluoridation is the most widely used approach in Europe. In fact, at least 70 million Europeans consume fluoridated salt, and this method of fluoridation reaches most of the population in Germany and Switzerland. These two countries have among the lowest rates of tooth decay in all of Europe. • Italy has not tried to create a national system of water fluoridation, but the main reasons are cultural and geological. First, many Italians regularly drink bottled water. Second, a number of areas in Italy have water supplies with natural fluoride levels that *already* reach the optimal level that prevents decay. • Technical challenges are a major reason why fluoridated water isn't widespread in Europe. In France and Switzerland, for example, water fluoridation is logistically difficult because of the terrain and because there are tens of thousands of separate sources for drinking water. This is why Western Europe relies more on salt fluoridation, fluoride rinse programs and other means to get fluoride to the public.

THE TRUTH	OPPONENT'S CLAIM	THE FACTS
Community water fluoridation is proven to reduce decay, but it isn't the only factor that affects the rate of tooth decay.	*"There are states with a high rate of water fluoridation that have higher decay rates than states where water fluoridation is less common."*	• Water fluoridation plays a critical role in decay prevention, but other factors also influence decay rates. Researchers often call these factors as "confounding factors." Someone who ignores confounding factors is violating a key scientific principle. A person's income level is a confounding factor in tooth decay because low-income Americans are more at risk for decay than upper-income people. This makes sense because income status shapes how often a person visits a dentist, their diet and nutrition, and other factors. • Comparing different states based solely on fluoridation rates ignores key income differences. For example, West Virginia and Connecticut reach roughly the same percentage of their residents with fluoridated water — 91 percent and 90 percent, respectively. Yet the percentage of West Virginians living below the poverty line is nearly double the percentage of those living in Connecticut. West Virginians are also more likely to get their drinking water from wells, which are not fluoridated to the optimal level. • It's misleading to compare states without considering other, confounding factors. A much more reliable approach is to compare residents of the *same* state who share similar traits, such as income levels. A 2010 study of New York counties did just this and found that people living in areas with fluoridated water needed fewer fillings and other corrective dental treatments.
Community water fluoridation is the most cost-effective way to protect oral health.	*"There are better ways of delivering fluoride than adding it to water."*	• A 2003 study of fluoridation in Colorado concluded that "even in the current situation of widespread use of fluoride toothpaste," water fluoridation "remains effective and cost saving" at preventing cavities. • Studies conducted in communities that fluoridated water in the years after fluoride toothpastes were widely used have shown a lower rate of tooth decay than communities without fluoridated water. • The co-author of a 2010 study stated that research confirms the "the most effective source of fluoride to be water fluoridation." • Water fluoridation is inexpensive to maintain and saves money down the road. The typical cost of fluoridating a local water system is between 40 cents and $2.70 per person, per year — less than the cost of medium-sized latte from Starbucks. • For low-income individuals who are at higher risk of dental problems, fluoride rinses are a costly expense, which is why these products are not the "easy" answer that opponents of fluoridation claim they are.

THE TRUTH	OPPONENT'S CLAIM	THE FACTS
Water fluoridation has been one of the most thoroughly studied subjects, and the evidence shows it is safe and effective.	*"The National Research Council's 2006 report said that fluoride can have harmful effects."*	• The NRC raised the possibility of health concerns about areas of the U.S. where the *natural* fluoride levels in well water or aquifers are unusually high. These natural fluoride levels are two to four times higher than the level used to fluoridate public water systems. • The National Research Council itself explained that its report was not an evaluation of the safety of water fluoridation. • The Centers for Disease Control and Prevention reviewed the NRC report and stated, "The report addresses the safety of high levels of fluoride in water that occur naturally, and does not question the use of lower levels of fluoride to prevent tooth decay."
Anti-fluoride groups cite many "studies" that were poorly designed, gathered unreliable data, and were not peer-reviewed by independent scientists.	*"Studies show that fluoride is linked to lower IQ scores in children."*	• The foreign studies that anti-fluoride activists cite involved fluoride levels that were at least double or triple the level used to fluoridate drinking water in the U.S. It is irresponsible to claim these studies have any real meaning for our situation in the U.S. • British researchers who evaluated these studies from China and other countries found "basic errors." These researchers pointed out that the lower IQs could be traced to other factors, such as arsenic exposure, the burning of high-fluoride coal inside homes and the eating of contaminated grain.
Much of the fluoride used to fluoridate public water systems is extracted from phosphate rock.	*"Fluoride is a by-product from the phosphate fertilizer industry."*	• Much of the fluoride used to fluoridate water is extracted from phosphate rock, and so is phosphoric acid—an ingredient in Coke and Pepsi. After fluoride is extracted from phosphate rock, much of that rock is later used to create fertilizers that will enrich soil. Opponents use this message a lot, maybe because they want to create the false impression that fluoride comes from fertilizer. • Corn produces several useful by-products, including corn oil, cornstarch and corn syrup. Fluoride is one example of many by-products that help to improve the quality of life or health.

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Savings from Water Fluoridation:
What the Evidence Shows

Research shows that community water fluoridation offers perhaps the greatest return-oninvestment of any public health strategy. The reduction in just the costs of filling and extracting diseased teeth and time lost from work to get care—not counting reduction in dental pain and discomfort—more than makes up for the cost of fluoridation. In recent decades, the evidence showing savings has grown:

- For most cities, every $1 invested in water fluoridation saves $38 in dental treatment costs.[1]
- A Texas study confirmed that the state saved $24 per child, per year in Medicaid expenditures for children because of the cavities that were prevented by drinking fluoridated water.[2]
- A 2010 study in New York State found that Medicaid enrollees in less fluoridated counties needed 33 percent more fillings, root canals, and extractions than those in counties where fluoridated water was much more prevalent.[3] As a result, the treatment costs per Medicaid recipient were $23.65 higher for those living in less fluoridated counties.[4]
- Researchers estimated that in 2003 Colorado saved nearly $149 million in unnecessary treatment costs by fluoridating public water supplies—average savings of roughly $61 per person.[5]
- A 1999 study compared Louisiana parishes (counties) that were fluoridated with those that were not. The study found that low-income children in communities without fluoridated water were three times more likely than those in communities with fluoridated water to need dental treatment in a hospital operating room.[6]
- By reducing the incidence of decay, fluoridation makes it less likely that toothaches or other serious dental problems will drive people to hospital emergency rooms (ERs)—where treatment costs are high. A 2010 survey of hospitals in Washington State found that dental disorders were the leading reason why uninsured patients visited ERs.[7]
- Scientists who testified before Congress in 1995 estimated that national savings from water fluoridation totaled $3.84 billion each year.

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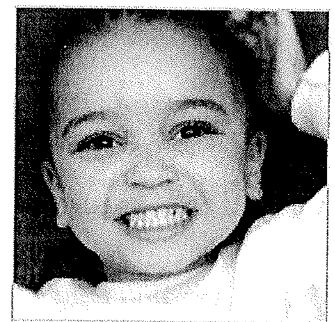
FAQ: Fluoride and Children



Fluoride from drinking water and other sources such as toothpaste can strengthen tooth enamel and help prevent tooth decay. Below is a list of questions that parents frequently ask about fluoride and how it can help their children.

Q: Why do children need fluoride?

A: Fluoride is an important mineral for all children. Bacteria in the mouth combine with sugars and produce acid that can harm tooth enamel and damage teeth. Fluoride protects teeth from acid damage and helps reverse early signs of decay. Make sure your children are drinking plenty of water and brushing with toothpaste that has fluoride in it.

Q: Is fluoridated water safe for my children?

A: Yes. The American Academy of Pediatrics (AAP), along with the American Dental Association (ADA) and the Centers for Disease Control and Prevention (CDC), agree that **water fluoridation** is a safe and effective way to **prevent tooth decay**.

Q: Should I mix infant formula with fluoridated water?

A: According to the ADA, it is safe to use fluoridated water to **mix infant formula**. The risk if mixing infant formula with fluoridated water is mild fluorosis (see below for more information on this condition). However, if you have concerns about this, talk with your **pediatrician** or **dentist**.

Q: What if I prefer not to use fluoridated water for infant formula?

A: If you prefer not to use fluoridated water with formula, you can:

- **Breastfeed** your baby
- Use bottled or purified water that has no fluoride with the formula
- Use ready-to-feed formula that does not need water to be added

Q: What if we live in a community where the water is not fluoridated? What can we do?

A: Check with your local water utility agency to find out if your water has fluoride in it. If it doesn't, ask your pediatrician or dentist if your child is at HIGH risk for dental caries (also known as tooth decay or a cavity). He or she may recommend you buy fluoridated water or give you a prescription for fluoride drops or tablets for your child.

Q: How else can my child get fluoride?

A: There are many sources of fluoride. Fluoridated water and toothpaste are the most common. It is also found in many foods and beverages. So making sure your child eats a balanced diet with plenty of **calcium** and **vitamin D** is a great way to keep teeth healthy. Your dentist or pediatrician may also recommend a topical fluoride treatment during well child or dental visits at various stages of your child's development.

Q: When should my child start using fluoride toothpaste?

A: The American Academy of Pediatric Dentistry recommends using a "smear" of toothpaste on children under the age of two twice each day. Children aged 2-5 can use a "pea-size" amount.

Recommendations regarding the use of fluoride toothpaste in children under the age of 2 vary. Talk to your pediatrician or dentist about what is best for your child.

Q: What is dental fluorosis and will fluoridated water mixed with infant formula increase the risk?

A: Although using fluoridated water to prepare infant formula might increase the risk of dental fluorosis, most cases are mild.

Fluorosis usually appears as very faint white streaks on the teeth. Often it is only noticeable by a dental expert during an exam. Mild fluorosis is not painful and does not affect the function or health of the teeth. **Click here** for examples from the American Dental Association on what mild fluorosis looks like.

Once your child's adult teeth come in (usually around age 8), the risk of developing fluorosis is over.

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topic landing page

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

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MMWR™
MORBIDITY AND MORTALITY WEEKLY REPORT

Achievements in Public Health, 1900–1999

Fluoridation of Drinking Water to Prevent Dental Caries

Fluoridation of community drinking water is a major factor responsible for the decline in dental caries (tooth decay) during the second half of the 20th century. The history of water fluoridation is a classic example of clinical observation leading to epidemiologic investigation and community-based public health intervention. Although other fluoride-containing products are available, water fluoridation remains the most equitable and cost-effective method of delivering fluoride to all members of most communities, regardless of age, educational attainment, or income level.

Dental Caries

Dental caries is an infectious, communicable, multifactorial disease in which bacteria dissolve the enamel surface of a tooth (*1*). Unchecked, the bacteria then may penetrate the underlying dentin and progress into the soft pulp tissue. Dental caries can result in loss of tooth structure and discomfort. Untreated caries can lead to incapacitating pain, a bacterial infection that leads to pulpal necrosis, tooth extraction and loss of dental function, and may progress to an acute systemic infection. The major etiologic factors for this disease are specific bacteria in dental plaque (particularly *Streptococcus mutans* and lactobacilli) on susceptible tooth surfaces and the availability of fermentable carbohydrates.

At the beginning of the 20th century, extensive dental caries was common in the United States and in most developed countries (*2*). No effective measures existed for preventing this disease, and the most frequent treatment was tooth extraction. Failure to meet the minimum standard of having six opposing teeth was a leading cause of rejection from military service in both world wars (*3,4*). Pioneering oral epidemiologists developed an index to measure the prevalence of dental caries using the number of decayed, missing, or filled teeth (DMFT) or decayed, missing, or filled tooth surfaces (DMFS) (*5*) rather than merely presence of dental caries, in part because nearly all persons in most age groups in the United States had evidence of the disease. Application of the DMFT index in epidemiologic surveys throughout the United States in the 1930s and 1940s allowed quantitative distinctions in dental caries experience among communities—an innovation that proved critical in identifying a preventive agent and evaluating its effects.

U.S. DEPARTMENT OF HEALTH & HUMAN SERVICES

Fluoridation — Continued

History of Water Fluoridation

Soon after establishing his dental practice in Colorado Springs, Colorado, in 1901, Dr. Frederick S. McKay noted an unusual permanent stain or "mottled enamel" (termed "Colorado brown stain" by area residents) on the teeth of many of his patients (*6*). After years of personal field investigations, McKay concluded that an agent in the public water supply probably was responsible for mottled enamel. McKay also observed that teeth affected by this condition seemed less susceptible to dental caries (*7*).

Dr. F. L. Robertson, a dentist in Bauxite, Arkansas, noted the presence of mottled enamel among children after a deep well was dug in 1909 to provide a local water supply. A hypothesis that something in the water was responsible for mottled enamel led local officials to abandon the well in 1927. In 1930, H. V. Churchill, a chemist with Aluminum Company of America, an aluminum manufacturing company that had bauxite mines in the town, used a newly available method of spectrographic analysis that identified high concentrations of fluoride (13.7 parts per million [ppm]) in the water of the abandoned well (*8*). Fluoride, the ion of the element fluorine, almost universally is found in soil and water but generally in very low concentrations (<1.0 ppm). On hearing of the new analytic method, McKay sent water samples to Churchill from areas where mottled enamel was endemic; these samples contained high levels of fluoride (2.0–12.0 ppm).

The identification of a possible etiologic agent for mottled enamel led to the establishment in 1931 of the Dental Hygiene Unit at the National Institute of Health headed by Dr. H. Trendley Dean. Dean's primary responsibility was to investigate the association between fluoride and mottled enamel (see box). Adopting the term "fluorosis" to replace "mottled enamel," Dean conducted extensive observational epidemiologic surveys and by 1942 had documented the prevalence of dental fluorosis for much of the United States (*9*). Dean developed the ordinally scaled Fluorosis Index to classify this condition. Very mild fluorosis was characterized by small, opaque "paper white" areas affecting ≤25% of the tooth surface; in mild fluorosis, 26%–50% of the tooth surface was affected. In moderate dental fluorosis, all enamel surfaces were involved and susceptible to frequent brown staining. Severe fluorosis was characterized by pitting of the enamel, widespread brown stains, and a "corroded" appearance (*9*).

Dean compared the prevalence of fluorosis with data collected by others on dental caries prevalence among children in 26 states (as measured by DMFT) and noted a strong inverse relation (*10*). This cross-sectional relation was confirmed in a study of 21 cities in Colorado, Illinois, Indiana, and Ohio (*11*). Caries among children was lower in cities with more fluoride in their community water supplies; at concentrations >1.0 ppm, this association began to level off. At 1.0 ppm, the prevalence of dental fluorosis was low and mostly very mild.

The hypothesis that dental caries could be prevented by adjusting the fluoride level of community water supplies from negligible levels to 1.0–1.2 ppm was tested in a prospective field study conducted in four pairs of cities (intervention and control) starting in 1945: Grand Rapids and Muskegon, Michigan; Newburgh and Kingston, New York; Evanston and Oak Park, Illinois; and Brantford and Sarnia, Ontario, Canada. After conducting sequential cross-sectional surveys in these communities over 13–15 years, caries was reduced 50%–70% among children in the communities with fluoridated water (*12*). The prevalence of dental fluorosis in the intervention

Fluoridation — Continued

H. Trendley Dean, D.D.S.

In 1931, dental surgeon and epidemiologist H. Trendley Dean (August 25, 1893–May 13, 1962) set out to study the harm that too much fluoride could do; however, his work demonstrated the good that a little fluoride could do.

Henry Trendley Dean grew up in East St. Louis, and received his D.D.S. from the St. Louis University School of Dentistry in 1916. After 1 year in private practice, Dean joined the Army, serving in a number of military camps stateside before going to France. In 1919, Captain Dean returned to private practice, but 2 years later joined the Public Health Service as acting assistant dental surgeon. During the next 10 years he served in Marine hospitals around the country, studied for a year at Boston University, and developed a reputation as both a skilled dental surgeon and researcher. In 1931, Dean became the first dental scientist at the National Institute of Health, advancing to director of the dental research section in 1945. After World War II, he directed epidemiologic studies for the Army in Germany. When Congress established the National Institute of Dental Research (NIDR) in 1948, Dean was appointed its director, a position he held until retiring in 1953.

The National Institute of Health (NIH) had hired Dean in 1931 to conduct a major study of mottled enamel. The team that Dean assembled reflected an interdisciplinary approach. The study required accurate assays of fluoride in water, so he enlisted Dr. Elias Elvove, senior chemist at NIH, who developed a technique for measuring the presence of fluoride in water to an accuracy of 0.1 ppm. He also hired experts in animal dentistry, dental pathology, and water chemistry. As accurate data on the incidence of fluorosis emerged, the apparent correlation between mottled teeth and lower caries rates grew more compelling. As early as 1932, Dean observed that individuals in an area where mottled teeth was endemic demonstrated "a lower incidence of caries than individuals in some nearby non-endemic area." By 1938, determining the prophylactic properties of fluoride became the study's primary focus.

Dean's legacy comes almost entirely from his association with the introduction of fluoridation, yet fluoride constituted only a small part of his professional activities. He also studied the effects of radium poisoning on alveolar bone; developed a program to study the prevention and cure of Vincent's angina (trench mouth); and undertook various studies of the causes, prevention, and cure of dental caries. More important, he played a major role in shaping federal participation in basic dental science research at the NIDR, integrating investigations of dental health into mainstream medical research. As he stated in a national radio address in 1950: "We can't divorce the mouth from the rest of the body."

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Fluoridation — Continued

communities was comparable with what had been observed in cities where drinking water contained natural fluoride at 1.0 ppm. Epidemiologic investigations of patterns of water consumption and caries experience across different climates and geographic regions in the United States led in 1962 to the development of a recommended optimum range of fluoride concentration of 0.7–1.2 ppm, with the lower concentration recommended for warmer climates (where water consumption was higher) and the higher concentration for colder climates (*13*).

The effectiveness of community water fluoridation in preventing dental caries prompted rapid adoption of this public health measure in cities throughout the United States. As a result, dental caries declined precipitously during the second half of the 20th century. For example, the mean DMFT among persons aged 12 years in the United States declined 68%, from 4.0 in 1966–1970 (*14*) to 1.3 in 1988–1994 (CDC, unpublished data, 1999) (Figure 1). The American Dental Association, the American Medical Association, the World Health Organization, and other professional and scientific organizations quickly endorsed water fluoridation. Knowledge about the benefits of water fluoridation led to the development of other modalities for delivery of fluoride, such as toothpastes, gels, mouth rinses, tablets, and drops. Several countries in Europe and Latin America have added fluoride to table salt.

Effectiveness of Water Fluoridation

Early studies reported that caries reduction attributable to fluoridation ranged from 50% to 70%, but by the mid-1980s the mean DMFS scores in the permanent dentition of children who lived in communities with fluoridated water were only 18% lower than among those living in communities without fluoridated water (*15*). A review of studies on the effectiveness of water fluoridation conducted in the United States during 1979–1989 found that caries reduction was 8%–37% among adolescents (mean: 26.5%) (*16*).

Since the early days of community water fluoridation, the prevalence of dental caries has declined in both communities with and communities without fluoridated water in the United States. This trend has been attributed largely to the diffusion of fluoridated water to areas without fluoridated water through bottling and processing of foods and beverages in areas with fluoridated water and widespread use of fluoride toothpaste (*17*). Fluoride toothpaste is efficacious in preventing dental caries, but its effectiveness depends on frequency of use by persons or their caregivers. In contrast, water fluoridation reaches all residents of communities and generally is not dependent on individual behavior.

Although early studies focused mostly on children, water fluoridation also is effective in preventing dental caries among adults. Fluoridation reduces enamel caries in adults by 20%–40% (*16*) and prevents caries on the exposed root surfaces of teeth, a condition that particularly affects older adults.

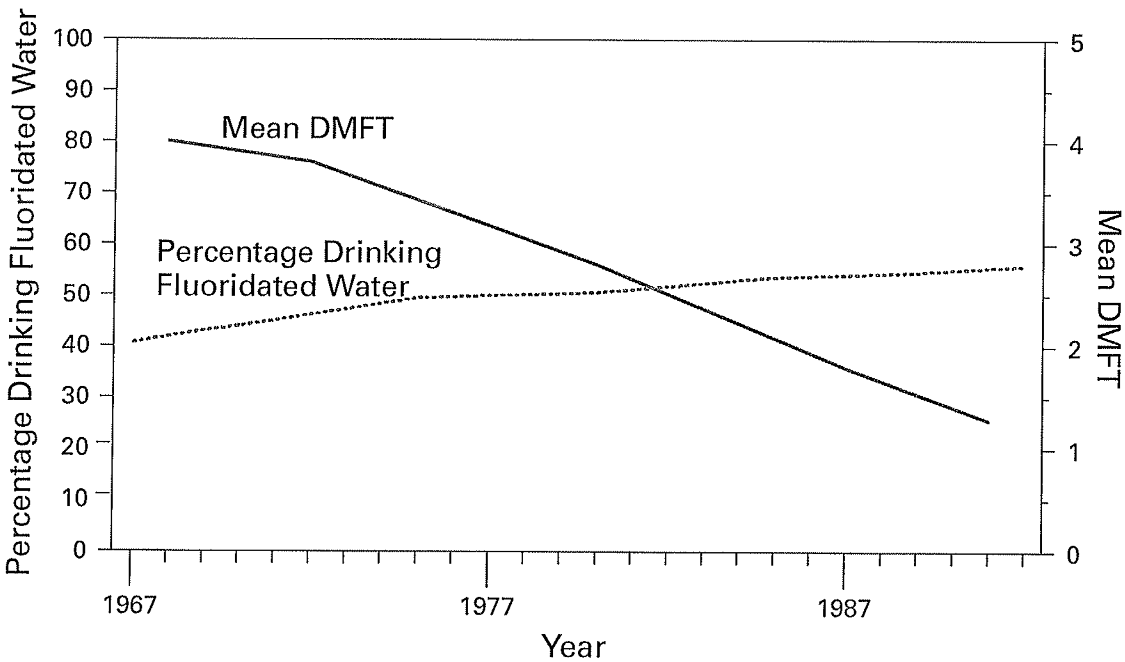
Water fluoridation is especially beneficial for communities of low socioeconomic status (*18*). These communities have a disproportionate burden of dental caries and have less access than higher income communities to dental-care services and other sources of fluoride. Water fluoridation may help reduce such dental health disparities.

Biologic Mechanism

Fluoride's caries-preventive properties initially were attributed to changes in enamel during tooth development because of the association between fluoride and

Fluoridation — Continued

FIGURE 1. Percentage of population residing in areas with fluoridated community water systems and mean number of decayed, missing (because of caries), or filled permanent teeth (DMFT) among children aged 12 years — United States, 1967–1992



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cosmetic changes in enamel and a belief that fluoride incorporated into enamel during tooth development would result in a more acid-resistant mineral. However, laboratory and epidemiologic research suggests that fluoride prevents dental caries predominately after eruption of the tooth into the mouth, and its actions primarily are topical for both adults and children (*1*). These mechanisms include 1) inhibition of demineralization, 2) enhancement of remineralization, and 3) inhibition of bacterial activity in dental plaque (*1*).

Enamel and dentin are composed of mineral crystals (primarily calcium and phosphate) embedded in an organic protein/lipid matrix. Dental mineral is dissolved readily by acid produced by cariogenic bacteria when they metabolize fermentable

Fluoridation — Continued

carbohydrates. Fluoride present in solution at low levels, which becomes concentrated in dental plaque, can substantially inhibit dissolution of tooth mineral by acid.

Fluoride enhances remineralization by adsorbing to the tooth surface and attracting calcium ions present in saliva. Fluoride also acts to bring the calcium and phosphate ions together and is included in the chemical reaction that takes place, producing a crystal surface that is much less soluble in acid than the original tooth mineral (*1*).

Fluoride from topical sources such as fluoridated drinking water is taken up by cariogenic bacteria when they produce acid. Once inside the cells, fluoride interferes with enzyme activity of the bacteria and the control of intracellular pH. This reduces bacterial acid production, which directly reduces the dissolution rate of tooth mineral (*19*).

Population Served by Water Fluoridation

By the end of 1992, 10,567 public water systems serving 135 million persons in 8573 U.S. communities had instituted water fluoridation (*20*). Approximately 70% of all U.S. cities with populations of >100,000 used fluoridated water. In addition, 3784 public water systems serving 10 million persons in 1924 communities had natural fluoride levels ≥0.7 ppm. In total, 144 million persons in the United States (56% of the population) were receiving fluoridated water in 1992, including 62% of those served by public water systems. However, approximately 42,000 public water systems and 153 U.S. cities with populations ≥50,000 have not instituted fluoridation.

Cost Effectiveness and Cost Savings of Fluoridation

Water fluoridation costs range from a mean of 31 cents per person per year in U.S. communities of >50,000 persons to a mean of $2.12 per person in communities of <10,000 (1988 dollars) (*21*). Compared with other methods of community-based dental caries prevention, water fluoridation is the most cost effective for most areas of the United States in terms of cost per saved tooth surface (*22*).

Water fluoridation reduces direct health-care expenditures through primary prevention of dental caries and avoidance of restorative care. Per capita cost savings from 1 year of fluoridation may range from negligible amounts among very small communities with very low incidence of caries to $53 among large communities with a high incidence of disease (CDC, unpublished data, 1999). One economic analysis estimated that prevention of dental caries, largely attributed to fluoridation and fluoride-containing products, saved $39 billion (1990 dollars) in dental-care expenditures in the United States during 1979–1989 (*23*).

Safety of Water Fluoridation

Early investigations into the physiologic effects of fluoride in drinking water predated the first community field trials. Since 1950, opponents of water fluoridation have claimed it increased the risk for cancer, Down syndrome, heart disease, osteoporosis and bone fracture, acquired immunodeficiency syndrome, low intelligence, Alzheimer disease, allergic reactions, and other health conditions (*24*). The safety and effectiveness of water fluoridation have been re-evaluated frequently, and no credible evidence supports an association between fluoridation and any of these conditions (*25*).

Fluoridation — Continued

21st Century Challenges

Despite the substantial decline in the prevalence and severity of dental caries in the United States during the 20th century, this largely preventable disease is still common. National data indicate that 67% of persons aged 12–17 years (*26*) and 94% of persons aged ≥18 years (*27*) have experienced caries in their permanent teeth.

Among the most striking results of water fluoridation is the change in public attitudes and expectations regarding dental health. Tooth loss is no longer considered inevitable, and increasingly adults in the United States are retaining most of their teeth for a lifetime (*12*). For example, the percentage of persons aged 45–54 years who had lost all their permanent teeth decreased from 20.0% in 1960–1962 (*28*) to 9.1% in 1988–1994 (CDC, unpublished data, 1999). The oldest post-World War II "baby boomers" will reach age 60 years in the first decade of the 21st century, and more of that birth cohort will have a relatively intact dentition at that age than any generation in history. Thus, more teeth than ever will be at risk for caries among persons aged ≥60 years. In the next century, water fluoridation will continue to help prevent caries among these older persons in the United States.

Most persons in the United States support community water fluoridation (*29*). Although the proportion of the U.S. population drinking fluoridated water increased fairly quickly from 1945 into the 1970s, the rate of increase has been much lower in recent years. This slowing in the expansion of fluoridation is attributable to several factors: 1) the public, some scientists, and policymakers may perceive that dental caries is no longer a public health problem or that fluoridation is no longer necessary or effective; 2) adoption of water fluoridation can require political processes that make institution of this public health measure difficult; 3) opponents of water fluoridation often make unsubstantiated claims about adverse health effects of fluoridation in attempts to influence public opinion (*24*); and 4) many of the U.S. public water systems that are not fluoridated tend to serve small populations, which increases the per capita cost of fluoridation. These barriers present serious challenges to expanding fluoridation in the United States in the 21st century. To overcome the challenges facing this preventive measure, public health professionals at the national, state, and local level will need to enhance their promotion of fluoridation and commit the necessary resources for equipment, personnel, and training.

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Water Fluoridation and the Environment:

Current Perspective in the United States

HOWARD F. POLLICK, BDS, MPH

Evidence of water fluoridation's effects on plants, animals, and humans is considered based on reviews by scientific groups and individual communities, including Fort Collins, CO, Port Angeles, WA, and Tacoma-Pierce County, WA. The potential for corrosion of pipes and the use of fluoridation chemicals, particularly fluorosilicic acid, are considered, as is the debate about whether fluoridation increases lead in water, with the conclusion that there is no such increase. The arguments of anti-fluoridationists and fluoridation proponents are examined with respect to the politics of the issue. *Key words*: fluoridation; environment; toxicology.

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Prior to 1945, epidemiologic and laboratory studies confirmed the association between the environment (naturally-occurring fluoride in water supplies) and the health and cosmetic appearance of teeth.[1] Where fluoride levels were low, prevalences and severity of dental caries were high among lifetime residents, yet where fluoride levels were high, the prevalences and severity of dental caries were low, but dental fluorosis occurred with high prevalence and severity. This led to the concept of creating an ideal environment for optimal dental health through adjusting the naturally occurring fluoride level to about 1 mg/L (1 part per million). In 1986, the U.S. Environmental Protection Agency (EPA) set the maximum contaminant level (MCL) for naturally-occurring fluoride in public drinking water at 4 mg/L, with a secondary standard at 2 mg/L.[2]

Water fluoridation, then, is the controlled adjustment of fluoride concentrations of community water systems to optimal levels to minimize the incidence of dental caries (tooth decay) and dental fluorosis (enamel mottling). From initial efforts begun as community trials in 1945, water is now fluoridated in thousands of public water systems and reaches two thirds of the U.S. population served by such systems.[3] Community water fluoridation and other uses of fluorides, such as in toothpaste, have significantly reduced the prevalence of dental caries in the United States.[1]

Early investigations into the physiologic effects of fluoride in drinking water predated the first community field trials.[4–7] Since 1950, opponents of fluoridation have claimed it increases the risks for cancer, Down's syndrome, heart disease, osteoporosis and bone fracture, acquired immunodeficiency syndrome, low intelligence, Alzheimer disease, allergic reactions, and other health conditions.[8] The safety and effectiveness of water fluoridation have been re-evaluated frequently, and no credible evidence supports an association between fluoridation and any of these conditions.[9,10]

The Environment

Environmental concerns have been investigated in literature reviews for the Tacoma–Pierce County Health Department, Washington (August 2002),[11] and the City of Port Angeles, Washington (October 2003),[12] and no negative impact of water fluoridation on the environment has been established. Issues related to discharge to water; emissions to air; production, storage, or release of toxic or hazardous substances; or production of noise have been found to be nonsignificant. Emissions of fluoride into the air are not released outside the well houses. Fluoride concentrations in rivers downstream of the discharges increase by less than 0.01 mg/L due to adding fluoride to the water supply system.

Fluoridated water losses during use, dilution of sewage by rain and groundwater infiltrate, fluoride removal during secondary sewage treatment, and diffusion dynamics at effluent outfall combine to eliminate fluoridation related environmental effects. In a literature review, Osterman found no instance of municipal water fluoridation causing recommended environmental concentrations to be exceeded, although excesses occurred in several cases of severe industrial water pollution not related to water fluoridation.[13] Osterman found that overall river fluoride concentrations theoretically would be raised by 0.001-0.002 mg/l, a value not measurable by current analytic techniques. All resulting concentrations would be well below those recommended for environmental safety.

A study conducted in Phoenix, Arizona, to test the efficacy of soil aquifer treatment systems indicated that fluoride concentrations decline as water travels under-

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ground. This study suggests that 40–50% of the fluoride discharged to groundwater is removed as the water travels through the soil and aquifer. Thus, fluoride does not concentrate in groundwater.[14]

PLANTS AND ANIMALS

The concentration of fluoride in the treated water does not reach levels that could harm any plant or animal species.[11,12] A report of the effect of industrial pollution, from an aluminum plant on salmon indicated that the usual fluoride concentration of the river was 0.1 mg/L, and when the concentration was raised experimentally to 0.5 mg/L, there was an effect on the salmon.[15] Since rivers and streams are not fluoridated and the increase in the fluoride concentration of a river as a result of runoff from fluoridated water would be insufficient to raise the level to even 0.2 mg/L, fluoridation of water can have no effect on salmon.

There is no evidence that fluoridated water has any effect on gardens, lawns, or plants. Although silver fluoride is not used in water fluoridation, silver fluoride at 1 mg/L used as a disinfectant had no effect on growth of wheat.[16] There is evidence that very high concentrations of fluoride have no toxic effect on plants in ponds:

> The fate of fluoride in a simulated accidental release into an experimental pond was observed for 30 days in Grenoble, France. The components investigated were water, sediments, plants, algae, molluscs, and fish. Twenty-four hours after the release, most (99.8%) of the fluoride was distributed in the physical components (water and sediments), and the biological agents contained only 0.2% of the fluoride released. Despite an exposure to hot spots of 5,000 ppm at the beginning of the accidental release, no visible toxic effects were observed on the biological components such as plants, algae, molluscs, and fish.[17]

There is evidence that ladyfinger (okra) can withstand up to 120 mg/L fluoride. The consumption by people of this plant grown with fluoridated water at 1 mg/L would be 0.2 mg per kg:

> Because of suggestions that food is a rich source of fluoride to humans and the absence of permissible and upper limits of fluoride for irrigation water, plant uptake studies were conducted using fluoride-rich irrigation water. Ladyfinger was grown in sand and soil cultures for 18 wk and the accumulation of fluoride in various plant parts was studied. The potential for ingestion of fluoride by humans through this route was also considered. The percentage uptake was greater in sand-cultured plants than in soil-cultured plants. The root accumulates most of the fluoride supplied through irrigation water and the fruit accumulates the least. Up to 120 mg/L fluoride of irrigation water did not harm the plants. The ingestion of fluoride by humans from plants irrigated with water containing 10 mg/L fluoride would be 0.20 mg per 100 g ladyfinger.[18]

HUMANS

The Institute of Medicine, Food and Nutrition Board has estimated that the tolerable upper limit for human daily intake of fluoride is 10 mg per day for adults and children over 8 years of age.[19] Ten independent U.S. and Canadian studies published from 1958 to 1987 showed that dietary fluoride intakes by adults ranged from 1.4 to 3.4 mg/day in areas where the water fluoride concentration was 1.0 mg/L. Where the water concentration was less than 0.3 mg/L, daily intakes ranged from 0.3 to 1.0 mg/day.[19]

Several municipal or territorial reviews of the water fluoride issue have concluded that available information indicates that there is no significant adverse health impact associated with water fluoridation. The Fort Collins review[20] included reviews from other communities, including Brisbane, Australia (1997),[21] Natick, Massachusetts (1997),[22] Calgary, Alberta, Canada (1998),[23] Ontario, Canada (1999),[24] and Escambia County Utilities Authority, Florida (2000).[25] Additionally, the Fort Collins review considered several "Tier One" reviews, including reviews by or for the Centers for Disease Control and Prevention,[1] the Institute of Medicine (1999),[19] the World Health Organization (1994),[26] the National Research Council (1993),[9] the U.S. Public Health Service (1991),[27] the International Programme on Chemical Safety (1984),[28] the Medical Research Council, UK (2002),[29] the Agency for Toxic Substances and Disease Registry, U.S. Public Health Service (2001 draft and 1993),[30] and York, U.K. (2000).[31]

The Fort Collins report found that:

- The weight of the evidence suggests that there is caries (cavities) reduction in populations exposed to water fluoridation at or near an optimal level
- Likely total exposure values for children older than six months living in communities with water fluoridated at up to 1.2 mg/L (ppm) do not exceed the upper limit set to be protective of moderate dental fluorosis by the Institute of Medicine. Total dietary exposures of fluoride can exceed this threshold amount (0.7mg/day) in infants fed formula reconstituted with optimally fluoridated water.
- There is no consistent evidence from human or animal studies that exposure to optimally fluoridated drinking water and other sources causes any form of cancer in humans, including bone and joint cancer
- The FTSG agrees with the conclusion of the Medical Research Council of Great Britain that states, "The possibility of an effect on the risk of hip fracture is the most important in public health terms. The available evidence on this suggests no effect, but cannot rule out the possibility of a small percentage change (either an increase or a decrease) in hip fractures." [Medical Research Council 2002, page 3]

- At the concentrations of fluoride provided in Fort Collins water including exposures from all sources over a lifetime, skeletal fluorosis caused by drinking water exposure is not likely to be a health issue.
- At the concentrations of fluoride provided in Fort Collins water, in combination with other sources of fluoride, as many as one in four children under age 8 may develop very mild to mild dental fluorosis. This degree of fluorosis may or may not be detectable by the layperson. With oral health as the goal, this degree of dental fluorosis is considered an acceptable adverse effect given the benefits of caries prevention.
- In the literature reviewed, doses appropriate for caries reduction were not shown to negatively impact thyroid function. Studies in which humans received doses significantly higher than the optimum fluoride intake for long periods of time showed no negative impact on thyroid function.
- Overall, evidence is lacking that exposure to fluoride through drinking water causes any problems to the human immune system.[20]

In general, there is no credible evidence indicating a cause-and-effect relationship between water fluoridation and increased health risks.

CORROSION

According to the U.S. Environmental Protection Agency and the National Association of Corrosion Engineers, corrosion is not related to fluoride.[32] Corrosion by potable water is primarily caused by dissolved oxygen, pH, water temperature, alkalinity, hardness, salt, hydrogen sulfide, and certain bacteria. Fluoride, at concentrations found in potable water, does not cause corrosion. A small increase in the corrosivity of potable water that is already corrosive may occur after treatment with alum, chlorine, fluorosilicic acid, or sodium silicofluoride, which decreases pH. This may occur in some potable water sources with little buffering capacity; it can easily be resolved by adjusting the pH upward.[11,12,33]

CHEMICALS USED FOR FLUORIDATION

Fluorosilicates

Urbansky reviewed available information on fluorosilicates, with three objectives:

> (1) to enumerate unresolved chemical issues germane to understanding fluoridation and ascertaining the fate of fluoride and fluorospecies, (2) to critically review what is known or reported, and (3) to assemble a knowledge base to provide a starting point for future study.[34]

Urbansky states:

> Since [1962], toxicity and adverse health impacts have tested fluoride rather than fluosilicates. As a recent example, in 2001, the FDA reported that Americans' exposure to fluoride had increased from dentifrices, and it demonstrated that any increases did not produce observable health effects in rats. Fluoride salts were continually tested instead of fluorosilicates because the complete and fast dissociation-hydrolysis (eq 1) of fluorosilicates to fluoride and (hydr)oxosilicates was generally accepted as a chemical fact. Accordingly, no reason was apparent to test fluorosilicates separately.
>
> $$H_2SiF_6(aq) + 4H_2O(l) = 6HF(aq) + Si(OH)_4(aq) \qquad \text{(eq 1)}$$
>
> all the rate data suggest that equilibrium should have been achieved by the time the water reaches the consumer's tap if not by the time it leaves the waterworks plant. . . . The most common fluoridating agents used by American waterworks are sodium fluoride (NaF), fluorosilicic acid (H_2SiF_6), and sodium fluorosilicate (Na_2SiF_6) (see table below).
>
> TABLE[34]
>
> | | Sodium Fluoride | Sodium Fluorosilicate | Fluorosilicic Acid |
> |---|---|---|---|
> | (a) Number of Utilities | 2491 | 1635 | 5876 |
> | (b) People served | 11,700,000 | 36,100,000 | 80,000,000 |
>
> *Data for the United States from the CDC's 1992 *Fluoridation Census*[35]: (a) Number of utilities using specific additives as reported by those that fluoridate their water; (b) Populations served by specific additives (millions of people) of those drinking supplementally fluoridated water (does not include waters with naturally occurring fluoride).
>
> Although 25% of the utilities reported using NaF, this corresponds to only 9.2% of the U.S. population drinking fluoride-supplemented tap water. The ease in handling NaF rather than fluorosilicates accounts for the disproportionate use of NaF by utilities serving smaller populations. On the other hand, the cost savings in using fluorosilicates result in large systems using those additives instead. The reduced cost of large volume offsets the costs associated with handling concentrated stocks of the fluorosilicates, which require accommodations similar to hydrochloric acid, which is sometimes used to adjust pH. In acidic solution, the dissociation and hydrolysis of fluorosilicic acid, which occurs upon dilution, is given by eq 1. In drinking water, pH is adjusted with the addition of base (e.g., NaOH, $NaHCO_3$). $H_2SiF_6(aq) + 4H_2O(l) = 6HF(aq) + Si(OH)_4(aq)$ (eq1).[34]

While there may be evidence of toxicity of these substances when workers involved in their production are not protected, there is no credible evidence of toxicity when they are diluted for use in fluoridated water. Fluorosilicic acid is diluted with water from an initial aqueous concentration of about 23–24% by about 1:250,000–1:300,000 when used for fluoridating water.[36] This produces the final concentration of between 0.7–1.2 mg/L, the specific level set according to CDC guidelines.[37]

Concerns have been raised about arsenic and lead in fluorosilicic-acid–treated water.[38,39] However, there is no credible evidence that this is of concern.[40] Urbansky and Schock add:

> The vast preponderance of the lead(II) in nearly all tap waters originates from the plumbing materials located between the water distribution mains and the end of the faucet used by the consumer.

Arsenic and lead may be present at minute undetectable concentrations, well below all current (50 ppb) and proposed (10 ppb) EPA standards. Following dilution with water, the calculated range of arsenic concentrations in the finished water contributed by fluorosilicic acid feed is 0.10 to 0.24 μg/L (parts per billion, ppb).[36] The analytic detection limit for arsenic is 2 μg/L, so the amount added by the fluorosilicic acid would not be detected.[36] In Fort Collins, the concentration of lead in the source waters was below the detection limit for lead in the department's laboratory of 1.0 μg/liter (ppb). Because lead levels are below the detection limits both before and after the addition of fluorosilicic acid, the actual changes in lead concentrations were not measurable.[36]

Masters and Coplan have alarmed the public with their reports linking fluoridation, increased lead levels and crime.[39,41] Urbansky and Schock criticize the conclusion reached by Masters and Coplan by stating:

> Interestingly, the bibliographies of the Masters and Coplan study most strongly asserting the adverse effects of silicofluoride shows only a single reference related to sampling of drinking water or the control of lead or other metals by water treatment, so the level of awareness in the design of the studies and interpretation of the data is highly questionable. By not measuring or statistically testing numerous other water and plumbing characteristics that could correlate with lead(II) levels with equal to or greater statistical significance than those relationships that were put forth, the studies of [Reference 2] are intentionally biased towards what appears to be a preconceived conclusion. Even simple analytes that are known to affect lead mobility, such as pH or alkalinity, or analytes known to play important dietary roles in health, such as calcium, sodium or magnesium, were not reported to be measured in their study, so possible confounding variables are conspicuously excluded from evaluation.
>
> . . . Recent reports [41, 39] that purport to link certain water fluoridating agents, such as fluorosilicic acid and sodium fluorosilicate, to human lead uptake are inconsistent with accepted scientific knowledge. The authors of those reports fail to identify or account for these inconsistencies, and mainly argue on the basis of speculation stated without proof as fact. The sampling scheme employed in the studies is entirely unrelated to any credible statistically-based study design to identify drinking water lead and fluoride exposure as a significant source of blood lead in the individuals. The authors use aggregated data unrelated in space and time and then attempt to selectively apply gross statistical techniques that do not include any of thousands of other possible water quality or exposure variables which could show similar levels of correlation utterly by accident. Many of the chemical assumptions are scientifically unjustified, are contradicted by known chemistry data and principles, and alternate explanations (such as multiple routes of PbII exposure) have not been satisfactorily addressed. The choice in water fluoridation approach is often made for economic, commercial or engineering reasons that may have a regional component that could also be related to various community socio-economic measures, and so should not be considered to be a purely independent variable without investigation. At present, the highly-promoted studies asserting enhanced lead uptake from drinking water and increased neurotoxicity still provide no credible evidence to suggest that the common practice of fluoridating drinking water has any untoward health impacts via effects on lead(II) when done properly under established guidelines so as to maintain total water quality. Our conclusion supports current EPA and PHS/CDC policies on water fluoridation.[40]

Nevertheless, concerns have been raised about the acidity of drinking water that may be created by fluoridation. According to Urbansky and Schock, "one cannot demonstrate that an increase in blood lead(II) ion levels can be linked to acidity from SiF_6^{2-} hydrolysis any more than one can demonstrate it results from consuming soft drinks." Additionally they state: "Note that the species $PbSiF_6^0$ is present at such low concentrations that we would expect to find *only one molecule of this complex in more than 1,000 liters of tap water* at pH 6, which of course, far exceeds the volume possible for water consumption and the human stomach."

A critique of this review was included in "Comments on The April 17, 2002 ICCEC Approach to Silicofluorides Study" by Coplan.[42] The ICCEC is the U.S. Public Health Service National Toxicology Program (NTP) Interagency Committee for Chemical Evaluation and Coordination. Coplan states his concerns about the way in which Urbansky and the EPA and CDC have investigated silicofluorides. For example, he provides the following headings in his review: "EPA's acknowledged ignorance about a position they have adamantly held"; "EPA's continued effort at misdirection"; "Why Urbansky and Schock cannot be trusted"; "Why the CDC cannot be trusted"; "A substantial body of evidence has been submitted to the NTP clearly supporting the need for a comprehensive program of animal testing for health effects from chronic ingestion of SiF treated water. This is true now and would remain true no matter what the EPA may learn about dissociation chemistry from a contractor selected by EPA employees whose objectivity and scientific integrity are less than impeccable."

Coplan's comments are in keeping with his stance as an anti-fluoridationist (one who is strongly opposed to the fluoridation of public water supplies).[43] It should be pointed out that Urbansky and Schock have been highly critical of the work of Masters and Coplan. It appears that the main thrust of contemporary anti-fluoridation tactics is to assert that the chemicals used in fluoridation are causing problems of one sort or another. Such tactics have emanated from the work of Masters and Coplan.

The toxicology of sodium fluorosilicate and fluorosilicic acid has been reviewed for the EPA.[44] The authors of that review state:

> In water, the compound (sodium fluorosilicate) readily dissociates to sodium ions and fluosilicate ions and then to hydrogen gas, fluoride ions, and hydrated silica. At the pH of drinking water (6.5-8.5) and at the concentration usually used for fluoridation (1 mg fluoride/L), the degree of hydrolysis is essentially 100%. . . . Like its salt, its (fluorosilicic acid) degree of hydrolysis is essentially 100% in drinking water. At equilibrium, the fluorosilicate remaining in drinking water is estimated to be <<1 part per trillion.[40] In addition, exposure to impurities in the fluoridating agent is judged to be of low health risk when properly treated water is ingested. For example, in fluorosilicic acid, iron and iodine are usually below the levels considered useful as a dietary supplement; the phosphorus level is reported to be insignificant; and silver is usually <4 parts per septillion in the fluoridated water.[45]

The Colorado City of Fort Collins has been fluoridating with fluorosilicic acid and has responded to concerns raised about that chemical.[36] The Report of the Fort Collins 2003 Fluoride Technical Study Group, April 2003, provides a comprehensive review that includes "The Potential for Increased Contaminant Levels Due to the Use of Hydrofluorosilicic Acid."

> The FTSG's review identified three potential concerns associated with hydrofluorosilicic acid (HFS). 1) co-contamination (i.e., arsenic and lead), 2) decreased pH leading to increased lead solubility or exposure, and 3) potential toxicological effects from incomplete dissociation products of HFS. The FTSG used the raw and finished water quality data for the City of Fort Collins to determine whether the addition of HFS was responsible for the potential addition of contaminants such as heavy metals to the city's drinking water. There was no evidence that the addition of HFS increased the concentrations of copper, manganese, zinc, cadmium, nickel, or molybdenum. The concentrations of arsenic and lead were below the detection limit for the Fort Collins Water Quality Control Laboratory in both the source water and the finished water and below the maximum contaminant level (MCL) for these naturally occurring elements. There was no evidence that the introduction of HFS changed the pH of the water appreciably. Concern that HFS incompletely disassociates may be unfounded when the fundamental chemical facts are considered. Therefore, it is unlikely that community water fluoridation poses a health risk from the exposure to any of these chemicals present in the water as it leaves the plant. Further studies related to the health effects of HFS are in progress.[36]

Reeves (fluoridation engineer at the CDC) outlined the process by which the safety of fluoridation chemicals is assured:

> Concern has been raised about the impurities in the fluoride chemicals. The American Water Works Association (AWWA), a well-respected water supply industry association, sets standards for all chemicals used in the water treatment plant, including fluoride chemicals. The AWWA standards are ANSI/AWWA B701-99 (sodium fluoride), ANSI/AWWA B702-99 (sodium fluorosilicate) and ANSI/AWWA B703-00 (fluorosilicic acid). The National Sanitation Foundation (NSF) also sets standards and does product certification for products used in the water industry, including fluoride chemicals. ANSI/NSF Standard 60 sets standards for purity and provides testing and certification for the fluoride chemicals. Standard 60 was developed by NSF and a consortium of associations, including the AWWA and the American National Standards Institute (ANSI). This standard provides for product quality and safety assurance to prevent the addition of harmful levels of contaminants from water treatment chemicals. More than 40 states have laws or regulations requiring product compliance with Standard 60. NSF tests the fluoride chemicals for the 11 regulated metal compounds that have an EPA MCL. In order for a product [for example, fluorosilicic acid] to meet certification standards, regulated metal contaminants must be present at the tap [in the home] at a concentration of less than ten percent of the MCL when added to drinking water at the recommended maximum use level. The EPA has not set any MCL for the silicates as there is no known health concerns, but Standard 60 has a Maximum Allowable Level (MAL) of 16 mg/L for sodium silicates as corrosion control agents primarily for turbidity reasons. NSF tests have shown the silicates in the water samples from public water systems to be well below these levels.[46]

Sources of Fluoride Pollution Unrelated to Water Fluoridation

The principal sources of fluoride pollution are industries, particularly phosphate ore production and use as well as aluminum manufacture, mining, and coal burning.[28,47,48] In the absence of adequate emission control in such settings environmental pollution can be a problem. Such pollution has been a problem in the past in industrialized countries, and the WHO warns that unless proper environmental safeguards are adhered to, there is a danger of its occurring in developing countries with increasing industrialization. Fluoride pollution is therefore recognized as an industrial hazard; however water fluoridation is not considered a potential source of fluoride pollution.[46]

Arguments of Opponents and Proponents

Whereas anti-fluoridationists try to prevent the unnecessary exposure of living things to fluoride, often in the misguided belief that any amount of fluoride is toxic, pro-fluoridationists try to reduce tooth decay through the judicious use of fluoride, with the understanding that there is an optimum amount, appropriately delivered, that is both beneficial and safe. This distinction leads to a difference in interpretation of the scientific and popular literature on this topic, whether related to the effects of water fluoridation on teeth or other organs of the body, or the effects on the environment. Similarly, there are those who may judge water fluoridation on political or philosophical grounds, such as being supportive or opposed to what government agencies may advocate. Some may have personal or anecdotal experience that is counter to what opponents or proponents recommend. Newbrun has characterized the fluoridation debate as a religious argument.[49]

While opponents of fluoridation are not without their supporters and supporting groups,[50] almost every reputable, recognized, competent scientific and/or public health organization or government unit endorses fluoridation of drinking water as safe and effective.[51,52] Furthermore, community water fluoridation has been heralded as one of the ten great public health measures of the 20th century.[53]

Proponents of fluoridation assert that the dose of fluoride determines whether it is beneficial or toxic, and that there are threshold levels that must be exceeded before there are toxic effects. This is a basic principle of toxicology and is true of every chemical approved for use in treating drinking water. "All substances are poisons: there is none which is not a poison. The right dose differentiates a poison and a remedy." Paracelsus (1493-1541).[54]

While there has been considerable scientific study of the effects of fluorides on health and the environment, there will *always* be the need for more research.[29] However, proponents argue that it is not rational that the gains made from water fluoridation should be undone because not all the research has been completed. Further, it is strongly recommended that those communities that have not yet fluoridated their water supplies should do so to protect the dental health of their current and future residents.[55]

Both sides use arguments related to freedom of choice. Those supporting fluoridation argue that the public water supply is designed to protect public health and it is more important to protect people's health than to protect some people's concern for their freedom to use unfluoridated water.[56,57] Additionally, pro-fluoridationists invoke the ethical principle of social justice arguing that the safe public health measure is socioeconomically equitable, providing greater benefit to the disadvantaged.[1]

Current anti-fluoridation tactics have focused on chemicals used to fluoridate water supplies. As has been shown above, there is no credible evidence to support the notion that the chemicals are unsafe. In the past, tactics have focused on studies that purported to show that fluoridation was linked to cancer and myriad other health problems.[48] However, such assertions were based on improper science, and numerous subsequent studies found no association between fluoridation and cancer.[58]

CONCLUSION

Scientific evidence supports the fluoridation of public water supplies as safe for the environment and beneficial to people. Reports at the local, national, and international levels have continued to support this most important public health measure. There appears to be no concern about the environmental aspects of water fluoridation among those experts who have investigated the matter. Furthermore, since the chemicals used for water fluoridation are co-products of the manufacture of phosphate fertilizers, and the raw material used is a natural resource (rocks excavated for their mineral content), water fluoridation could accurately be described as environmentally friendly, as it maximizes the use made of these natural resources, and reduces waste.[59]

Note: In the text, the term "fluorosilicic" has been substituted for fluosilicic, hydrofluorosilicic, and hexafluorosilicic (all being synonymous); similarly, "fluorosilicate" for fluosilicate, hexafluorosilicate, and silicofluoride. However, the original terms in all references have not been substituted.

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Recommendations and Reports

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Recommendations for Using Fluoride to Prevent and Control Dental Caries in the United States

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Summary

Widespread use of fluoride has been a major factor in the decline in the prevalence and severity of dental caries (i.e., tooth decay) in the United States and other economically developed countries. When used appropriately, fluoride is both safe and effective in preventing and controlling dental caries. All U.S. residents are likely exposed to some degree to fluoride, which is available from multiple sources. Both health-care professionals and the public have sought guidance on selecting the best way to provide and receive fluoride. During the late 1990s, CDC convened a work group to develop recommendations for using fluoride to prevent and control dental caries in the United States. This report includes these recommendations, as well as a) critical analysis of the scientific evidence regarding the efficacy and effectiveness of fluoride modalities in preventing and controlling dental caries, b) ordinal grading of the quality of the evidence, and c) assessment of the strength of each recommendation.

Because frequent exposure to small amounts of fluoride each day will best reduce the risk for dental caries in all age groups, the work group recommends that all persons drink water with an optimal fluoride concentration and brush their teeth twice daily with fluoride toothpaste. For persons at high risk for dental caries, additional fluoride measures might be needed. Measured use of fluoride modalities is particularly appropriate during the time of anterior tooth enamel development (i.e., age <6 years).

The recommendations in this report guide dental and other health-care providers, public health officials, policy makers, and the public in the use of fluoride to achieve maximum protection against dental caries while using resources efficiently and reducing the likelihood of enamel fluorosis. The recommendations address public health and professional practice, self-care, consumer product industries and health agencies, and further research. Adoption of these recommendations could further reduce dental caries in the United States and save public and private resources.

INTRODUCTION

Dental caries (i.e., tooth decay) is an infectious, multifactorial disease afflicting most persons in industrialized countries and some developing countries (*1*). Fluoride reduces the incidence of dental caries and slows or reverses the progression of existing lesions (i.e., prevents cavities). Although pit and fissure sealants, meticulous oral hygiene, and appropriate dietary practices contribute to caries prevention and control, the most effective and widely used approaches have included fluoride use. Today, all U.S. residents are exposed to fluoride to some degree, and widespread use of fluoride has been a major factor in the decline in the prevalence and severity of dental caries in the United States and other economically developed countries (*1*). Although this decline is a major public health achievement, the burden of disease is still considerable in all age groups. Because many fluoride modalities are effective, inexpensive, readily available, and can be used in both private and public health settings, their use is likely to continue.

Fluoride is the ionic form of the element fluorine, the 13th most abundant element in the earth's crust. Fluoride is negatively charged and combines with positive ions (e.g., calcium or sodium) to form stable compounds (e.g., calcium fluoride or sodium fluoride). Such fluorides are released into the environment naturally in both water and air. Fluoride compounds also are produced by some industrial processes that use the mineral apatite, a mixture of calcium phosphate compounds. In humans, fluoride is mainly associated with calcified tissues (i.e., bones and teeth) because of its high affinity for calcium.

Fluoride's ability to inhibit or even reverse the initiation and progression of dental caries is well documented. The first use of adjusted fluoride in water for caries control began in 1945 and 1946 in the United States and Canada, when the fluoride concentration was adjusted in the drinking water supplying four communities (*2--5*). The U.S. Public Health Service (PHS) developed recommendations in the 1940s and 1950s regarding fluoride concentrations in public water supplies. At that time, public health officials assumed that drinking water would be the major source of fluoride for most U.S. residents. The success of water fluoridation in preventing and controlling dental caries led to the development of fluoride-containing products, including toothpaste (i.e., dentifrice), mouthrinse, dietary supplements, and professionally applied or prescribed gel, foam, or varnish. In addition, processed beverages, which constitute an increasing proportion of the diets of many U.S. residents (*6,7*), and food can contain small amounts of fluoride, especially if they are processed with fluoridated water. Thus, U.S. residents have more sources of fluoride available now than 50 years ago.

Much of the research on the efficacy and effectiveness of individual fluoride modalities in preventing and controlling dental caries was conducted before 1980, when dental caries was more common and more severe. Modalities were usually tested separately and with the assumption that the method would provide the main source of fluoride. Thus, various modes of fluoride use have evolved, each with its own recommended concentration, frequency of use, and dosage schedule. Health-care professionals and the public have sought guidance regarding selection of preventive modalities from among the available options. The United States does not have comprehensive recommendations for caries prevention and control through various combinations of fluoride modalities. Adoption of such recommendations could further reduce dental caries while saving public and private resources and reducing the prevalence of enamel fluorosis, a generally cosmetic developmental condition of tooth enamel.

This report presents comprehensive recommendations on the use of fluoride to prevent and control dental caries in the United States. These recommendations were developed by a work group of 11 specialists in fluoride research or policy convened by CDC during the late 1990s and reviewed by an additional 23 specialists. Although the recommendations were developed specifically for the United States, aspects of this report could be relevant to other countries. The recommendations guide health-care providers and the public on efficient and appropriate use of fluoride modalities, direct attention to fluoride intake among children aged <6 years to decrease the risk for enamel fluorosis, and suggest areas for further research. This report focuses on critical analysis of the scientific evidence regarding the efficacy and effectiveness of each fluoride modality in preventing and controlling dental caries and on the use of multiple sources of fluoride. The safety of fluoride, which has been documented comprehensively by other scientific and public health organizations (e.g., PHS [*8*], National Research Council [*9*], World Health Organization [*10*], and Institute of Medicine [*11*]) is not addressed.

HOW FLUORIDE PREVENTS AND CONTROLS DENTAL CARIES

Dental caries is an infectious, transmissible disease in which bacterial by-products (i.e., acids) dissolve the hard surfaces of teeth. Unchecked, the bacteria can penetrate the dissolved surface, attack the underlying dentin, and reach the soft pulp tissue. Dental caries can result in loss of tooth structure, pain, and tooth loss and can progress to acute systemic infection.

Cariogenic bacteria (i.e., bacteria that cause dental caries) reside in dental plaque, a sticky organic matrix of bacteria, food debris, dead mucosal cells, and salivary components that adheres to tooth enamel. Plaque also contains minerals, primarily calcium and phosphorus, as well as proteins, polysaccharides, carbohydrates, and lipids. Cariogenic bacteria colonize on tooth surfaces and produce polysaccharides that enhance adherence of the plaque to enamel. Left undisturbed, plaque will grow and harbor increasing numbers of cariogenic bacteria. An initial step in the formation of a carious lesion takes place when cariogenic bacteria in dental plaque metabolize a substrate from the diet (e.g., sugars and other fermentable carbohydrates) and the acid produced as a metabolic by-product demineralizes (i.e., begins to dissolve) the adjacent enamel crystal surface (Figure 1). Demineralization involves the loss of calcium, phosphate, and carbonate. These minerals can be captured by surrounding plaque and be available for reuptake by the enamel surface. Fluoride, when present in the mouth, is also retained and concentrated in plaque.

Fluoride works to control early dental caries in several ways. Fluoride concentrated in plaque and saliva inhibits the demineralization of sound enamel and enhances the remineralization (i.e., recovery) of demineralized enamel (*12,13*). As cariogenic bacteria metabolize carbohydrates and produce acid, fluoride is released from dental plaque in response to lowered pH at the tooth-plaque interface (*14*). The released fluoride and the fluoride present in saliva are then taken up, along with calcium and phosphate, by de-mineralized enamel to establish an improved enamel crystal structure. This improved structure is more acid resistant and contains more fluoride and less carbonate (*12,15--19*) (Figure 1). Fluoride is more readily taken up by demineralized enamel than by sound enamel (*20*). Cycles of demineralization and remineralization continue throughout the lifetime of the tooth.

Fluoride also inhibits dental caries by affecting the activity of cariogenic bacteria. As fluoride concentrates in dental plaque, it inhibits the process by which cariogenic bacteria metabolize carbohydrates to produce acid and affects bacterial production of adhesive polysaccharides (*21*). In laboratory studies, when a low concentration of fluoride is constantly present, one type of cariogenic bacteria, *Streptococcus mutans*, produces less acid (*22--25*). Whether this reduced acid production reduces the cariogenicity of these bacteria in humans is unclear (*26*).

Saliva is a major carrier of topical fluoride. The concentration of fluoride in ductal saliva, as it is secreted from salivary glands, is low --- approximately 0.016 parts per million (ppm) in areas where drinking water is fluoridated and 0.006 ppm in nonfluoridated areas (*27*). This concentration of fluoride is not likely to affect cariogenic activity. However, drinking fluoridated water, brushing with fluoride toothpaste, or using other fluoride dental products can raise the concentration of fluoride in saliva present in the mouth 100- to 1,000-fold. The concentration returns to previous levels within 1--2 hours but, during this time, saliva serves as an important source of fluoride for concentration in plaque and for tooth remineralization (*28*).

Applying fluoride gel or other products containing a high concentration of fluoride to the teeth leaves a temporary layer of calcium fluoride-like material on the enamel surface. The fluoride in this material is released when the pH drops in the mouth in response to acid production and is available to remineralize enamel (*29*).

In the earliest days of fluoride research, investigators hypothesized that fluoride affects enamel and inhibits dental caries only when incorporated into developing dental enamel (i.e., preeruptively, before the tooth erupts into the mouth) (*30,31*). Evidence supports this hypothesis (*32--34*), but distinguishing a true preeruptive effect after teeth erupt into a mouth where topical fluoride exposure occurs regularly is difficult. However, a high fluoride concentration in sound enamel cannot alone explain the marked reduction in dental caries that fluoride produces (*35,36*). The prevalence of dental caries in a population is not inversely related to the concentration of fluoride in enamel (*37*), and a higher concentration of enamel fluoride is not necessarily more efficacious in preventing dental caries (*38*).

The laboratory and epidemiologic research that has led to the better understanding of how fluoride prevents dental caries indicates that fluoride's predominant effect is posteruptive and topical and that the effect depends on fluoride being in the right amount in the right place at the right time. Fluoride works primarily after teeth have erupted, especially when small amounts are maintained constantly in the mouth, specifically in dental plaque and saliva (*37*). Thus, adults also benefit from fluoride, rather than only children, as was previously assumed.

RISK FOR DENTAL CARIES

The prevalence and severity of dental caries in the United States have decreased substantially during the preceding 3 decades (*39*). National surveys have reported that the prevalence of any dental caries among children aged 12--17 years declined from 90.4% in 1971--1974 to 67% in 1988--1991; severity (measured as the mean number of decayed, missing, or filled teeth) declined from 6.2 to 2.8 during this period (*40--43*).

These decreases in caries prevalence and severity have been uneven across the general population; the burden of disease now is concentrated among certain groups and persons. For example, 80% of the dental caries in permanent teeth of U.S. children aged 5--17 years occurs among 25% of those children (*43*). To develop and apply appropriate and effective caries prevention and control strategies, identification and assessment of groups and persons at high risk for developing new carious lesions is essential (*44*). Caries risk assessment is difficult because it attempts to account for the complex interaction of multiple factors. Although various methods for assessing risk exist, no single model predominates in this emerging science. Models that take multiple factors into account predict the risk more accurately, especially for groups rather than persons. However, for persons in a clinical setting, models do not improve on a dentist's perception of risk after examining a patient and considering the personal circumstances (*45*).

Populations believed to be at increased risk for dental caries are those with low socioeconomic status (SES) or low levels of parental education, those who do not seek regular dental care, and those without dental insurance or access to dental services (*45--47*). Persons can be at high risk for dental caries even if they do not have these recognized factors. Individual factors that possibly increase risk include active dental caries; a history of high caries in older siblings or caregivers; root surfaces exposed by gingival recession; high levels of infection with cariogenic bacteria; impaired ability to maintain oral hygiene; malformed enamel or dentin; reduced salivary flow because of medications, radiation treatment, or disease; low salivary buffering capacity (i.e., decreased ability of saliva to neutralize acids); and the wearing of space maintainers, orthodontic appliances, or dental prostheses. Risk can increase if any of these factors are combined with dietary practices conducive to dental caries (i.e., frequent consumption of refined carbohydrates). Risk decreases with adequate exposure to fluoride (*44,45*).

Risk for dental caries and caries experience* exists on a continuum, with each person at risk to some extent; 85% of U.S. adults have experienced tooth decay (*48*). Caries risk can vary over time --- perhaps numerous times during a person's lifetime --- as risk factors change. Because caries prediction is an inexact, developing science, risk is dichotomized as low and high in this report. If these two categories of risk were applied to the U.S. population, most persons would be classified as low risk at any given time.

Children and adults who are at low risk for dental caries can maintain that status through frequent exposure to small amounts of fluoride (e.g., drinking fluoridated water and using fluoride toothpaste). Children and adults at high risk for dental caries might benefit from additional exposure to fluoride (e.g., mouthrinse, dietary supplements, and professionally applied products). All available information on risk factors should be considered before a group or person is identified as being at low or high risk for dental caries. However, when classification is uncertain, treating a person as high risk is prudent until further information or experience allows a more accurate assessment. This assumption increases the immediate cost of caries prevention or treatment and might increase the risk for enamel fluorosis for children aged <6 years, but reduces the risk for dental caries for groups or persons misclassified as low risk.

RISK FOR ENAMEL FLUOROSIS

The proper amount of fluoride helps prevent and control dental caries. Fluoride ingested during tooth development can also result in a range of visually detectable changes in enamel opacity (i.e., light refraction at or below the surface) because of hypomineralization. These changes have been broadly termed enamel fluorosis, certain extremes of which are cosmetically objectionable (*49*). (Many other developmental changes that affect the appearance of enamel are not related to fluoride [*50*].) Severe forms of this condition can occur only when young children ingest excess fluoride, from any source, during critical periods of tooth development. The occurrence of enamel fluorosis is reported to be most strongly associated with cumulative fluoride intake during enamel development, but the severity of the condition depends on the dose, duration, and timing of fluoride intake. The transition and early maturation stages of enamel development appear to be most susceptible to the effects of fluoride (*51*); these stages occur at varying times for different tooth types. For central incisors of the upper jaw, for example, the most sensitive period is estimated at age 15--24 months for boys and age 21--30 months for girls (*51,52*).

Concerns regarding the risk for enamel fluorosis are limited to children aged ≤8 years; enamel is no longer susceptible once its preeruptive maturation is complete (*11*). Fluoride sources for children aged ≤8 years are drinking water, processed beverages and food, toothpaste, dietary supplements that include fluoride (tablets or drops), and other dental products. This report discusses the risk for enamel fluorosis among children aged <6 years. Children aged ≥6 years are considered past the age that fluoride ingestion can cause cosmetically objectionable fluorosis because only certain posterior teeth are still at a susceptible stage of enamel development, and these will not be readily visible. In addition, the swallowing reflex has developed sufficiently by age 6 years for most children to be able to control inadvertent swallowing of fluoride toothpaste and mouthrinse.

The very mild and mild forms of enamel fluorosis appear as chalklike, lacy markings across a tooth's enamel surface that are not readily apparent to the affected person or casual observer (*53*). In the moderate form, >50% of the enamel surface is opaque white. The rare, severe form manifests as pitted and brittle enamel. After eruption, teeth with moderate or severe fluorosis might develop areas of brown stain (*54*). In the severe form, the compromised enamel might break away, resulting in excessive wear of the teeth. Even in its severe form, enamel fluorosis is considered a cosmetic effect, not an adverse functional effect (*8,11,55,56*). Some persons choose to modify this condition with elective cosmetic treatment.

The benefits of reduced dental caries and the risk for enamel fluorosis are linked. Early studies that examined the cause of "mottled enamel" (now called moderate to severe enamel fluorosis) led to the unexpected discovery that fluoride in community drinking water inhibits dental caries (*57*). Historically, a low prevalence of the milder forms of enamel fluorosis has been accepted as a reasonable and minor consequence balanced against the substantial protection from dental caries from drinking water containing an optimal concentration of fluoride, either naturally occurring or through adjustment (*11,53*). When enamel fluorosis was first systematically investigated during the 1930s and 1940s, its prevalence was 12%--15% for very mild and mild forms and zero for moderate and severe forms among children who lived in communities with drinking water that naturally contained 0.9--1.2 ppm fluoride (*53*). Although the prevalence of this condition in the United States has since increased (*8,58,59*), most fluorosis today is of the mildest form, which affects neither cosmetic appearance nor dental function. The increased prevalence in areas both with and without fluoridated community drinking water (*8*) indicates that, during the first 8 years of life (i.e., the window of time when this condition can develop), the total intake of fluoride from all sources has increased for some children.

The 1986--1987 National Survey of Dental Caries in U.S. School Children (the most recent national estimates of enamel fluorosis prevalence) indicated that the prevalence of any enamel fluorosis among children was 22%--23% (range: 26% of children aged 9 years to 19% of those aged 17 years) (*60,61*). Almost all cases reported in the survey were of the very mild or mild form, but some cases of the moderate (1.1%) and severe (0.3%) forms were observed. Cases of moderate and severe forms occurred even among children living in areas with low fluoride concentrations in the drinking water (*61*). Although this level of enamel fluorosis is not considered a public health problem (*53*), prudent public health practice should seek to minimize this condition, especially moderate to severe forms. In addition, changes in public perceptions of what is cosmetically acceptable could influence support for effective caries-prevention measures. Research into the causes of enamel fluorosis has focused on identifying risk factors (*62--65*). Adherence to the recommendations in this report regarding appropriate use of fluoride for children aged ≤6 years will reduce the prevalence and severity of enamel fluorosis.

NATIONAL GUIDELINES FOR FLUORIDE USE

PHS recommendations for fluoride use include an optimally adjusted concentration of fluoride in community drinking water to maximize caries prevention and limit enamel fluorosis. This concentration ranges from 0.7 ppm to 1.2 ppm depending on the average maximum daily air temperature of the area (*66--68*). In 1991, PHS also issued policy and research recommendations for fluoride use (*8*). The U.S. Environmental Protection Agency (EPA), which is responsible for the safety and quality of drinking water in the United States, sets a maximum allowable limit for fluoride in community drinking water at 4 ppm and a secondary limit (i.e., nonenforceable guideline) at 2 ppm (*69,70*). The U.S. Food and Drug Administration (FDA) is responsible for approving prescription and over-the-counter fluoride products marketed in the United States and for setting standards for labeling bottled water (*71*) and over-the-counter fluoride products (e.g., toothpaste and mouthrinse) (*72*).

Nonfederal agencies also have published guidelines on fluoride use. The American Dental Association (ADA) reviews fluoride products for caries prevention through its voluntary Seal of Acceptance program; accepted products are listed in the *ADA Guide to Dental Therapeutics* (*73*). A dosage schedule for fluoride supplements for infants and children aged ≤16 years, which is scaled to the fluoride concentration in the community drinking water, has been jointly recommended by ADA, the

American Academy of Pediatric Dentistry (AAPD), and the American Academy of Pediatrics (AAP) (Table 1) (*44,74,75*). In 1997, the Institute of Medicine published age-specific recommendations for total dietary intake of fluoride (Table 2). These recommendations list adequate intake to prevent dental caries and tolerable upper intake, defined as a level unlikely to pose risk for adverse effects in almost all persons.

FLUORIDE SOURCES AND THEIR EFFECTS

Fluoridated community drinking water and fluoride toothpaste are the most common sources of fluoride in the United States and are largely responsible for the low risk for dental caries for most persons in this country. Persons at high risk for dental caries might require more frequent or more concentrated exposure to fluoride and might benefit from use of other fluoride modalities (e.g., mouthrinse, dietary supplements, and topical gel, foam, or varnish). The effects of each of these fluoride sources on dental caries and enamel fluorosis are described.

Fluoridated Drinking Water and Processed Beverages and Food

Fluoridated drinking water contains a fluoride concentration effective for preventing dental caries; this concentration can occur naturally or be reached through water fluoridation, which is the controlled addition of fluoride to a public water supply. When fluoridated water is the main source of drinking water, a low concentration of fluoride is routinely introduced into the mouth. Some of this fluoride is taken up by dental plaque; some is transiently present in saliva, which serves as a reservoir for plaque fluoride; and some is loosely held on the enamel surfaces (*76*). Frequent consumption of fluoridated drinking water and beverages and food processed in fluoridated areas maintains the concentration of fluoride in the mouth.

Estimates of fluoride intake among U.S. and Canadian adults have ranged from ≤1.0 mg fluoride per day in nonfluoridated areas to 1--3 mg fluoride per day in fluoridated areas (*77--80*). The average daily dietary fluoride intake for both children and adults in fluoridated areas has remained relatively constant for several years (*11*). For children who live in optimally fluoridated areas, this average is approximately 0.05 mg/kg/day (range: 0.02--0.10); for children who live in nonfluoridated areas, the average is approximately half (*11*). In a survey of four U.S. cities with different fluoride concentrations in the drinking water (range: 0.37--1.04 ppm), children aged 2 years ingested 0.41--0.61 mg fluoride per day and infants aged 6 months ingested 0.21--0.54 mg fluoride per day (*81,82*).

In the United States, water and processed beverages (e.g., soft drinks and fruit juices) can provide approximately 75% of a person's fluoride intake (*83*). Many processed beverages are prepared in locations where the drinking water is fluoridated. Foods and ingredients used in food processing vary in their fluoride content (*11*). As consumption of processed beverages by children increases, fluoride intake in communities without fluoridated water will increase whenever the water source for the processed beverage is fluoridated (*84*). In fluoridated areas, dietary fluoride intake has been stable because processed beverages have been substituted for tap water and for beverages prepared in the home using tap water (*11*).

A study of Iowa infants estimated that the mean fluoride intake from water during different periods during the first 9 months of life, either consumed directly or added to infant formula or juice, was 0.29--0.38 mg per day, although estimated intake for some infants was as high as 1.73 mg per day (*85*). As foods are added to an infant's diet, replacing some of the formula prepared with fluoridated water, the amount of fluoride the infant receives typically decreases (*86*). The Iowa study also reported that infant formula and processed baby food contained variable amounts of fluoride. Since 1979, U.S. manufacturers of infant formula have voluntarily lowered the fluoride concentration of their products, both ready-to-feed and concentrates, to <0.3 ppm fluoride (*87*).

Drinking Water

Community Water. During the 1940s, researchers determined that 1 ppm fluoride was the optimal concentration in community drinking water for climates similar to the Chicago area (*88,89*). This concentration would substantially reduce the prevalence of dental caries, while allowing an acceptably low prevalence (i.e., 10%--12%) of very mild and mild enamel fluorosis and no moderate or severe enamel fluorosis. Water fluoridation for caries control began in 1945 and 1946, when the fluoride concentration was adjusted in the drinking water supplying four communities in the United States and Canada (*2--5*). This public health approach followed a long period of epidemiologic research into the effects of naturally occurring fluoride in drinking water (*53,57,88,89*).

Current federal fluoridation guidelines, maintained by the PHS since 1962, state that community drinking water should contain 0.7--1.2 ppm fluoride, depending on the average maximum daily air temperature of the area. These temperature-related guidelines are based on epidemiologic studies conducted during the 1950s that led to the development of an algebraic formula for determining optimal fluoride concentrations (*67,90--92*). This formula determined that a lower fluoride concentration was appropriate for communities in warmer climates because persons living in warmer climates drank more tap water. However, social and environmental changes since 1962 (e.g., increased use of air conditioning and more sedentary lifestyles) have reduced the likelihood that persons in warmer regions drink more tap water than persons in cooler regions (*7*).

By 1992, fluoridated water was reaching 144 million persons in the United States (56% of the total population and 62% of those receiving municipal water supplies) (*93*). Approximately 10 million of these persons were receiving water containing naturally occurring fluoride at a concentration of ≥0.7 ppm. In 11 states and the District of Columbia, >90% of the population had such access, whereas <5% received this benefit in two states. In 2000, a total of 38 states and the District of Columbia provided access to fluoridated public water supplies to ≥50% of their population (CDC, unpublished data, 2000) (Figure 2).

Initial studies of community water fluoridation demonstrated that reductions in childhood dental caries attributable to fluoridation were approximately 50%--60% (*94--97*). More recent estimates are lower --- 18%--40% (*98,99*). This decrease in attributable benefit is likely caused by the increasing use of fluoride from other sources, with the widespread use of fluoride toothpaste probably the most important. The diffusion or "halo" effect of beverages and food processed in fluoridated areas but consumed in nonfluoridated areas also indirectly spreads some benefit of fluoridated water to nonfluoridated communities. This effect lessens the differences in caries experience among communities (*100*).

Quantifying the benefits of water fluoridation among adults is more complicated because adults are rarely surveyed, their fluoride histories are potentially more varied, and their tooth loss or restorations might be caused by dental problems other than caries (e.g., trauma or periodontal diseases). Nevertheless, adults are reported to receive caries-preventive benefits from community water fluoridation (*99,101--103*). These benefits might be particularly advantageous for adults aged >50 years, many of whom are at increased risk for dental caries. Besides coronal caries, older adults typically experience gingival recession, which results in teeth with exposed root surfaces. Unlike the crowns of teeth, these root surfaces are not covered by enamel and are more susceptible to caries. Because tooth retention among older age groups has increased in recent decades in the United States (*39*), these groups' risk for caries will increase as the country's population ages. Older adults also frequently require multiple medications for chronic conditions, and many of these medications can reduce salivary output (*104*). Drinking water containing an optimal concentration of fluoride can mitigate the risk factors for caries among older adults. Studies have reported that the prevalence of root caries among adults is inversely related to fluoride concentration in the community drinking water (*105--107*).

Water fluoridation also reduces the disparities in caries experience among poor and nonpoor children (*108--111*). Caries experience is considerably higher among persons in low SES strata than among those in high SES strata (*39,46,112*). The reasons for this discrepancy are not well understood; perhaps persons in low SES strata have less knowledge of oral diseases, have less access to dental care, are less likely to follow recommended self-care practices, or are harder to reach through traditional approaches, including public health programs and private dental care (*48*). Thus, these persons might receive more benefit from fluoridated community water than persons from high SES strata. Regardless of SES, water fluoridation is the most effective and efficient strategy to reduce dental caries (*112*).

Enamel fluorosis occurs among some persons in all communities, even in communities with a low natural concentration of fluoride. During 1930--1960, U.S. studies documented that, in areas with a natural or adjusted concentration of fluoride of approximately 1.0 ppm in the community drinking water, the permanent teeth of 7%-- 16% of children with lifetime residence in those areas exhibited very mild or mild forms of enamel fluorosis (*53,113,114*). Before 1945, when naturally fluoridated drinking water was virtually the only source of fluoride, the moderate and severe forms of this condition were not observed unless the natural fluoride concentration was ≥2 ppm (*53*). The likelihood of a child developing the mild forms of enamel fluorosis might be higher in a fluoridated area than in a nonfluoridated area, but prevalence might not change in every community (*115,116*). The most recent national study of this condition indicated that its prevalence had increased in both fluoridated and nonfluoridated areas since the 1940s, with the relative increase higher in nonfluoridated areas. In communities with drinking water containing 0.7--1.2 ppm fluoride, the prevalence was 1.3% for the moderate form of enamel fluorosis and zero for the severe form; thus, few cases of enamel fluorosis were likely to be of cosmetic consequence (*8,61*). Because combined fluoride intake from drinking water and processed beverages and food by children in fluoridated areas has reportedly remained stable since the 1940s, the increase in fluoride intake resulting in increased enamel fluorosis almost certainly stems from use of fluoride-containing dental products by children aged <6 years (*11*).

Two studies reported that extended consumption of infant formula beyond age 10--12 months was a risk factor for enamel fluorosis, especially when formula concentrate was mixed with fluoridated water (*62,63*). These studies examined children who used pre-1979 formula (with higher fluoride concentrations). Whether fluoride intake from formula that exceeds the recommended amount during only the first 10--12 months of life contributes to the prevalence or severity of enamel fluorosis is unknown.

Fluoride concentrations in drinking water should be maintained at optimal levels, both to achieve effective caries prevention and because changes in fluoride concentration as low as 0.2 ppm can result in a measurable change in the prevalence and severity of enamel fluorosis (*52,117*). Since the late 1970s, CDC has provided guidelines and recommendations for managers of fluoridated water supply systems at state and local levels to help them establish and maintain appropriate fluoride concentrations. CDC periodically updates these guidelines; the most recent revision was published in 1995 (*68*).

School Water Systems. In some areas of the United States where fluoridating a community's drinking water was not feasible (e.g., rural areas), the alternative of fluoridating a school's public water supply system was promoted for many years. This method was used when a school had its own source of water and was not connected to a community water supply system (i.e., stand-alone systems). Because children are at school only part of each weekday, a fluoride concentration of 4.5 times the optimal concentration for a community in the same geographic area was recommended (*118*) to compensate for the more limited consumption of fluoridated water. At the peak of this practice in the early 1980s, a total of 13 states had initiated school water fluoridation in 470 schools serving 170,000 children (*39*). Since then, school water fluoridation has been phased out in several states; the current extent of this practice is not known.

Studies of the effects of school water fluoridation in the United States reported that this practice reduced caries among schoolchildren by approximately 40% (*118--122*). A more recent study indicated that this effect might no longer be as pronounced (*123*).

Several concerns regarding school water fluoridation exist. Operating and maintaining small fluoridation systems (i.e., those serving <500 persons) create practical and logistical difficulties (*68*). These difficulties have occasionally caused higher than recommended fluoride concentrations in the school drinking water, but no lasting effects among children have been observed (*124--126*). In schools that enroll preschoolers in day care programs, children aged <6 years might receive more than adequate fluoride.

Bottled Water. Many persons drink bottled water, replacing tap water partially or completely as a source of drinking water. Water is classified as "bottled water" if it meets all applicable federal and state standards, is sealed in a sanitary container, and is sold for human consumption. Although some bottled waters marketed in the United States contain an optimal concentration of fluoride (approximately 1.0 ppm), most contain <0.3 ppm fluoride (*127--129*). Thus, a person substituting bottled water with a low fluoride concentration for fluoridated community water might not receive the full benefits of community water fluoridation (*130*). For water bottled in the United States, current FDA regulations require that fluoride be listed on the label only if the bottler adds fluoride during processing; the concentration of fluoride is regulated but does not have to be stated on the label (Table 3). Few bottled water brands have labels listing the fluoride concentration.

Determining Fluoride Concentration. Uneven geographic coverage of community water fluoridation throughout the United States, wide variations in natural fluoride concentrations found in drinking water, and almost nonexistent labeling of fluoride concentration in bottled water make knowing the concentration of fluoride in drinking water difficult for many persons. Persons in nonfluoridated areas can mistakenly believe their water contains an optimal concentration of fluoride. To obtain the fluoride concentration of community drinking water, a resident can contact the water supplier or a local public health authority, dentist, dental hygienist, physician, or other knowledgeable source. EPA requires that all community water supply systems provide each customer an annual report on the quality of water, including the fluoride concentration (*131*). Testing for private wells is available through local and state public health departments as well as some private laboratories. If the fluoride concentration is not listed on the label of bottled water, the bottler can be contacted directly to obtain this information.

Fluoride Toothpaste

Fluoride is the only nonprescription toothpaste additive proven to prevent dental caries. When introduced into the mouth, fluoride in toothpaste is taken up directly by dental plaque (*132--134*) and demineralized enamel (*135,136*). Brushing with fluoride toothpaste also increases the fluoride concentration in saliva 100- to 1,000-fold; this concentration returns to baseline levels within 1--2 hours (*137*). Some of this salivary fluoride is taken up by dental plaque. The ambient fluoride concentration in saliva and plaque can increase during regular use of fluoride toothpaste (*132,133*).

By the 1990s, fluoride toothpaste accounted for >90% of the toothpaste market in the United States, Canada, and other developed countries (*138*). Because water fluoridation is not available in many countries, toothpaste might be the most important source of fluoride globally (*1*).

Studies of 2--3 years duration have reported that fluoride toothpaste reduces caries experience among children by a median of 15%--30% (*139--148*). This reduction is modest compared with the effect of water fluoridation, but water fluoridation studies usually measured lifetime --- rather than a few years' --- exposure. Regular lifetime use of fluoride toothpaste likely provides ongoing benefits that might approach those of fluoridated water. Combined use of fluoride toothpaste and fluoridated water offers protection above either used alone (*99,149,150*).

Few studies evaluating the effectiveness of fluoride toothpaste, gel, rinse, and varnish among adult populations are available. Child populations have typically been used for studies on caries prevention because of perceived increased caries susceptibility and logistical reasons. However, teeth generally remain susceptible to caries throughout life, and topically applied fluorides could be effective in preventing caries in susceptible patients of any age (*151,152*).

Most persons report brushing their teeth at least once per day (*153,154*), but more frequent use can offer additional protection (*139,141,155--158*). Brushing twice a day is a reasonable social norm that is both effective and convenient for most persons' daily routines, and this practice has become a basic recommendation for caries prevention. Whether increasing the number of daily brushings from two to three times a day results in lower dental caries experience is unclear. Because the amount and vigor of rinsing after toothbrushing affects fluoride concentration in the mouth and reportedly affects caries experience (*157--160*), persons aged ≥6 years can retain more fluoride in the mouth by either rinsing briefly with a small amount of water or not at all.

In the United States, the standard concentration of fluoride in fluoride toothpaste is 1,000--1,100 ppm. Toothpaste containing 1,500 ppm fluoride has been reported to be slightly more efficacious in reducing dental caries in U.S. and European studies (*161--164*). Products with this fluoride concentration have been marketed in the United States, but are not available in all areas. These products might benefit persons aged ≥6 years at high risk for dental caries.

Children who begin using fluoride toothpaste at age <2 years are at higher risk for enamel fluorosis than children who begin later or who do not use fluoride toothpaste at all (*62,63,165--170*). Because studies have not used the same criteria for age of initiation, amount of toothpaste used, or frequency of toothpaste use, the specific contribution of each factor to enamel fluorosis among this age group has not been established.

Fluoride toothpaste contributes to the risk for enamel fluorosis because the swallowing reflex of children aged <6 years is not always well controlled, particularly among children aged <3 years (*171,172*). Children are also known to swallow toothpaste deliberately when they like its taste. A child-sized toothbrush covered with a full strip of toothpaste holds approximately 0.75--1.0 g of toothpaste, and each gram of fluoride toothpaste, as formulated in the United States, contains approximately 1.0 mg of fluoride. Children aged <6 years swallow a mean of 0.3 g of toothpaste per brushing (*11*) and can inadvertently swallow as much as 0.8 g (*138,173--176*). As a result, multiple brushings with fluoride toothpaste each day can result in ingestion of excess fluoride (*177*). For this reason, high-fluoride toothpaste (i.e., containing 1,500 ppm fluoride) is generally contraindicated for children aged <6 years.

Use of a pea-sized amount (approximately 0.25 g) of fluoride toothpaste ≤2 times per day by children aged <6 years is reported to sharply reduce the importance of fluoride toothpaste as a risk factor for enamel fluorosis (*65*). Since 1991, manufacturers of fluoride toothpaste marketed in the United States have, as a requirement for obtaining the ADA Seal of Acceptance, placed instructions on the package label stating that children aged <6 years should use only this amount of toothpaste. Toothpaste labeling requirements mandated by FDA in 1996 (*72*) also direct parents of children aged <2 years to seek advice from a dentist or physician before introducing their child to fluoride toothpaste.

The propensity of young children to swallow toothpaste has led to development of "child-strength" toothpaste with lower fluoride concentrations (*176*). Such a product would be a desirable alternative to currently available products for many young children. Clinical trials outside the United States have reported that toothpaste containing 250 ppm fluoride is less effective than toothpaste containing 1,000 ppm fluoride in preventing dental caries (*178,179*). However, toothpaste containing 500--550 ppm fluoride might be almost as efficacious as that containing 1,000 ppm fluoride (*180*). A British study reported that the prevalence of diffuse enamel opacities (an indicator of mild enamel fluorosis) in the upper anterior incisors was substantially lower among children who used toothpaste containing 550 ppm fluoride than among those who used toothpaste containing 1,050 ppm fluoride (*181*). Toothpaste containing 400 ppm fluoride has been available in Australia and New Zealand for approximately 20 years, but has not been tested in clinical trials, and no data are available to assess whether toothpaste at this concentration has reduced the prevalence of enamel fluorosis in those countries. A U.S. clinical trial of the efficacy of toothpaste with lower fluoride concentrations, required by FDA before approval for marketing and distribution, has not been conducted (*182*).

Fluoride Mouthrinse

Fluoride mouthrinse is a concentrated solution intended for daily or weekly use. The fluoride from mouthrinse, like that from toothpaste, is retained in dental plaque and saliva to help prevent dental caries (*183*). The most common fluoride compound used in mouthrinse is sodium fluoride. Over-the-counter solutions of 0.05% sodium fluoride (230 ppm fluoride) for daily rinsing are available for use by persons aged >6 years. Solutions of 0.20% sodium fluoride (920 ppm fluoride) are used in supervised, school-based weekly rinsing programs. Throughout the 1980s, approximately 3 million children in the United States participated in school-based fluoride mouthrinsing programs (*39*). The current extent of such programs is not known.

Studies indicating that fluoride mouthrinse reduces caries experience among schoolchildren date mostly from the 1970s and early 1980s (*184--191*). In one review, the average caries reduction in nonfluoridated communities attributable to fluoride mouthrinse was 31% (*191*). Two studies reported benefits of fluoride mouthrinse approximately 2.5 and 7 years after completion of school-based mouthrinsing programs (*192,193*), but a more recent study did not find such benefits 4 years after completion of a mouthrinsing program (*194*). The National Preventive Dentistry Demonstration Program (NPDDP), a large project conducted in 10 U.S. cities during 1976--1981 to compare the cost and effectiveness of combinations of caries-prevention procedures, reported that fluoride mouthrinse had little effect among schoolchildren, either among first-grade students with high and low caries experience (*195*) or among all second- and fifth-grade students (*196*). NPDDP documented only a limited reduction in dental caries attributable to fluoride mouthrinse, especially when children were also exposed to fluoridated water.

Although no studies of enamel fluorosis associated with use of fluoride mouthrinse have been conducted, studies of the amount of fluoride swallowed by children aged 3--5 years using such rinses indicated that some young children might swallow substantial amounts (*191*). Use of fluoride mouthrinse by children aged ≥6 years does not place them at risk for cosmetically objectionable enamel fluorosis because they are generally past the age that fluoride ingestion might affect their teeth.

Dietary Fluoride Supplements

Dietary fluoride supplements in the form of tablets, lozenges, or liquids (including fluoride-vitamin preparations) have been used throughout the world since the 1940s. Most supplements contain sodium fluoride as the active ingredient. Tablets and lozenges are manufactured with 1.0, 0.5, or 0.25 mg fluoride. To maximize the topical effect of fluoride, tablets and lozenges are intended to be chewed or sucked for 1--2 minutes before being swallowed. For infants, supplements are available as a liquid and used with a dropper.

In 1986, an estimated 16% of U.S. children aged <2 years used fluoride supplements (*197*). All fluoride supplements must be prescribed by a dentist or physician. The prescription should be consistent with the 1994 dosage schedule developed by ADA, AAPD, and AAP (Table 1). Because fluoride supplements are intended to compensate for fluoride-deficient drinking water, the dosage schedule requires knowledge of the fluoride content of the child's primary drinking water; consideration should also be given to other sources of water (e.g., home, child care settings, school, or bottled water) and to other sources of fluoride (e.g., toothpaste or mouthrinse), which can complicate the prescribing decision.

The evidence for using fluoride supplements to mitigate dental caries is mixed. Use of fluoride supplements by pregnant women does not benefit their offspring (*198*). Several studies have reported that fluoride supplements taken by infants and children before their teeth erupt reduce the prevalence and severity of caries in teeth (*98,199--207*), but several other studies have not (*19,208--212*). Among children aged 6--16 years, fluoride supplements taken after teeth erupt reduce caries experience (*213--215*). Fluoride supplements might be beneficial among adults who have limitations with toothbrushing, but this use requires further study.

A few studies have reported no association between supplement use by children aged <6 years and enamel fluorosis (*208,216*), but most have reported a clear association (*19,62,64,165,170,199--201,209,210,212,217--222*). In one study, the risk for this condition was high when supplements were used in fluoridated areas (odds ratio = 23.74; 95% confidence interval = 3.43--164.30) (*62*), a use inconsistent with the supplement schedule. Reports of the frequency of supplement use in fluoridated areas have ranged from 7% to 35% (*223--228*). In response to the accumulated data on fluoride intake and the prevalence of enamel fluorosis, the supplement dosage schedule for children aged <6 years was markedly reduced in 1994 when ADA, AAPD, and AAP jointly established the current schedule (Table 1) (*73*). The risk for enamel fluorosis among children this age attributable to fluoride supplements could be lower, but not enough information is available yet to evaluate the effects of this change.

When prescribing any pharmaceutical agent, dentists and physicians should attempt to maximize benefit and minimize harm (*229*). For infants and children aged <6 years, both a benefit of dental caries prevention and a risk for enamel fluorosis are possible. Although the primary (i.e., "baby") teeth of children aged 1--6 years would benefit from fluoride's posteruptive action, and some preeruptive benefit for developing permanent teeth could exist, fluoride supplements also could increase the risk for enamel fluorosis at this age (*138,223*).

Professionally Applied Fluoride Compounds

In the United States, dentists and dental hygienists have been applying high-concentration fluoride compounds directly to patients' teeth for approximately 50 years. Application procedures were developed on the assumption that the fluoride would be incorporated into the crystalline structure of the dental enamel and develop a more acid-resistant enamel. To maximize this reaction, a professional tooth cleaning was considered mandatory before the application. However, subsequent research has demonstrated that high-concentration fluoride compounds (e.g., those in gel or varnish) do not directly enter the enamel's crystalline structure (*230*). The compound forms a calcium fluoride-like material on the enamel's surface that releases fluoride for remineralization when the pH in the mouth drops. Thus, professional tooth cleaning solely to prepare the teeth for application of a fluoride compound is unnecessary; toothbrushing and flossing appear equally effective in improving the efficacy of high-concentration fluoride compounds (*231*).

Fluoride Gel and Foam

Because an early study reported that fluoride uptake by dental enamel increased in an acidic environment (*232*), fluoride gel is often formulated to be highly acidic (pH of approximately 3.0). Products available in the United States include gel of acidulated phosphate fluoride (1.23% [12,300 ppm] fluoride), gel or foam of sodium fluoride (0.9% [9,040 ppm] fluoride), and self-applied (i.e., home use) gel of sodium fluoride (0.5% [5,000 ppm] fluoride) or stannous fluoride (0.15% [1,000 ppm] fluoride) (*73*).

Clinical trials conducted during 1940--1970 demonstrated that professionally applied fluorides effectively reduce caries experience in children (*233*). In more recent studies, semiannual treatments reportedly caused an average decrease of 26% in caries experience in the permanent teeth of children residing in nonfluoridated areas (*191,234--236*). The application time for the treatments was 4 minutes. In clinical practice, applying fluoride gel for 1 minute rather than 4 minutes is common, but the efficacy of this shorter application time has not been tested in human clinical trials. In addition, the optimal schedule for repeated application of fluoride gel has not been adequately studied to support definitive guidelines, and studies that have examined the efficacy of various gel application schedules in preventing and controlling dental caries have reported mixed results. On the basis of the available evidence, the usual recommended frequency is semiannual (*151,237,238*).

Because these applications are relatively infrequent, generally at 3- to 12-month intervals, fluoride gel poses little risk for enamel fluorosis, even among patients aged <6 years. Proper application technique reduces the possibility that a patient will swallow the gel during application.

Fluoride Varnish

High-concentration fluoride varnish is painted directly onto the teeth. Fluoride varnish is not intended to adhere permanently; this method holds a high concentration of fluoride in a small amount of material in close contact with the teeth for many hours. Fluoride varnish has practical advantages (e.g., ease of application, a nonoffensive taste, and use of smaller amounts of fluoride than required for gel applications). Such varnishes are available as sodium fluoride (2.26% [2,600 ppm] fluoride) or difluorsilane (0.1% [1,000 ppm] fluoride) preparations.

Fluoride varnish has been widely used in Canada and Europe since the 1970s to prevent dental caries (*152,239*). FDA's Center for Devices and Radiological Health has cleared fluoride varnish as a medical device to be used as a cavity liner (i.e., to provide fluoride at the junction of filling material and tooth) and root desensitizer (i.e., to reduce sensitivity to temperature and touch that sometimes occurs on root surfaces exposed by receding gingiva) (*240*); FDA has not yet approved this product as an anticaries agent. Caries prevention is regarded as a drug claim, and companies would be required to submit appropriate clinical trial evidence for review before this product could be marketed as an anticaries agent. However, a prescribing practitioner can use fluoride varnish for caries prevention as an "off-label" use, based on professional judgement (*241*).

Studies conducted in Canada (*242*) and Europe (*243--246*) have reported that fluoride varnish is efficacious in preventing dental caries in children. Applied semiannually, this modality is as effective as professionally applied fluoride gel (*247*). Some researchers advocate application of fluoride varnish as many as four times per year to achieve maximum effect, but the evidence of benefits from more than two applications per year remains inconclusive (*240,246,248*). Other studies have reported that three applications in 1 week, once per year, might be more effective than the more conventional semiannual regimen (*249,250*).

European studies have reported that fluoride varnish prevents decalcification (i.e., an early stage of dental caries) beneath orthodontic bands (*251*) and slows the progression of existing enamel lesions (*252*). Studies examining the effectiveness of varnish in controlling early childhood caries are being conducted in the United States. Research on fluoride varnish (e.g., optimal fluoride concentration, the most effective application protocols, and its efficacy relative to other fluoride modalities) is likely to continue in both Europe and North America.

No published evidence indicates that professionally applied fluoride varnish is a risk factor for enamel fluorosis, even among children aged <6 years. Proper application technique reduces the possibility that a patient will swallow varnish during its application and limits the total amount of fluoride swallowed as the varnish wears off the teeth over several hours.

Fluoride Paste

Fluoride-containing paste is routinely used during dental prophylaxis (i.e., cleaning). The abrasive paste, which contains 4,000--20,000 ppm fluoride, might restore the concentration of fluoride in the surface layer of enamel removed by polishing, but it is not an adequate substitute for fluoride gel or varnish in treating persons at high risk for dental caries (*151*). Fluoride paste is not accepted by FDA or ADA as an efficacious way to prevent dental caries.

Combinations of Fluoride Modalities

Studies comparing various combinations of fluoride modalities have generally reported that their effectiveness in preventing dental caries is partially additive. That is, the percent reduction in the prevalence or severity of dental caries from a combination of modalities is higher than the percent reduction from each modality, but less than the sum of the percent reduction of the modalities combined. Attempts to use a formula to apply sequentially the percent reduction of an additional modality to the estimated remaining caries increment have overestimated the effect (*151,253*). For example, if the first modality reduces caries by 40% and the second modality reduces caries by 30%, then the calculation that caries will be reduced by a total of 58% (i.e., 40% plus 18% [30% of the 60% decay remaining after the first modality]) will likely be an overestimate.

QUALITY OF EVIDENCE FOR DENTAL CARIES PREVENTION AND CONTROL

Members of the work group convened by CDC identified the published research in their areas of expertise and evaluated the quality of scientific evidence for each fluoride modality in preventing and controlling dental caries. Evidence was drawn from the most relevant English-language, peer-reviewed scientific publications regarding the current effectiveness of fluoride modalities. Additional references were suggested by reviewers. Members used their own methods for critically analyzing articles. A formal protocol for duplicate review was not followed, but members collectively agreed on the grade reflecting the quality of evidence regarding each fluoride modality. Criteria used to grade the quality of scientific evidence (i.e., ordinal grading) was adapted from the U.S. Preventive Services Task Force (Box 1) (*254*). Grades range from I to III.

Community Water Fluoridation

Studies on the effectiveness of adjusting fluoride in community water to the optimal concentration cannot be designed as randomized clinical trials. Random allocation of study subjects is not possible when a community begins to fluoridate the water because all residents in a community have access to and are exposed to this source of fluoride. In addition, clinical studies cannot be conducted double-blind because both study subjects and researchers usually know whether a community's water has been fluoridated. Efforts to blind the examiners by moving study subjects to a neutral third site for clinical examinations, using radiographs of teeth without revealing where the subjects live, or including transient residents as study subjects have not fully resolved these inherent limitations. Early studies that led to the unexpected discovery that dental caries was less prevalent and severe among persons with mottled enamel (subsequently identified as a form of enamel fluorosis) were conducted before the caries-preventive effects of fluoride were known (*255*). In those studies, researchers did not have an a priori reason to suspect they would find either reduced or higher levels of dental caries experience in communities with low levels of mottled enamel. Researchers also had no reason to believe that patients selected where they lived according to their risk for dental caries. In that regard, these studies were randomized, and examiners were blinded.

Despite the strengths of early studies of the efficacy of naturally occurring fluoride in community drinking water, the limitations of these studies make summarizing the quality of evidence on community water fluoridation as Grade I inappropriate (Table 1). The quality of evidence from studies on the effectiveness of adjusting fluoride concentration in community water to optimal levels is Grade II-1. Research limitations are counterbalanced by broadly similar results from numerous well-conducted field studies by other investigators that included thousands of persons throughout the world (*256,257*).

School Water Fluoridation

Field trials on the effect of school water fluoridation were not blindly conducted and had no concurrent controls (*118*). Thus, the quality of evidence for this modality is Grade II-3.

Fluoride Toothpaste

Studies that have demonstrated the efficacy of fluoride toothpaste in preventing and controlling dental caries include all of the essential features of well-conducted clinical trials. These include randomized groups, double-blind designs, placebo controls, and meticulous procedural protocols. Taken together, the trials on fluoride toothpaste provide solid evidence that fluoride is efficacious in controlling caries (*144*). The quality of evidence for toothpaste is Grade I.

Fluoride Mouthrinse

Early studies of the efficacy of fluoride mouthrinse in reducing dental caries experience were randomized clinical trials (*184,185*) or studies that used historical control groups rather than concurrent control groups (*186--189*). The quality of evidence for fluoride mouthrinse is Grade I.

Dietary Fluoride Supplements

The only randomized controlled trial to assess fluoride supplements taken by pregnant women provides Grade I evidence of no benefit for their children. Many studies of the effectiveness of fluoride supplements in preventing dental caries among children aged <6 years have been flawed in design and conduct. Problems included self-selection into test and control groups, absence of concurrent controls, high attrition rates, and nonblinded examiners. Because of these flaws, the quality of evidence to support use of fluoride supplements by children aged <6 years is Grade II-3. The well-conducted randomized clinical trials on the effects of fluoride supplements on dental caries among children aged 6--16 years in programs conducted in schools provide Grade I evidence.

Fluoride Gel

The quality of evidence for using fluoride gel to prevent and control dental caries in children is Grade I. However, data were gathered when dental caries was more prevalent and severe than today. Subjects in earlier studies were probably more representative of persons who now would be characterized as being at high risk for caries.

Fluoride Varnish

The quality of evidence for the efficacy of high-concentration fluoride varnish in preventing and controlling dental caries in children is Grade I. Although the randomized controlled clinical studies that established Grade I evidence were conducted in Europe, U.S. results should be the same.

COST-EFFECTIVENESS OF FLUORIDE MODALITIES

Documented effectiveness is the most basic requirement for providing a health-care service and an important prerequisite for preventive services (e.g., caries-preventive modalities). However, effectiveness alone is not a sufficient reason to initiate a service. Other factors, including cost, must be considered (*254*). A modality is more cost-effective when deemed a less expensive way, from among competing alternatives, of meeting a stated objective (*258*). In public health planning, determination of the most cost-effective alternative for prevention is essential to using scarce resources efficiently. Dental-insurance carriers are also interested in cost-effectiveness so they can help purchasers use funds efficiently. Because half of dental expenditures are out of pocket (*259*), this topic interests patients and their dentists as well. Potential improvement to quality of life is also a consideration. The contribution of a healthy dentition to quality of life at any age has not been quantified, but is probably valued by most persons.

Although solid data on the cost-effectiveness of fluoride modalities alone and in combination are needed, this information is scarce. In 1989, the Cost Effectiveness of Caries Prevention in Dental Public Health workshop, which was attended by health economists, epidemiologists, and dental public health professionals, attempted to assess the cost-effectiveness of caries-preventive approaches available in the United States (*260*).

All other things being equal, fluoride modalities are most cost-effective for persons at high risk for dental caries. Because persons at low risk develop little dental caries, limited benefit is gained by adding caries-preventive modalities to water fluoridation and fluoride toothpaste, even those demonstrated to be effective among populations at high risk. Members of the CDC work group reached consensus regarding the populations for which each modality would be expected to have the necessary level of cost-effectiveness to warrant its use.

Community Water Fluoridation

Health economists at the 1989 workshop on cost-effectiveness of caries prevention calculated that the average annual cost of water fluoridation in the United States was $0.51 per person (range: $0.12--$5.41) (*260*). In 1999 dollars,** this cost would be $0.72 per person (range: $0.17--$7.62). Factors reported to influence the per capita cost included

- • size of the community (the larger the population reached, the lower the per capita cost);
- • number of fluoride injection points in the water supply system;
- • amount and type of system feeder and monitoring equipment used;
- • amount and type of fluoride chemical used, its price, and its costs of transportation and storage; and
- • expertise of personnel at the water plant.

When the effects of caries are repaired, the price of the restoration is based on the number of tooth surfaces affected. A tooth can have caries at >1 location (i.e., surface), so the number of surfaces saved is a more appropriate measure in calculating cost-effectiveness than the number of teeth with caries. The 1989 workshop participants concluded that water fluoridation is one of the few public health measures that results in true cost savings (i.e., the measure saves more money than it costs to operate); in the United States, water fluoridation cost an estimated average of $3.35 per carious surface saved ($4.71 in 1999 dollars**) (*260*). Even under the least favorable assumptions in 1989 (i.e., cities with populations <10,000, higher operating costs, and effectiveness projected at the low end of the range), the cost of a carious surface saved because of community water fluoridation ranged from $8 to $12 ($11--$17 in 1999 dollars**) (*260*), which is still lower than the fee for a one-surface restoration ($54 in 1995 or $65 in 1999 dollars***) (*261*).

A Scottish study conducted in 1980 reported that community water fluoridation resulted in a 49% saving in dental treatment costs for children aged 4--5 years and a 54% saving for children aged 11--12 years (*262*). These savings were maintained even after the secular decline in the prevalence of dental caries was recognized (*263*). The effect of community water fluoridation on the costs of dental care for adults is less clear. This topic cannot be fully explored until the generations who grew up drinking optimally fluoridated water are older.

School Water Fluoridation

Costs for school water fluoridation are similar to those of any public water supply system serving a small population (i.e., <1,000 persons). In 1988, the average annual cost of school water fluoridation was $4.52 per student per year (range: $0.81--$9.72) (*264*). In 1999 dollars,**** this cost would be $6.37 per person (range: $1.14--$13.69). Use of this modality must be carefully weighed in the current environment of low caries prevalence, widespread use of fluoride toothpaste, and availability of other fluoride modalities that can be delivered in the school setting.

Fluoride Toothpaste

Fluoride toothpaste is widely available, no more expensive than nonfluoride toothpaste, and periodically improved. Use of a pea-sized amount (0.25 g) twice per day requires approximately two tubes of toothpaste per year, for an estimated annual cost of $6--$12, depending on brand, tube size, and retail source (*265*). Persons who brush and use toothpaste regularly to maintain periodontal health and prevent stained teeth and halitosis (i.e., bad breath) incur no additional cost for the caries-preventive benefit of fluoride in toothpaste. Because of its multiple benefits, most persons consider fluoride toothpaste a highly cost-effective caries-preventive modality.

Fluoride Mouthrinse

Public health programs of fluoride mouthrinsing have long been presumed to be cost-effective, especially when teachers can supervise weekly rinsing in classrooms at no direct cost to the program. In other programs, volunteers or hourly workers provide supervision. Under these circumstances, administrators of fluoride mouthrinsing programs have claimed annual program costs of approximately $1 per child ($1.41 in 1999 dollars****) (*264*). This figure likely is an underestimate because indirect costs are not included (*196,266*). Fluoride mouthrinsing is a reasonable procedure for groups and persons at high risk for dental caries, but its cost-effectiveness as a universal, population-wide strategy in the modern era of widespread fluoride exposure is questionable (*267*).

Dietary Fluoride Supplements

Dietary fluoride supplements prescribed to persons cost an estimated $37 per year. Fluoride supplements in school programs have direct costs of approximately $2.50 per child ($3.52 in 1999 dollars****) for the tablet or lozenge (*264*); program administrative costs and considerations are similar to those in school mouthrinsing programs.

Professionally Applied Fluoride Compounds

High-concentration fluoride gel and varnish are effective in preventing dental caries, but because application requires professional expertise, they are inherently more expensive than self-applied methods (e.g., drinking fluoridated water or brushing with fluoride toothpaste). For groups and persons at low risk for dental caries, professionally applied methods are unlikely to be cost-effective (*268,269*). In the NPDDP study, prophylactic cleaning and gel application costs were $23 per year ($66 in 1999 dollars*****) for semiannual applications, which prevented 0.03--0.26 decayed surfaces per year (*196*). A Swedish study claimed that fluoride varnish was cost-effective, but few supporting data were presented (*270*). Varnish might be cost-effective in Scandinavian school dental services, in which dental professionals regularly examine and treat each student, but the cost-effectiveness of fluoride varnish in public health programs in the United States remains undocumented. Whether fluoride varnish or gel would be most efficiently used in clinical programs targeting groups at high risk for dental caries or should be reserved for individual patients at high risk is unclear.

Combinations of Fluoride Modalities

Because the caries-preventive effects of a combination of fluoride modalities are only partially additive, estimates of the cost-effectiveness when adding a modality (e.g., fluoride mouthrinse for a group already drinking fluoridated water and using fluoride toothpaste) should take into account these smaller, incremental reductions in caries. This consideration is particularly relevant for groups and persons at low risk for caries (*253*). The scarcity of research on the costeffectiveness of combinations limits the ability to draw more detailed conclusions.

RECOMMENDATIONS

In developing the recommendations for specific fluoride modalities that address public health and clinical practice and self-care, the CDC work group considered the quality of evidence of each modality's effect on dental caries, its association with enamel fluorosis, and its cost-effectiveness. The strength of the recommendation for each fluoride modality was determined by the work group, which adapted a coding system used by the U.S. Preventive Services Task Force (Box 2). The work group considered these factors when determining the population for which each recommendation applies (Table 4). The work group recognized that some recommendations can only be addressed by health-care industries or agencies and that additional research is required to resolve some questions regarding fluoride modalities.

Before promoting a fluoride modality or combination of modalities, the dental-care or other health-care provider must consider a person's or group's risk for dental caries, current use of other fluoride sources, and potential for enamel fluorosis. Although these recommendations are based on assessments of caries risk as low or high, the health-care provider might also differentiate among patients at high risk and provide more intensive interventions as needed. Also, a risk category can change over time; the type and frequency of preventive interventions should be adjusted accordingly.

Public Health and Clinical Practice

Continue and Extend Fluoridation of Community Drinking Water

Community water fluoridation is a safe, effective, and inexpensive way to prevent dental caries. This modality benefits persons in all age groups and of all SES, including those difficult to reach through other public health programs and private dental care. Community water fluoridation also is the most cost-effective way to prevent tooth decay among populations living in areas with adequate community water supply systems. Continuation of community water fluoridation for these populations and its adoption in additional U.S. communities are the foundation for sound caries-prevention programs.

In contrast, the appropriateness of fluoridating stand-alone water systems that supply individual schools is limited. Widespread use of fluoride toothpaste, availability of other fluoride modalities that can be delivered in the school setting, and the current environment of low caries prevalence limit the appropriateness of fluoridating school drinking water at 4.5 times the optimal concentration for community drinking water. Decisions to initiate or continue school fluoridation programs should be based on an assessment of present caries risk in the target school(s), alternative preventive modalities that might be available, and periodic evaluation of program effectiveness.

Counsel Parents and Caregivers Regarding Use of Fluoride Toothpaste by Young Children, Especially Those Aged <2 Years

Fluoride toothpaste is a cost-effective way to reduce the prevalence of dental caries. However, for children aged <6 years, especially those aged <2 years, an increased risk for enamel fluorosis exists because of inadequately developed control of the swallowing reflex. Parents or caregivers should be counseled regarding selfcare recommendations for toothpaste use for young children (i.e., limit the child's toothbrushing to ≤2 times a day, apply a peasized amount to the toothbrush, supervise toothbrushing, and encourage the child to spit out excess toothpaste).

For children aged <2 years, the dentist or other healthcare provider should consider the fluoride level in the community drinking water, other sources of fluoride, and factors likely to affect susceptibility to dental caries when weighing the risk and benefits of using fluoride toothpaste.

Target Mouthrinsing to Persons at High Risk

Because fluoride mouthrinse has resulted in only limited reductions in caries experience among schoolchildren, especially as their exposure to other sources of fluoride has increased, its use should be targeted to groups and persons at high risk for caries (see Risk for Dental Caries). Children aged <6 years should not use fluoride mouthrinse without consultation with a dentist or other health-care provider because enamel fluorosis could occur if such mouthrinses are repeatedly swallowed.

Judiciously Prescribe Fluoride Supplements

Fluoride supplements can be prescribed for children at high risk for dental caries and whose primary drinking water has a low fluoride concentration. For children aged <6 years, the dentist, physician, or other health-care provider should weigh the risk for caries without fluoride supplements, the caries prevention offered by supplements, and the potential for enamel fluorosis. Consideration of the child's other sources of fluoride, especially drinking water, is essential in determining this balance. Parents and caregivers should be informed of both the benefit of protection against dental caries and the possibility of enamel fluorosis. The prescription dosage of fluoride supplements should be consistent with the schedule established by ADA, AAPD, and AAP. Supplements can be prescribed for persons as appropriate or used in school-based programs. When practical, supplements should be prescribed as chewable tablets or lozenges to maximize the topical effects of fluoride.

Apply High-Concentration Fluoride Products to Persons at High Risk for Dental Caries

High-concentration fluoride products can play an important role in preventing and controlling dental caries among groups and persons at high risk. Dentists and other health-care providers must consider the risk status and age of the patient to determine the appropriate intensity of treatment. Routine use of professionally applied fluoride gel or foam likely provides little benefit to persons not at high risk for dental caries, especially those who drink fluoridated water and brush daily with fluoride toothpaste.

If FDA approves use of fluoride varnish to prevent and control dental caries, its indications for use will be similar to those of fluoride gel. Such varnishes have practical advantages for children aged <6 years at high risk.

Self-Care

Know the Fluoride Concentration in the Primary Source of Drinking Water

All persons should know whether the fluoride concentration in their primary source of drinking water is below optimal, optimal, or above optimal. This knowledge is the basis for all individual and professional decisions regarding use of other fluoride modalities (e.g., mouthrinse or supplements). Parents and caregivers of children, especially children aged <6 years, must know the fluoride concentration in their child's drinking water when considering whether to alter the child's fluoride intake. For example, in nonfluoridated areas where the natural fluoride concentration is below optimal, fluoride supplements might be considered, whereas in areas where the natural fluoride concentration is >2 ppm, children should use alternative sources of drinking water. Knowledge of the water's fluoride concentration is also key in public policy discussions regarding community water fluoridation.

Frequently Use Small Amounts of Fluoride

All persons should receive frequent exposure to small amounts of fluoride, which minimizes dental caries by inhibiting demineralization of tooth enamel and facilitating tooth remineralization. This exposure can be readily accomplished by drinking water with an optimal fluoride concentration and brushing with a fluoride toothpaste twice daily.

Supervise Use of Fluoride Toothpaste Among Children Aged <6 Years

Children's teeth should be cleaned daily from the time the teeth erupt in the mouth. Parents and caregivers should consult a dentist or other health-care provider before introducing a child aged <2 years to fluoride toothpaste. Parents and caregivers of children aged <6 years who use fluoride toothpaste should follow the directions on the label, place no more than a pea-sized amount (0.25 g) of toothpaste on the toothbrush, brush the child's teeth (recommended particularly for preschool-aged children) or supervise the toothbrushing, and encourage the child to spit excess toothpaste into the sink to minimize the amount swallowed. Indiscriminate use can result in inadvertent swallowing of more fluoride than is recommended.

Consider Additional Measures for Persons at High Risk for Dental Caries

Persons at high risk for dental caries might require additional fluoride or other preventive measures to reduce development of caries. This additional fluoride can come from daily use of another fluoride product at home or from professionally applied, topical fluoride products. Other preventive measures might include dental sealants and targeted antimicrobial therapies. Parents and caregivers should not provide additional fluoride to children aged <6 years without consulting a dentist or other health-care provider regarding the associated benefits and potential for enamel fluorosis. Persons should seek professional advice regarding their risk status or that of their children.

Use an Alternative Source of Water for Children Aged ≤8 Years Whose Primary Drinking Water Contains >2 ppm Fluoride

In some regions in the United States, community water supply systems and home wells contain a natural concentration of fluoride >2 ppm. At this concentration, children aged ≤8 years are at increased risk for developing enamel fluorosis, including the moderate and severe forms, and should have an alternative source of drinking water, preferably one containing fluoride at an optimal concentration.

In areas where community water supply systems contain >2 ppm but <4 ppm fluoride, EPA requires that each household be notified annually of the desirability of using an alternative source of water for children aged ≤8 years. For families receiving water from home wells, testing is necessary to determine the natural fluoride concentration.

Consumer Product Industries and Health Agencies

Label the Fluoride Concentration of Bottled Water

Producers of bottled water should label the fluoride concentration of their products. Such labeling will allow consumers to make informed decisions and dentists, dental hygienists, and other health-care professionals to appropriately advise patients regarding fluoride intake and use of fluoride products.

Promote Use of Small Amounts of Fluoride Toothpaste Among Children Aged <6 Years

Labels and advertisements for fluoride toothpaste should promote use of a pea-sized amount (0.25 g) of toothpaste on a child-sized toothbrush for children aged <6 years. Efforts to educate parents and caregivers and to encourage supervised use of fluoride toothpaste among young children can reduce inadvertent swallowing of excess toothpaste.

Develop a Low-Fluoride Toothpaste for Children Aged <6 Years

Manufacturers are encouraged to develop a dentifrice for children aged <6 years that is effective in preventing dental caries but alleviates the risk for enamel fluorosis. A "child-strength" toothpaste with a fluoride concentration lower than current products could reduce the risk for cosmetic concerns associated with inadvertent swallowing of toothpaste.

Collaborate to Educate Health-Care Professionals and the Public

Professional health-care organizations, public health agencies, and suppliers of oral-care products should collaborate to educate health-care professionals and trainees and the public regarding the recommendations in this report. Broad collaborative efforts to educate health-care professionals and the public and to encourage behavior change can promote improved, coordinated use of fluoride modalities.

Further Research

Continue Metabolic Studies of Fluoride

Metabolic studies with animals and humans to determine the influence of environmental, physiological, and pathological conditions on the pharmacokinetics and effects of fluoride should continue. Research in these areas will enhance the knowledge base concerning fluoride use, thereby resulting in more effective and efficient use of fluoride.

Identify Biomarkers of Fluoride

As an alternative to direct fluoride intake measurement, biomarkers (i.e., distinct biological indicators) should be identified to estimate a person's fluoride intake and the amount of fluoride in the body. Identification of such biomarkers could allow more efficient research.

Reevaluate the Method of Determining Optimal Fluoride Concentration of Community Drinking Water

The current method of determining the optimal concentration of fluoride in community drinking water, which depends on the average maximum annual ambient air temperature, should be reevaluated because of the social and environmental changes that have occurred since it was adopted in 1962. Research into current consumption patterns of water, processed beverages, and processed foods is also needed. Such research will either validate the current method for determining optimal fluoride concentration in community drinking water or indicate improved methods.

Evaluate the Effect of Fluoride Mouthrinse, Fluoride Supplements, and Other Fluoride Modalities on Dental Caries

Additional clinical trials are needed to evaluate the current effect of fluoride mouthrinse, supplements, and other modalities on dental caries both individually and in combination. Cohorts of particular interest are groups and persons at high risk for dental caries, including older adults (i.e., those aged >50 years). Such research, as well as studies to determine the effects of new fluoride modalities and various combinations among groups and persons at high risk, could lead to more effective and efficient use of these interventions.

Study the Current Cost-Effectiveness of Fluoride Modalities

The increasing availability of multiple fluoride modalities and the lower caries prevalence in the United States indicate a need for current cost-effectiveness studies of fluoride modalities, especially logical combinations of regimens in populations with different caries risks. Such research will allow both more efficient use of resources and a better understanding of the additive effects of combined modalities.

Conduct Descriptive and Analytic Epidemiologic Studies

Descriptive and analytic epidemiologic studies should be conducted to determine the association between dental caries and fluoride exposure from several sources, as well as the current role of community water fluoridation in preventing coronal and root caries among adults. Studies should assess the effect of interruption or discontinuation of water fluoridation; the prevalence of fluorosis

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associated with different patterns of fluoride use and intake among various populations; and the relationship between objectively measured fluorosis and the aesthetic perceptions of persons, parents, and dentists and other health-care professionals. Studies are needed to refine methods of caries risk assessment. As appropriate, studies should use national, state, and local data. Research addressing these questions will improve understanding of the relationships between fluoride modalities and the benefits and unintended effects of their use.

Identify Effective Strategies to Promote Adoption of Recommendations for Using Fluoride

Effective strategies should be identified to promote adherence by parents, caregivers, children, adults, and health-care providers to recommendations regarding fluoride use. Such research could result in more effective behavior change, more efficient use of resources, improved caries prevention, and less enamel fluorosis.

CONCLUSION

When used appropriately, fluoride is a safe and effective agent that can be used to prevent and control dental caries. Fluoride has contributed profoundly to the improved dental health of persons in the United States and other countries. Fluoride is needed regularly throughout life to protect teeth against tooth decay. To ensure additional gains in oral health, water fluoridation should be extended to additional communities, and fluoride toothpaste should be used widely. Adoption of these and other recommendations in this report could lead to considerable savings in public and private resources without compromising fluoride's substantial benefit of improved dental health.

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*For this report, the term "caries experience" is used to mean the sum of filled and unfilled cavities, along with any missing teeth resulting from tooth decay.

**US$ 1988 converted to US$ 1999 using the Consumer Price Index for All Urban Customers (CPI-Urban) (all items). More information is available at the U.S. Department of Labor, Bureau of Labor Statistics website at <http://stats.bls.gov/cpihome.htm>. Accessed June 25, 2001.

***US$ 1995 converted to US$ 1999 using CPI-Urban (dental services). More information is available at the U.S. Department of Labor, Bureau of Labor Statistics website at <http://stats.bls.gov/cpihome.htm>. Accessed June 25, 2001.

****US$ 1988 converted to US$ 1999 using CPI-Urban (all items). More information is available at the U.S. Department of Labor, Bureau of Labor Statistics website at <http://stats.bls.gov/cpihome.htm>. Accessed June 25, 2001.

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Table 1

TABLE 1. Recommended dietary fluoride supplement* schedule

	Fluoride concentration in community drinking water†		
Age	**<0.3 ppm**	**0.3–0.6 ppm**	**>0.6 ppm**
0–6 months	None	None	None
6 months–3 years	0.25 mg/day	None	None
3–6 years	0.50 mg/day	0.25 mg/day	None
6–16 years	1.0 mg/day	0.50 mg/day	None

* Sodium fluoride (2.2 mg sodium fluoride contains 1 mg fluoride ion).

† 1.0 parts per million (ppm) = 1 mg/L.

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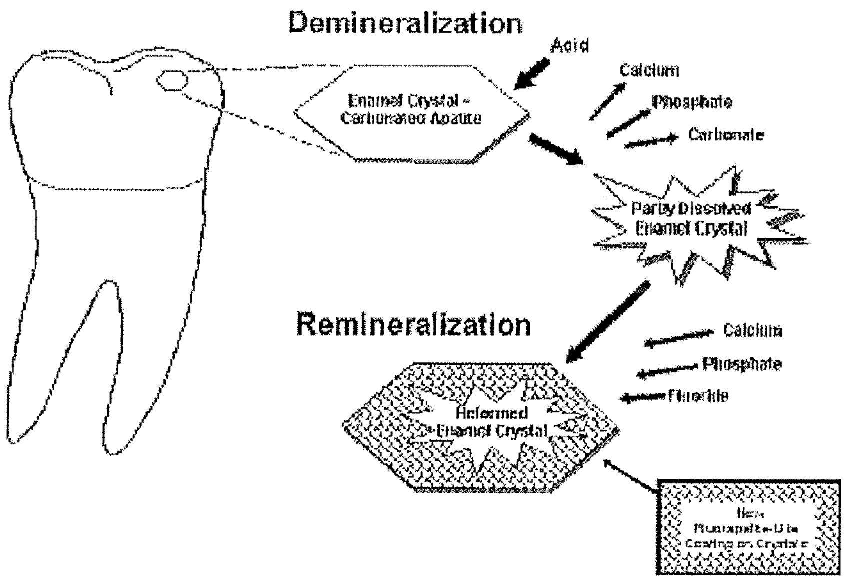
Figure 1

FIGURE 1. The demineralization and remineralization processes lead to remineralized enamel crystals with surfaces rich in fluoride and lower in solubility



Source: Adapted from Featherstone JDB. Prevention and reversal of dental caries: role of low level fluoride. Community Dent Oral Epidemiol 1999;27:31–40. Reprinted with permission from Munksgaard International Publishers Ltd., Copenhagen, Denmark.

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Table 2

TABLE 2. Recommended total dietary fluoride intake

Age	Reference weight*		Adequate intake†	Tolerable upper intake§
	kg	lb	mg/day	mg/day
0–6 months	7	16	0.01	0.7
6–12 months	9	20	0.5	0.9
1–3 years	13	29	0.7	1.3
4–8 years	22	48	1.1	2.2
≥9 years	40–76	88–166	2.0–3.8	10.0

* Values based on data collected during 1988–1994 as part of the third National Health and Nutrition Examination Survey.

† Intake that maximally reduces occurrence of dental caries without causing unwanted side effects, including moderate enamel fluorosis.

§ Highest level of nutrient intake that is likely to pose no risks for adverse health effects in almost all persons.

Source: Adapted from Institute of Medicine. Fluoride. In: Dietary reference intakes for calcium, phosphorus, magnesium, vitamin D, and fluoride. Washington, DC: National Academy Press, 1997:288–313.

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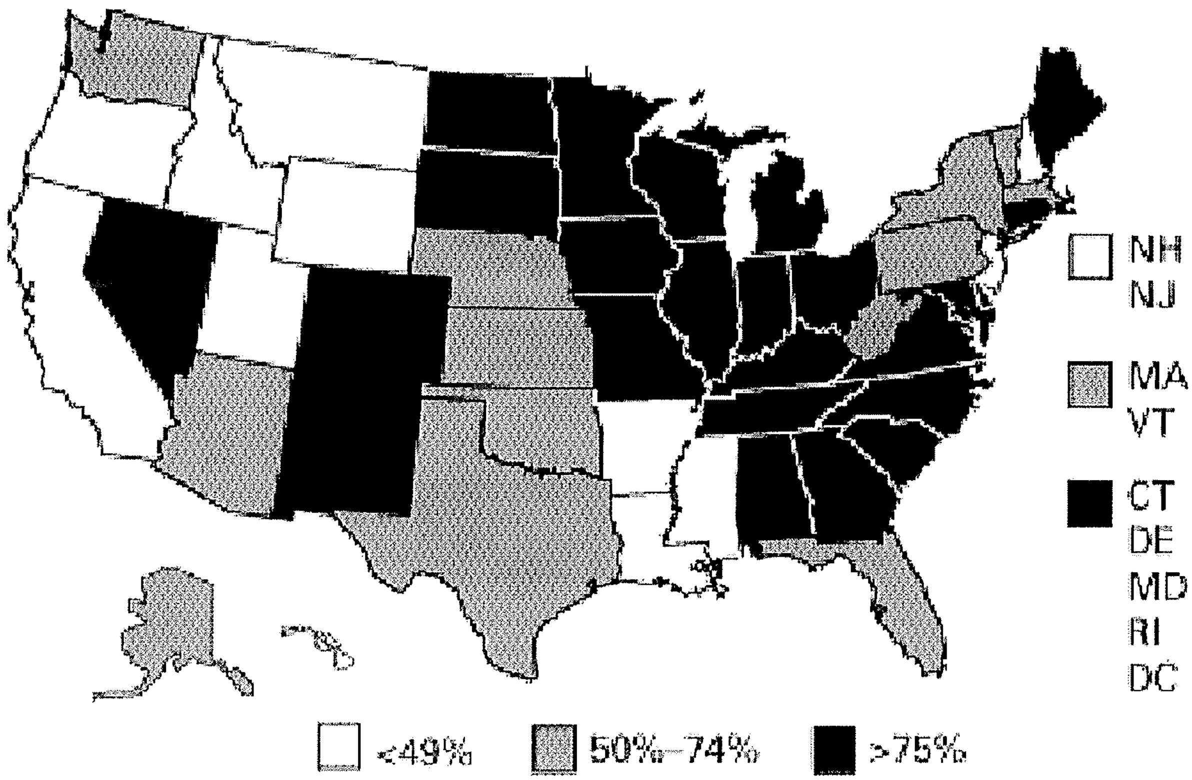
Figure 2

FIGURE 2. Percentage of state populations with access to fluoridated water through public water systems



Source: CDC, unpublished data, 2000.

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Table 3

TABLE 3. U.S. Food and Drug Administration (FDA) fluoride requirements for bottled water packaged in the United States

Annual average of maximum daily air temperature (F) where the bottled water is sold at retail	Maximum fluoride concentration (mg/L) allowed in bottled water: No fluoride added to bottled water	Maximum fluoride concentration (mg/L) allowed in bottled water: Fluoride added to bottled water
≤53.7	2.4	1.7
53.8–58.3	2.2	1.5
58.4–63.8	2	1.3
63.9–70.6	1.8	1.2
70.7–79.2	1.6	1
79.3–90.5	1.4	0.8

Note: FDA regulations require that fluoride be listed on the label only if the bottler adds fluoride during processing; the bottler is not required to list the fluoride concentration, which might or might not be optimal. FDA does not allow imported bottled water with no added fluoride to contain >1.4 mg fluoride/L or imported bottled water with added fluoride to contain >0.8 mg fluoride/L.

Source: US Department of Health and Human Services, Food and Drug Administration. 21 CFR Part 165.110. Bottled water. Federal Register 1995;60:57124–30.

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Table 4

TABLE 4. Quality of evidence, strength of recommendation, and target population of recommendation for each fluoride modality to prevent and control dental caries

Modality*	Quality of evidence (grade)	Strength of recommendation (code)	Target population†
Community water fluoridation	II-1	A	All areas
School water fluoridation	II-3	C	Rural, nonfluoridated areas
Fluoride toothpaste	I	A	All persons
Fluoride mouthrinse	I	A	High risk§
Fluoride supplements			
Pregnant women	I	E	None
Children aged <6 years	II-3	C	High risk
Children aged 6–16 years	I	A	High risk
Persons aged >16 years	¶	C	High risk
Fluoride gel	I	A	High risk
Fluoride varnish	I	A	High risk

* Modalities are assumed to be used as directed in terms of dosage and age of user.

† Quality of evidence for targeting some modalities to persons at high risk is grade III (i.e., representing the opinion of respected authorities) and is based on considerations of cost-effectiveness that were not included in the studies establishing efficacy or effectiveness.

§ Populations believed to be at increased risk for dental caries are those with low socioeconomic status or low levels of parental education, those who do not seek regular dental care, and those without dental insurance or access to dental services. Individual factors that possibly increase risk include active dental caries; a history of high caries experience in older siblings or caregivers; root surfaces exposed by gingival recession; high levels of infection with cariogenic bacteria; impaired ability to maintain oral hygiene; malformed enamel or dentin; reduced salivary flow because of medications, radiation treatment, or disease; low salivary buffering capacity (i.e., decreased ability of saliva to neutralize acids); and the wearing of space maintainers, orthodontic appliances, or dental prostheses. Risk can increase if any of these factors are combined with dietary practices conducive to dental caries (i.e., frequent consumption of refined carbohydrates). Risk decreases with adequate exposure to fluoride.

¶ No published studies confirm the effectiveness of fluoride supplements in controlling dental caries among persons aged >16 years.

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Box 1

BOX 1. Grading system used for determining the quality of evidence for a fluoride modality

Grade	Criteria
I	Evidence obtained from one or more properly conducted randomized clinical trials (i.e., one using concurrent controls, double-blind design, placebos, valid and reliable measurements, and well-controlled study protocols).
II-1	Evidence obtained from one or more controlled clinical trials without randomization (i.e., one using systematic subject selection, some type of concurrent controls, valid and reliable measurements, and well-controlled study protocols).
II-2	Evidence obtained from one or more well-designed cohort or case-control analytic studies, preferably from more than one center or research group.
II-3	Evidence obtained from cross-sectional comparisons between times and places; studies with historical controls; or dramatic results in uncontrolled experiments (e.g., the results of the introduction of penicillin treatment in the 1940s).
III	Opinions of respected authorities on the basis of clinical experience, descriptive studies or case reports, or reports of expert committees.

Source: US Preventive Services Task Force. Guide to clinical preventive services. 2nd ed. Alexandria, VA: International Medical Publishing, 1996.

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Box 2

BOX 2. Coding system used to classify recommendations for use of specific fluoride modalities to control dental caries

Code	Criteria
A	Good evidence to support the use of the modality.
B	Fair evidence to support the use of the modality.
C	Lack of evidence to develop a specific recommendation (i.e., the modality has not been adequately tested) or mixed evidence (i.e., some studies support the use of the modality and some oppose it).
D	Fair evidence to reject the use of the modality.
E	Good evidence to reject the use of the modality.

Source: US Preventive Services Task Force. Guide to clinical preventive services. 2nd ed. Alexandria, VA: International Medical Publishing, 1996.

*US$ 1981 converted to US$ 1999 using CPI-Urban (dental services). More information is available at the U.S. Department of Labor, Bureau of Labor Statistics website at <http://stats.bls.gov/cpihome.htm>. Accessed June 25, 2001.

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When public action undermines public health: a critical examination of antifluoridationist literature

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Abstract

Background: The addition of the chemical fluorine to the water supply, called water fluoridation, reduces dental caries by making teeth more resistant to demineralisation and more likely to remineralise when initially decayed. This process has been implemented in more than 30 countries around the world, is cost-effective and has been shown to be efficacious in preventing decay across a person's lifespan. However, attempts to expand this major public health achievement in line with Australia's National Oral Health Plan 2004–2013 are almost universally met with considerable resistance from opponents of water fluoridation, who engage in coordinated campaigns to portray water fluoridation as ineffective and highly dangerous.

Discussion: Water fluoridation opponents employ multiple techniques to try and undermine the scientifically established effectiveness of water fluoridation. The materials they use are often based on Internet resources or published books that present a highly misleading picture of water fluoridation. These materials are used to sway public and political opinion to the detriment of public health. Despite an extensive body of literature, both studies and results within studies are often selectively reported, giving a biased portrayal of water fluoridation effectiveness. Positive findings are downplayed or trivialised and the population implications of these findings misinterpreted. Ecological comparisons are sometimes used to support spurious conclusions. Opponents of water fluoridation frequently repeat that water fluoridation is associated with adverse health effects and studies are selectively picked from the extensive literature to convey only claimed adverse findings related to water fluoridation. Techniques such as "the big lie" and innuendo are used to associate water fluoridation with health and environmental disasters, without factual support. Half-truths are presented, fallacious statements reiterated, and attempts are made to bamboozle the public with a large list of claims and quotes often with little scientific basis. Ultimately, attempts are made to discredit and slander scientists and various health organisations that support water fluoridation.

Summary: Water fluoridation is an important public health initiative that has been found to be safe and effective. Nonetheless, the implementation of water fluoridation is still regularly interrupted by a relatively small group of individuals who use misinformation and rhetoric to induce doubts in the minds of the public and government officials. It is important that public health officials are aware of these tactics so that they can better counter their negative effect.

Background

The addition of fluorine to the water supply, termed water fluoridation, is carried out as a public health measure to improve oral health. One of the ways fluorine confers its benefit is by changing the crystalline structure of teeth. Fluorine ions replace hydroxide ions in calcium hydroxyapatite, $Ca_5\{(PO_4)_3OH\}$, in teeth, forming calcium fluoroapatite, $Ca_5\{(PO_4)_3F\}$, which is more chemically stable and more resistant to acid attack than calcium hydroxyapatite [1]. However, as well as making the enamel more resistant to acid attack by altering the chemical structure of the enamel, fluoride helps to protect teeth by promoting the remineralisation of early decayed lesions and by reducing the ability of the bacteria on the teeth to produce acid.

Water fluoridation was first carried out in the USA after studies by Dean [2,3] found that higher levels of fluoride (fluorine when part of a chemical compound) in the water supply appeared to confer a caries preventive effect. Since then, water fluoridation has been adopted in over 30 countries, reaching an estimated 350 million people worldwide [4]. Indeed, the fluoridation of drinking water to control dental disease has been referred to by the US Centers for Disease Control as one of the Top 10 public health achievements of the 20th century [5]. Fluoridated water reaches people from all socio-economic strata of society [6-8] helping to erode the socio-economic gradient in oral disease experience. It is efficient, cost-effective and considered the single most effective means of preventing tooth decay over a person's lifetime [9]. In addition, water fluoridation alters the dynamics of decay initiation. Rather than just affecting an individual at a point in time, water fluoridation reduces the incidence of decay. This is a phenomenon played out over a person's lifetime. The effect of water fluoridation is not a static 'one-off' benefit.

Oral health is fundamental to overall health, yet many adult Australians and a significant percentage of children still suffer persistent high levels of oral disease and disability. As a response to a report released in 2001 on the 'Oral Health of Australians' [10], the National Advisory Committee on Oral Health, established by the Australian Health Minister's Conference, signed off on 'Australia's National Oral Health Plan 2004–2013' [11]. One of the four broad themes underpinning the plan was the need to adopt a population health approach, with a strong focus on oral health promotion and the early identification and treatment of oral disease. Although most dental services are provided within the private sector, both the Commonwealth and the States and Territory governments can and do provide financial support for dental services to certain sections of the population. State and Territory governments are also responsible for the implementation of water fluoridation under a raft of different legislative arrangements, although in practice, and for various reasons, those responsibilities are often devolved to local councils. One of the short term goals of population oral health promotion under the National Oral Health Plan was the extension of the fluoridation of public water supplies to all communities across Australia with populations of 1000 people or more. The suggested population cut-off was based on research from New Zealand which showed that this was the practical lower bound at which water fluoridation remained cost-effective [12].

Discussion

Partially in response to the objective of extending water fluoridation announced in the National Oral Health Plan, there has been renewed advocacy at the State and Territory level for fluoride to be added to public waters to improve oral health. Nonetheless, this major public health initiative continues to meet considerable opposition where ever it is mooted. Such a response is not confined to Australia. Attempts worldwide to introduce water fluoridation are often thwarted [13,14]. In the US and Canada, for example, one antifluoridation organisation claims that more than 150 communities have rejected water fluoridation in referenda since 1990 [15] while between 1989 and 1994 just over 40% of referenda were defeated in the US [13].

Efforts to introduce water fluoridation are almost universally met with a coordinated campaign involving newspaper articles, calls to talkback radio, letterbox leaflet drops, public forums and community agitation. Proponents of water fluoridation are invited to public forums to debate against fluoridation opponents and these are often given prominent media coverage. If advocates of water fluoridation attend these debates they may be bombarded with one claim after another of which they have no hope of adequately addressing in the limited opportunities afforded in a public debating match [16]. If, however, water fluoridation proponents decline to attend public fluoride debates they are labelled as being arrogant, condescending and contemptuous [17] and their desire to not attend lambasted as "an insult to both science and democracy" [18]. Opponents of water fluoridation make the inaccurate claim that public debates are a forum for "open, rational, scientific argument and evidence" and that by refusing to attend debates proponents of water fluoridation are maintaining the process by using political power and influence [19].

Statements regarding the scientific controversy surrounding water fluoridation are generally regarded as artefacts of antifluoridationist activity, with actual scientific debate over water fluoridation being resolved decades ago. Almost all major dental and health organisations either support water fluoridation or have found no association between it and adverse health effects [20]. Nonetheless, propagating the idea of an ongoing scientific debate gives the illusion of scientific uncertainty and is a favoured tactic of water fluoridation opponents. In 1978, *Consumer Reports* published a two-part series on fluoridation that concluded:

> The simple truth is that there's no "scientific controversy" over the safety of fluoridation. The practice is safe, economical, and beneficial. The survival of this fake controversy represents, in Consumers Union's opinion, one of the major triumphs of quackery over science in our generation." [21]

And yet, more than a quarter of a century after these words were printed the manufactured 'controversy' shows no signs of diminishing.

In the US, those opposed to water fluoridation have been described as a heterogenous group and range from well-intentioned and concerned citizens to professional activists to extremists [22]. In the 1980s, Hastreiter argued that the leaders of the movement in the US were "individuals who are marginal to the social, psychological, political, and professional mainstream" [23]. Also involved in water fluoridation opposition in most countries are companies selling bottled water and water filters, purveyors of alternative medicines and therapies, and some environmental scientists. Opponents of water fluoridation share the characteristic of being highly mobilised and organised and rely heavily on propagating their opinion via the popular media, which is often willing, if not keen, to publish their sensationalist claims. While provocative and emotive arguments are commonly aired in the media, the ability of water fluoridation opponents to delay or halt the introduction of water fluoridation though their public lobbying campaigns represents a serious and detrimental public health outcome. Campaigns are often based on information available on anti-fluoride websites and are often spearheaded by one of a small number of ardent fluoridation opponents.

Scientific journals provide an essential role in both information sharing and as a forum for scientific debate. The process of peer review in these journals helps ensure that poor quality research is rejected, unsupported conclusions are censured, and ascientific speculation is appropriately identified. With the advent of the World Wide Web, however, opinion can be propagated from any web site, by anyone, to reach a potential audience of millions.

Because Internet resources are increasingly being used by the public as a source for dental and general health information [24-26], the uncontrolled spread of information on the Internet 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 outright fraud [27]. Although the overwhelming majority of scientific enquiry supports the benefits of water fluoridation, members of the public who type the term "water fluoridation" into any of the major search engines would immediately be presented with a disproportionate percentage of anti-fluoridation websites (Table 1). If a concerned member of the public were to type in the search term "water fluoridation dangers" almost the only information presented to them would reflect an anti-fluoride perspective.

Adding to the one-sided presentation of information on water fluoridation on the Internet is a bias in media reporting. Although the media have a social responsibility to inform the public of possible impending dangers [28], they are often poorly equipped to adequately explain the underlying complexities of risk issues in science [29]. There is a payoff for generating controversy in an increased audience. In 2001, the Dental Health Foundation in Ireland analysed 240 recent print, radio and television articles relating to water fluoridation over a one-year period, finding the media coverage to be predominantly negative (52%) with only 14% of articles judged as being positive [30]. A similar bias was found with press cuttings in the UK [31]. Easley explains this bias as demonstrating subversion of the media; that is, winning over the media

Table 1: Classification of first 20 results based on Internet searches for "water fluoridation" and "water fluoridation dangers" using five major search engines

	"water fluoridation"				"water fluoridation dangers"			
Search engine	For	Against	Reviews	Other	For	Against	Reviews	Other
Google	7	9	3	1	0	20	0	0
Yahoo	5	11	1	3	0	19	0	1
MSN	8	10	1	1	1	18	0	1
AOL	6	9	3	2	0	20	0	0
Ask	3	16	1	0	0	20	0	0

Note: Search conducted on 10 April 2006, from Australia. Listed search engines account for 90.3% of all US Internet searches (AC Nielson, 2005) by presenting controversy, sensationalist claims and a David vs Goliath concept which appeals to people's proclivity to support the 'underdog' in conflicts [16]. Radio talk shows, an increasingly powerful force in US politics, have been found to present a barrage of negativity about water fluoridation and have been known to screen out supportive viewpoints so that only a one-sided view reaches the public [13].

Researchers in Ireland argue that the high percentage of negative coverage most likely stems from its increased dramatic and sensationalist appeal, providing a payoff in an increased readership or audience [30]. Of course, concerns regarding the content of media coverage effect not just water fluoridation but other public health strategies. For example, an analysis of the print media's coverage of heroin prescription trials [32], compulsory vaccinations [33] and many other public health and health related issues reveals similar bias. Of concern is that consumers may more readily recall this negative media coverage than the positive coverage.

The major public health implications of the spread of misinformation regarding water fluoridation on the Internet is that this information finds its way into local anti-fluoride campaign materials which are used to influence councils who ultimately are required to make decisions on water fluoridation implementation. The standard procedure for making council decisions on matters outside of the expertise of council members is to invite comment from representatives of different sides of the issue. Councillors are presented with conflicting information of which they are not qualified to judge, and under public pressure by a small number of committed activists, may decide to maintain the status quo which means to not introduce water fluoridation. Other councillors may decide to carry out their own research and may turn to the Internet which is the primary source of misinformation regarding the fluoridation of water. One councillor from Northern NSW has quipped that "It took five minutes of research to confirm my opinion about fluoride" [34].

Public plebiscites are also frequently adopted by councillors as a solution to not having to make what is sometimes viewed as an unpopular decision, and anti-fluoride misinformation is used to sway the public opinion in this scenario as well. For example, a leaflet distributed by a rural council area in NSW prior to a public plebiscite on the addition of fluoride to the town water supply claimed that water fluoridation was unethical, unsafe and ineffective [35]. That the antifluoride rhetoric was given the same space as for the 'Yes campaign' puts these viewpoints on a par and gives the impression that both viewpoints have equal weight, despite the fact that no credible public health, dental or medical organisations anywhere in the world are opposed to water fluoridation. Opponents of water fluoridation in Australia make extensive use of the steady stream of ready-made misinformation available from overseas sources.

In modern democracies it is vital that choices be informed, and scientific evidence is critical for this to occur. Scientific evidence forms the fundamental bedrock for decision making for public health practitioners, but the process for much of the population is more complex with any decision based on a range of opinions, beliefs, emotions, risk assessments, and experiences. Indeed, it has been argued that appealing to facts, and to accredited experts for their interpretation, has been increasingly compromised by an awareness of the limitations of experts and expert knowledge in resolving issues of public controversy [36]. Further, it is believed that there is a growing public perception that experts can and do disagree and that purportedly "disinterested" advice may be influenced by economic, professional, or political considerations [36]. Such perceptions are attributed partly for the increased resistance of the general public to health promotion messages and interventions [37]. At the same time, levels of cynicism regarding politicians are at an historic high [38]. Unfortunately, decisions to do with the implementation of water fluoridation are often subverted to political purposes. Politicians as well as opposition groups are quick to pick up on rhetoric which may resonate with the public, with resistance to public health measures often having at their heart an appeal to an individualistic ideology that valourises the fight against the erosion of civil liberties and promotes suspicion of 'faceless' authority figures [39].

In population public health there is frequently a tension between public good and individual freedoms. Kass, for instance, has described the dilemma faced by the population-based focus of public health concerning the infringement on individual liberties in ethically troublesome ways [40,41]. The introduction of bans on public smoking, the requirements to wear seatbelts in cares or helmets on motorcycles, and compulsory childhood immunisations all infringe to some extent on personal choice, yet all are supported by public health advocates and backed by government legislation. The ethics behind this process is now well established, and generally accepted by the community. This perhaps explains why a significant majority of the Australian population continue to support the practice of water fluoridation [42,43].

It should be noted that antagonism towards and opposition to the views of public health practitioners by minority groups is not restricted to the fight over water fluoridation. Parallels can be drawn with some other public health controversies such as compulsory child immunisations or the use of genetically modified (GM) foods. There is now, for example, an extensive body of research analysing the debate over the safety of the MMR (measles, mumps, and rubella) vaccine [44-48]. Concerns over the MMR vaccine first surfaced following a study by Wakefield et al. published in the Lancet linking the vaccine to autism [49]. The study prompted widespread concern and the resultant controversy has been blamed on a significant decrease in vaccination rates in the UK [48,50] and to a lesser extent in Australia and the US [45]. Fitzpatrick has argued that the perceptions of risk, choice and chance are central to the public's response to the controversy [46] and as a result of these concerns a number of groups have formed to oppose the compulsory MMR immunisation of children. However, while a number of anti-vaccination websites do exist [51,52], concerns over vaccinations are believed to have been led more by the media in response to the Wakefield et al. study than by organised or influential opposition groups as with water fluoridation [48,53].

While the moral, ethical and social concerns over water fluoridation are both legitimate and fully deserving of further investigation, they lie outside of the intent of this current paper. Instead, this paper will restrict its analysis to a critique of antifluoridationist literature. Rather than attempt a rebuttal to every claim and research finding put forward by water fluoridation opponents, a task attempted elsewhere [20,54,55], an analysis of the anti-fluoride lobby's techniques and tactics will be pursued. It is hoped that this may achieve two purposes: (1) to aid health and public health officials in countering the antifluoridationist strategies; and (2) to provide information to help both the general public and public health advocates sort the truth from the fiction and learn to identify the use of rhetoric, misinformation and misrepresentation relating to water fluoridation. Indeed, the irony of water fluoridation opponents claim that "fluoridation is an issue where the scientific method and principles are being set aside by public health authorities" [56] is that nowhere is the scientific approach more blatantly flouted than within anti-fluoridation literature.

Denying the benefits of water fluoridation

One of the fundamental tactics of water fluoridation opponents is to either deny or to besmirch the benefits of water fluoridation. It is argued that water fluoridation is either not effective or, at best, only minimally effective [57,58]. It has even been argued that water fluoridation actually harms teeth, making them more susceptible to caries [59]. These claims have been adequately addressed elsewhere with numerous systematic reviews finding that water fluoridation is associated with improved oral health [60-62]. Nonetheless, opponents of water fluoridation use several techniques to try and mislead the public in terms of the effectiveness of water fluoridation.

Selective reporting of studies

Each year hundreds of studies are published in the scientific literature regarding the effects of fluoride on animals and humans. In order to examine a relationship between variables across an extensive body of literature scientists often make use of literature reviews or meta-analyses. Water fluoridation opponents, however, take a contrary approach. Rather than trying to discern a given outcome for fluoride exposure across all available studies, they handpick studies to cite. Findings not supporting their viewpoint are entirely disregarded while other findings may be prominently utilised. As an example, the York report, a large and comprehensive systematic review of the water fluoridation literature published in 2000, found that of the 29 studies included that examined the relationship between incidence of bone fracture and water fluoridation, four indicated a significant increased risk of fracture, five indicated a significant decrease in risk of fracture, while the other studies found no significant associations [60]. An article by Kauffman, however, stated that one of the harmful effects of water fluoridation is bone fracture [63] with this contention based on a single published study from the systematic review [64]. While the cited study does represent one of the four studies identified in the York Report as indicating increased risk, no mention is made of the studies finding lower incidence of fractures with water fluoridation nor is any mention made of the 20 studies that failed to find a significant result in any direction.

Selective reporting of results

To make the selective reporting of studies even more misleading, often specific results within specific studies are reported while any disconfirming results are ignored. For example, in a study examining the relationship between children's caries experience and consumption of non-fluoridated bottle and tank water [65] the lack of a statistically significant effect on the permanent tooth decay experience of 12-year-olds was the source of numerous articles, paid for press releases, and world-wide presentations. Water fluoridation opponents cite the study as evidence that water fluoridation is ineffective [66,67]. However, the finding of a strong beneficial effect of water fluoridation on the caries experience of younger children's teeth has been entirely ignored. Interestingly, while Pollick [68] in his article 'Scientific evidence continues to support fluoridation of public water supplies' cites this study as supporting water fluoridation, Connett [69] uses the same study to support a diametrically opposed view in his paper 'Scientific evidence fails to support fluoridation of public water supplies'.

Downplaying or ignoring the evidence

Water fluoridation opponents claim that there is either no 'significant' or no 'substantial' reduction in tooth decay resulting from exposure to fluoridated water [57]. Numerous studies are cited showing no difference, many of which simply compare one community with another without any control for other possible variations between those communities. Systematic reviews, such as the York report [60], which include no studies classified by its criteria as Level A, are cited as supposed proof of the total absence of high quality evidence [59], confusing the concept of quality with the York report's evidence classification. Reductions of 'a fraction of one decayed tooth per child' are dismissed as not substantial. Finally, findings of reductions in decay experience in non-fluoridated areas are used as evidence that fluoridation provides no added benefit to changes occurring in the absence of water fluoridation [59,70]. All of these arguments, however, are flawed and misrepresent study results.

Water fluoridation is a population-level caries preventive strategy. Therefore, the appropriate method of measuring effectiveness is to look at the population level effect rather than look at the effect on any given individual. The York report's systematic review [60] found reductions of between 0.5 and 4.4 decayed, missing and filled teeth per child on average. Reductions of between 20% and 40% have elsewhere been commonly reported. Differences of between 32% and 55% in the deciduous teeth and 20% and 65% in the permanent teeth have been reported in Australia [71]. Contrary to claims made by opponents of water fluoridation, these differences have been found to be statistically significant in published scientific research. In addition, although the generally low caries levels in Australia and some other countries might make such percentage differences work out to only a fraction of a tooth per child, at a population level this equates to a tremendous reduction in the amount of disease present. For instance, a recent Australian study found that across socio-economic groups water fluoridation was associated with caries reductions of between 48% and 75% [72]. However, in a paid-for press release by the New York State Coalition Opposed to Fluoridation (NYSCOF), Paul Beeber, President of the NYSCOF, argued that this indicates a waste of taxpayers money "for such a slim, if any, benefit" [73]. While a difference in decay experience between fluoridated and non-fluoridated areas of 0.7 teeth on average might be dismissed by anti-fluoridation lobby groups as "meagre" [73], if this finding could be extended across the Australian child population of 1.8 million children, it would translate into over a million teeth saved from decay, affecting hundreds of thousands of children. Such a result would be significant in terms of the extra disease prevented, the associated reduction in suffering, and savings in treatment costs.

Another example of downplaying the evidence of the effectiveness of water fluoridation is the argument that fluoridated water is not required to be ingested to be effective. Opponents of water fluoridation often present quotes by researchers saying that the primary effect of fluoride is topical (that is acting on the tooth surface) rather than systemic [59]. However, recent research in Australia by Singh and colleagues [74-76] has found that the pre-eruptive or systemic effect of fluoride in water supplies is at least as important in accounting for the caries preventive effect of consumption of fluoridated water as the post-eruptive or topical effect. It is common for opponents of water fluoridation to cling to old or out-of-date research while ignoring newer research that might cast doubt on their theories. Sometimes statistics and results from many decades ago are quoted to support their beliefs and statements.

Using ecological comparisons

Another ploy of water fluoridation opponents is to use ecological comparisons in an effort to demonstrate that water fluoridation is ineffective. With this tactic, the decay experience of children in a specific fluoridated area is compared unfavourably to that of children in a specific non-fluoridated area [59,77]. Despite such ecological comparisons providing a poor level of evidence due to their inability to take into account other variations between the areas which are also related to dental health (such as differences in diet, socio-economic status, exposure to discretionary fluorides, and oral health behaviours) this type of 'evidence' has been frequently used to shore up the arguments of water fluoridation opponents [72]. Although selected associations such as these provide no evidence of causality, many people may be inclined to accept ecological comparisons as a valid test of the effectiveness of water fluoridation and opponents of water fluoridation continue to use this approach to mislead the public and government officials.

Fear mongering

One of the easiest ways to preserve the status quo is by raising potentially dangerous or fearful consequences associated with possible change. This technique is common in politics where allusion to personal impropriety or dire economic consequences may be enough to taint a political candidate or party. Water fluoridation opponents, like politicians, make extensive use of fear mongering. Fluoride exposure has been linked in the antifluoridationist literature to poisonings and various accidents, allergies, brain dysfunctions such as Alzheimer's disease, hyperactivity, low intelligence, arthritis, bone diseases including hip fractures and osteosarcomas, cancers, dental fluorosis, gastrointestinal problems, diseases of the kidney, pineal gland and thyroid gland, reproductive issues, AIDS, and even with increased tooth decay [20]. Links have been made between fluoride consumption and birth defects, perinatal deaths and increased crime. Claims that governments are using water fluoridation to 'dumb down' the population [78-80], help the spread of communism [81], or prepare the way for the New World Order [81,82] are used occasionally in antifluoridationist writings. A consistent thread is that those scientists and government officials who are pro-fluoride are under the sway of multi-national corporations or funded to support water fluoridation.

Despite the extensive claims of water fluoridation opponents, the only substantiated link between fluoride exposure and any health side effect is for dental fluorosis [60,61]. This condition involves a hypomineralisation of the tooth surface in contrast to the demineralisation of the tooth surface associated with decay. In addition, there is no evidence that there is any financial remuneration from the sugar or aluminium industry for scientists publishing materials that show the benefits of water fluoridation.

Misrepresentation of the truth

In many cases information is misrepresented in order to support the anti-fluoride argument. Misrepresentation involves taking information out of the context in which it is presented in order to make it support a viewpoint which the author or authors did not intend. Statements are taken out of context, and results are selectively reported. In Australia, for example, opponents of water fluoridation make the false claim that the National Health and Medical Research Council (NHMRC) recommends "that NO additional fluoride be given to children under three years" [59]. It is argued that there is a contradiction between this claimed recommendation and support by the NHMRC for water fluoridation. However, the NHMRC actually recommends that no fluoride supplements be given to children under three years of age [62]. Fluoride supplements are tablets or drops, often available from a chemist, used to increase intake of fluoride in non-fluoridated areas. There is, therefore, no contradiction with the NHMRC supporting water fluoridation. Yet, such misrepresentations continue to be made.

Misrepresentation often takes place by omission. Connett [83,84], for example, has regularly cited a study from China [85] as finding a doubling of hip fractures when people consume water with 1.5 ppm fluoride and a tripling of fractures when consuming water of greater than 4.3 ppm fluoride. This is cited as evidence of the deleterious effect of water fluoridation on the bones. What Connett does not state is that the doubling of hip fractures at 1.5ppm is not statistically significant and that the authors' find a 'U' shaped relationship between the amount of fluoride in the water and fractures, with optimally fluoridated water actually conferring a protective effect on bone fractures. Yet, handpicked and misrepresentative information may find its way from the Internet to prominent pieces in national newspapers [86] with little regard for the truth.

The big lie

Bernhardt and Sprague have argued that the basic technique of antifluoridationists is to make the claim that water fluoridation causes a number of serious ailments that people fear [87]. This technique involves telling a lie so large that it defies anyone to believe that someone would distort the truth to such an extreme extent, and is aided in its effectiveness by constant repetition. Research findings indicate that if something is said often enough people will tend to think there is some truth in it, a process now called the illusory-truth effect [88]. Further to this technique is what is called the 'laundry list' approach, listing so many 'evils' that even if water fluoridation proponents can adequately respond to some they can not address all [89]. Such a technique is particularly effective in debates, letters to the editor or in the popular media where the time and opportunity to reply is limited or nonexistent. The American Dental Association catalogues about 30 adverse health effects linked in anti-fluoridation literature to water fluoridation [20].

Half-truths

A half-truth is a statement that is only partly true and is generally intended to deceive. If an uninformed member of the public were to read and believe the following text, taken from an anti-fluoride website, they might have good grounds for being concerned about water fluoridation:

> "Did you know that sodium Fluoride is ... one of the basic ingredients in both PROZAC (Fluoxetene Hydrochloride) and Sarin Nerve Gas (Isopropyl-Methyl-Phosphoryl FLUORIDE) – (Yes, folks the same Sarin Nerve Gas that terrorists released on a crowded Japanese subway train!). Let me repeat: the truth the American public needs to understand is the fact that Sodium Fluoride is nothing more (or less) than a hazardous waste by-product of the nuclear and aluminium industries. In addition to being the primary ingredient in rat and cockroach poisons, it is also a main ingredient in anesthetic, hypnotic, and psychiatric drugs as well as military NERVE GAS! Why, oh why then is it allowed to be added to the toothpastes and drinking water of the American people?" [78]

People may not normally consider that many substances can be harmful or poisonous depending upon the dose. Excessive intake of vitamin D, salt or even water may result in poisoning. The issue of dosage and its relationship to toxicity is rarely mentioned in antifluoridationist rhetoric because it undermines the intended link between water fluoridation and harm. The inclusion of a substance in a poison or toxin does not mean that at smaller doses in humans the substance is still toxic. For example, Warfarin, an anti-coagulant which is the active ingredient in the common rat poison, RatSAK, is also used as a medicine for people in danger of stroke [90,91] and in cases of deep-vein thrombosis [92,93]. The toxic Sarin gas ($C_4H_{10}FO_2P$), contains not just fluoride but oxygen, hydrogen and carbon. The fact that a given substance is toxic does not mean that every element contributing to it is also toxic.

Innuendo

Innuendo involves an indirect or subtle, usually derogatory, implication in expression. Water fluoridation opponents often link water fluoridation to other medical and government sanctioned practices that have led to aversive and unexpected consequences. An example is thalidomide, a drug that was prescribed to pregnant women during the late 1950s and 1960s to aid sleeping, morning sickness and other pregnancy symptoms and was later found to be teratogenic in foetal development, causing physical deformities [94,95]. Statements such as "When the truth about fluoridation is finally exposed, it may well dwarf the thalidomide tragedy", attributed to Albert Schatz and published by the New Zealand Fluoride Action Network [96], is an example of the use of innuendo. Similarly, Bryson writes "It was an era of thalidomide and plutonium; school segregation and human experimentation; ... atmospheric Hbomb testing and DDT...Fluoridated water was idealized as the ultimate form of 1950's failsafe social engineering" [97]. Again, water fluoridation is linked to a number of dangerous and now controversial practices in an attempt to discredit it by association. The question: "Can we not learn from past assurances of the safety of DDT, thalidomide, and the hundreds of other 'safe' chemicals?" [98], uses innuendo to imply that water fluoridation is also an environmental disaster waiting to happen. It should be realised that this rhetorical practice is intended to sway the opinion of an audience and presents no evidence indicating that water fluoridation causes harm. Thousands of drugs, medicines and chemicals have proven safe and effective and have led to a longer and better quality life. Only a small number of medical substances have proven harmful in the long run and there is no validity in using these as evidence for the danger of any other substance.

Follow the leader

Opponents of water fluoridation, despite arguing that water fluoridation should not be introduced just because other areas have implemented it, argue that it should be rejected in Australia in the same way that it has been allegedly rejected by 98% of Western Europe [99]. They state that Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Sweden and large sectors of the United Kingdom do not have water fluoridation in place and directly or by insinuation make the argument that there must be something wrong with water fluoridation for these countries to have not implemented the practice. This argument is flawed for two reasons. First, it is equally applicable to argue that because the United States, Australia, New Zealand, Ireland, Brazil, some sectors of the United Kingdom, and various other countries have introduced water fluoridation then other nonfluoridated countries should alsointroduce the process. The second is that countries that do not have water fluoridation have mostly not rejected the benefits or science of water fluoridation but have not introduced water fluoridation for a range of other reasons [4]. These have to do with cost, the use of other population preventive practices such as salt fluoridation or the belief that water fluoridation is unnecessary because universal and extensive dental care programs are already in place.

Enforced medication

Antifluoridationist literature is replete with scare words, such as "pollutant", "chemical" and "toxic waste" that reinforce the idea of harm. The idea of "enforced medication" is another expression that comes up repeatedly when efforts are made to extend water fluoridation to non-fluoridated areas. According to this argument, fluoride is a medicine, taking medicine should only be a function of individual choice, and therefore water fluoridation is an impingement on our freedom of choice. Use of the term medicine implies something which should only be administered by a doctor acting for the good of an individual. Terminology such as "mass medication" or "forced medication" is often picked up on and used by local government officials who are responsible for decision making [100,101].

The rejoinder to this line of argument is that fluoride added to the water supply is not a medicine. In Australia, for example, fluoride only appears in the Standard for the Uniform Scheduling of Drugs and Poisons as a schedulable substance when used in amounts of more than 1000ppm. In any event, such a population preventive strategy is certainly not without precedent. Iodine is added to salt to help prevent goiter and low intelligence. Folate is added to bread and rice products because of its importance in the development of babies. Vitamins, minerals and other additives are now commonplace in many foods because they are believed to confer health benefits. While fluoride may differ from iodine, folate and other substances in terms of its pharmacological effect, it shares the feature of being one of a number of successful population preventive public health strategies.

Bamboozling with science

Anti-fluoridation literature attempts to overwhelm readers with claims about scientific research, with figures and statistics, and with scientific terms and buzzwords. Unpacking such a dense presentation of facts, quotes and figures is beyond most people, who have neither the time nor capacity to access most of the publications required to check on the plethora of claims. A classic example of bamboozling with science is the 8-page Lifesavers Guide to Fluoridation, produced by Yiamouyiannis [102], which contains 250 references from a variety of journals, court cases, books, newsletters, symposia and newspapers, as well as several personal communications. Many of these references were subsequently used in the book 'Fluoride: the aging factor' [103], a major reference source for water fluoridation opponents. A two-year search for the cited literature by a team of people revealed less than half of the cited references to be in peer reviewed journals [54]. Almost all references were found to be incompletely cited and Yiamouyiannis was found to make superficial observations, leap to unwarranted conclusions and present a pervasive bias in his evaluation of data. However, more than two decades later the same studies continue to be cited in anti-fluoridation literature.

Opponents of water fluoridation may also attempt to bamboozle the public with language, often verging on nonsensical, yet purveying a sense of drama and foreboding. An example is shown in this quote taken from a prominent Australian fluoridation opponent:

> "A maze is a model of fluoridation dental thinking, its paths (claims) leading to nowhere but neonlighted with imaginary posters of great rewards at the end of the rainbow trail which never ends, and importantly has no qualified scientific exit...The fluoridation maze hides the secrets of so-called dental science where it can be worshipped unseen with its faceless hierarchy of long on words but short of substance." [104].

Such bombastic language, combined with a litany of unsubstantiated claims, is designed to overwhelm the reader who may well find it easer to simply believe what they are being told than to try and trace the facts for themselves.

Moving the goalposts

Ultimately, whatever research is released showing that water fluoridation is not associated with aversive outcomes will be judged as unacceptable by fluoridation opponents. The goalposts have now been moved to such an extent that satisfying calls for supporting studies is practically impossible. Chairman of the Anti-fluoridation Association of Victoria, Glen Walker, expresses this sentiment with his statement that "there is no evidence of a scientific study proving fluoridation is perfectly safe for humans in all public circumstances" [105].

Paranoia, conspiracy theories and extremism

Although many opponents of water fluoridation distance themselves from extremist views, any Internet search will reveal numerous instances of these still being propounded. There is an audience for such views. Extremist arguments find fertile ground among disenfranchised, psychologically disturbed, and alienated individuals [23]. A subculture has now developed around and for such people who are believed to find psychological gratification in imagining themselves heroically in the possession of such secret and 'subversive' information [106].

Conspiracy theories relating to water fluoridation are common. Some claim that the basis of the science for water fluoridation is rooted in protecting the U.S. atomic bomb program from litigation [107]. Others argue that adding fluoride to water was pioneered by a German chemical giant to "reduce an individual's power to resist domination, by slowly poisoning and narcotizing a certain area of the brain, thus making him submissive to the will of those who wish to govern him" [108]. Still others claim that water fluoridation is part of a plot by the New World Order, a group of Illuminati, intent on taking over the world [109]. An example of paranoia is demonstrated by the following excerpt from a Christian organisation based on the preachings of William Branham:

> "Fluoride is a hypnotic drug that accumulates in the body, producing schizophrenia. It was used in Russian prison camps and is harmful to dental health. The real purpose behind water fluoridation is to reduce the resistance of the masses to domination and control, and loss of liberty." [110]

The belief that water fluoridation was a communist plot to alter society was famously parodied in the movie Dr Strangelove. However, such claims were common in the 1950s at the height of the cold war between the USSR and USA. Indeed, Newbrun has described a chronology of antifluoridation propaganda in the US since the 1950s with the main themes found to reflect the social and political environment in the US at the different points in time [22].

Even some of the more prominent water fluoridation opponents often engage in what Newbrun calls the conspiracy gambit [22]. Researchers and bureaucrats are believed to be in the pay of and therefore beholden to the sugar and aluminium industries. In a pamphlet distributed by local council to residents of the rural Australian town of Deniliquin prior to a plebiscite on water fluoridation in 2004, it was claimed that: "Behind the dental and medical associations, who promote fluoridation with religious fervour, are powerful corporate and political interests" [35]. The sugary food industry, the phosphate fertiliser industry, the aluminium industry, and some governments are listed as the ominous forces behind the proponents of water fluoridation [19]. Others see water fluoridation as a cover used by generations of decision makers for the alleged failure to provide dental care to poor people. Again, no evidence is or can be offered for any of these claims.

Summary

The list of techniques and methods described and analysed above are by no means the full extent of techniques used by water fluoridation opponents, although they are perhaps most pertinent to their promulgated literature. Common additional ploys involve neutralising politicians by massive letter writing campaigns to give the illusion of controversy, requesting public plebiscites which often have low turnouts and are dominated by people opposing change, the use of so-called experts to lend credence to anti-fluoridation claims, urging that fluoridation be delayed until better research is conducted or until the fabricated doubts can be resolved, inventing organisations with official sounding names in order to create credibility, and using public debates which give the illusion of scientific controversy and move dialogue away from scientific discussion by allowing rhetorical practices [16,111,112].

The evidence for the effectiveness of water fluoridation is incontrovertible. More than a dozen large-scale literature reviews have found water fluoridation, even against a backdrop of high discretionary fluoride use, to confer a caries preventive benefit in children. Further to this, water fluoridation and its effect on the tooth structure provides a benefit to adults across their lifespan. The situation whereby a small group of determined individuals can manage to deny half a century of science pays testimony to the power of emotional arguments and the potential of misleading propaganda. It is here that scientists must continue their stand, reinforcing the arguments for water fluoridation while using their knowledge of the literature and their understanding of anti-fluoridation tactics to assist health departments. Table 2 presents both a number of the arguments put forward by water fluoridation opponents and a possible response by water fluoridation proponents. While it is not the intention here to provide a response to every possible argument, Table 2 provides brief useful responses for the most common claims and arguments made by water fluoridation opponents. Other lists, such as those put out by the Department of Human Services Victoria, offer more complete and extensive coverage [113].

Despite more than half a century of implementation, the addition of fluoride to the water for the prevention of dental decay is still considered a controversial and debated public health measure by some segments of the population. In and of itself this state of affairs is nothing new. Campaigns have been waged over the addition of chlorine to water supplies, compulsory child immunisations, the compulsory wearing of seatbelts in cars and many other public health initiatives. However, water fluoridation suffers the inglorious distinction of being one of only a few public health initiatives to still be regularly thwarted as a result of public action based on emotional and often misleading appeals.

If Australia's National Oral Health Plan is to be implemented and water fluoridation extended to all those non-fluoridated Australian communities with populations in excess of 1000 people, a considerable effort of political will is going to be required. With decision making in most States devolved to local councils, extension of water fluoridation will occur only in a piece-meal fashion typified by a succession of emotionally charged battles between public health official and organised anti-fluoridation groups both attempting to engage the support of the public. It is therefore hoped that by better understanding the techniques and tactics of water fluoridation opponents, public health advocates, government officials, and ultimately the public, will come to dismiss many of the ant-fluoridation arguments as little more than fallacious non-science, paving the way for the extension of water fluoridation to those areas yet to benefit from its implementation.

Competing interests

The author(s) declare that they have no competing interests.

Table 2: Suggested responses to antifluoridationist arguments

Anti-fluoride argument	Suggested response
Water fluoridation confers no oral health benefit	Numerous systematic literature reviews from a number of countries have found water fluoridation to provide a significant caries preventive effect.
Water fluoridation causes hip fractures, cancers, Alzheimer's, reduced intelligence in children, etc.	Research finding associations between water fluoridation and various diseases offer no proof, as causality cannot be established in these studies. Water fluoridation opponents handpick studies and may misrepresent the results so as to support their views. Large-scale systematic reviews have not confirmed any associations between water fluoridation and the large list of diseases linked to it by opponents of water fluoridation.
Fluoride is a toxic poison.	Fluorine is a naturally occurring element that, like many other natural substances, can be toxic if consumed in excess. Water fluoridation ensures ingestion of fluoride well below any toxic level, both for adults and children.
Fluoride is used in rat poison and other dangerous substances.	It is dose that determines the level of toxicity. Many essential and commonly occurring elements form poisonous or toxic substances.
Numerous other countries have rejected water fluoridation.	Some other countries have elected not to introduce water fluoridation because they prefer, or already have, other approaches to improving dental health. Nonetheless, many countries do have water fluoridation and benefits are conferred to all people, including those at high risk who may not effectively use individual fluoride exposures.
Water fluoridation is supported only by 'shoddy' science.	Decades of research and hundreds of scientific articles published in peer-reviewed journals support water fluoridation. This research is so convincing that almost all major dental and health authorities support it.
There should be a public plebiscite. It is undemocratic to have water fluoridation forced upon us.	In almost all democratic systems representatives of a population are elected to make decisions on behalf of the population. Plebiscites or public referendums are not required to pass legislation that is compatible with the constitution or charter under which the country operates. Water fluoridation fits within a government's duty of care to the country's citizens.
Tooth decay has declined in countries with and those without water fluoridation. Water fluoridation makes no difference.	Declines in tooth decay have occurred as a result of changing exposures to fluoride and dietary changes. Regardless, water fluoridation reduces tooth decay above and beyond these other effects. Ecological comparisons of some countries with others offer no support for or against water fluoridation as many other factors may account for differences in disease experience from one country to the next. Water fluoridation does make a difference.
Most people do not want water fluoridation.	Independent research in most places where water fluoridation is being considered shows that people support water fluoridation. Generally, the more knowledge people have the more likely they are to support it.
Water fluoridation is costly and not economically viable.	Research has previously found water fluoridation to be cost-effective. Newer technologies have made water fluoridation cost-effective for increasingly smaller populations. In addition to being cost-effective, it is also necessary to keep in mind the reduction in dental disease and therefore the pain and suffering reduced as a result of water fluoridation.
Water fluoridation infringes freedom of choice and individual rights and is unconstitutional.	Adding fluoride to water is just one of many instances where a chemical or nutrient is added to a food or beverage for public health benefits. It already occurs in water with the addition of chlorine, which aids greatly in eliminating water borne disease, as well as in several foodstuffs. Water fluoridation sets no precedent.
Water fluoridation is being pushed on us as a result of 'big business' interests.	The scientists researching the effectiveness of water fluoridation as well as health officials and dentists do not receive money from sugar, aluminium or any other companies for their research or opinions.
There is more caries in fluoridated X than in non-fluoridated Y. This proves water fluoridation does not work.	Ecological comparisons involving the arbitrary selection of fluoridated and non-fluoridated communities or areas do not provide credible evidence of the effectiveness or otherwise of water fluoridation as any differences may be the result of other factors which are linked to tooth decay but differ across the areas. Scientific research has found water fluoridation to be effective.
We should wait until water fluoridation is proved to be safe.	Water fluoridation has been implemented in some places for more than half a century – long enough that any dangers would be apparent if they existed. The weight of evidence strongly indicates that water fluoridation is safe.

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Oregon Department of Human Services

Oregon Smile Survey 2007

Public Health Division, Department of Human Services
November 15, 2007

To the people of Oregon:

Tooth decay is the most common childhood disease, affecting five times more children than asthma. Tooth decay among children is a major concern for a number of reasons, often causing oral pain and infection, which in turn can affect a child's school attendance and success, nutrition, self-esteem and general health.

"Smile Survey 2007" is an important step in addressing this problem. This survey is the second in a series of assessments and presents the findings of oral screenings of first-, second- and third-graders attending Oregon public schools in 2006-07. The first survey was conducted in 2002.

Identifying the current oral health of Oregon's children is critical in identifying needs for targeting more early-stage prevention measures, including appropriate professional care and community-based interventions, all of which can significantly reduce the amount and severity of tooth decay.

In addition to addressing current problems, an accurate assessment of the oral health of Oregon's children is important for reducing the challenges of the future. It is commonly recognized that untreated tooth decay worsens with age and eventually affects a person's overall general health.

Taking a look at many of the same measurements addressed in the 2002 Smile Survey, this year's report also provides an important tool for gauging changes in the oral health of Oregon's children over the past five years, important for assessing trends in dental disease patterns.

The information found in this report can be used to develop and implement community-based prevention strategies designed to ensure all of Oregon's children have a healthy smile.

Yours in oral health,

Gordon B. Empey, D.M.D., M.P.H.
Executive dental health consultant,
Oral Health Program, Office of Family Health

Katherine J. Bradley, Ph.D., R.N.
Administrator, Office of Family Health

Acknowledgments

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We would also like to thank the principals and staff of participating schools. Without their assistance, this report would not have been possible.

If you need this document in an alternate format, please call 971-673-0252

Oregon Department of Human Services
Public Health Division
Office of Family Health
Oral Health Program

Table of Contents

Executive summary

During the 2006-2007 school year, 3,865 first, second and third-graders in Oregon public schools participated in a statewide oral health survey conducted by the state's Oral Health Program, an effort of the Office of Family Health. Using national Basic Screening Survey (BSS) criteria recommended by the Centers for Disease Control and Prevention and the Association of State and Territorial Dental Directors, specially trained dental hygienists performed a brief, simple visual screening of each child's mouth. In addition, parents were invited to complete a questionnaire that included questions about the child's age, race/ethnicity, participation in the Federal Free or Reduced Lunch (FRL) Program, language spoken at home, gender, medical insurance, dental insurance, and time since last dental visit. Approximately half of the parents returned the questionnaire.*

The results of the study were sobering. Nearly two-thirds of all students have already had a cavity, a dental condition that is 100 percent preventable. More than half of the children identified as ever having a cavity had untreated dental decay.

The survey also determined many children in Oregon do not get the dental care they need. At the time of the survey, more than one in four children had not seen a dentist in the previous year. More than one in three needed treatment the day they were examined by the survey hygienist.

Since the first Smile Survey conducted in 2002, every major measure of oral health among Oregon's school children has worsened. Compared with the 32 other states with BSS data, Oregon ranks 25th – or seventh from the bottom, in percentage of children with untreated decay.

The survey also pointed out oral disease disparities exist in Oregon based on geographic residence, dental insurance coverage, income and race/ethnicity.

* A complete description of the survey methods and sampling is available at www.oregon.gov/DHS/ph/oralhealth/index.shtml.

Yet the reality is oral health among Oregon school children does not have to be this bad. There are several nationally recognized best practice strategies that rely on strong collaboration between dental providers, public health programs, schools and others with a vested interest in the oral health of children. The four key community-based preventive measures that have been proven effective in reducing tooth decay are:

- Community water fluoridation
- Early-childhood caries prevention programs
- School-based dental sealant programs
- School-based fluoride supplement programs

Fast facts from the 2007 Smile Survey

- Dental decay remains a significant public health problem among Oregon's children. What's more, the 2007 Smile Survey found the oral health of Oregon's youngsters is worsening.
  - ♦ Compared with a survey conducted five years earlier, Oregon scored worse in every major measure of oral health for children.
  - ♦ The proportion of school children with untreated decay increased by 49 percent.

- The oral health of Oregon's school children lags behind those of children in Washington, Idaho, Alaska and California. Of 32 states with similar reporting methods, Oregon ranks 25th, or seventh from the bottom, in the percent of school children with untreated decay.

- Nearly two of every three children in first, second and third grade in Oregon already have had a cavity. More than half of those children have untreated decay.

- More than one in three children in Oregon need treatment for tooth decay. At the time of the survey, an estimated 27 percent of Oregon's children had not seen a dentist in the previous year.

- Fewer than half of Oregon's third-graders have sealants – a simple, safe, effective, and low-cost method for preventing tooth decay.

- School children who live outside of the Portland metropolitan area experience more tooth decay, more untreated decay, and more decay severe enough to require urgent treatment than their urban counterparts.

- Children without dental insurance have poorer oral health and lower access to care. The estimated 24 percent of school children who are without dental insurance are more likely to have untreated decay, less likely to have visited a dentist in the previous year, and are less likely to have valuable, decay-preventing sealants on their teeth.

- Low-income children suffer from poorer oral health and lower access to care. Compared with those in the highest income bracket, children in the lowest bracket suffer twice the rate of untreated decay, almost three times the rate of rampant decay, and are 30 percent less likely to have seen a dentist in the previous year.

- The racial and ethnic disparities in oral health are easing somewhat. Compared with the 2002 Smile Survey:

  - ♦ All categories of children experienced worsening oral health conditions.
  - ♦ Children of Hispanic ethnicity continue to have a substantially higher rate of oral disease than their White, non-Hispanic counterparts.
  - ♦ The gap between Hispanic children and White, non-Hispanic children has narrowed.

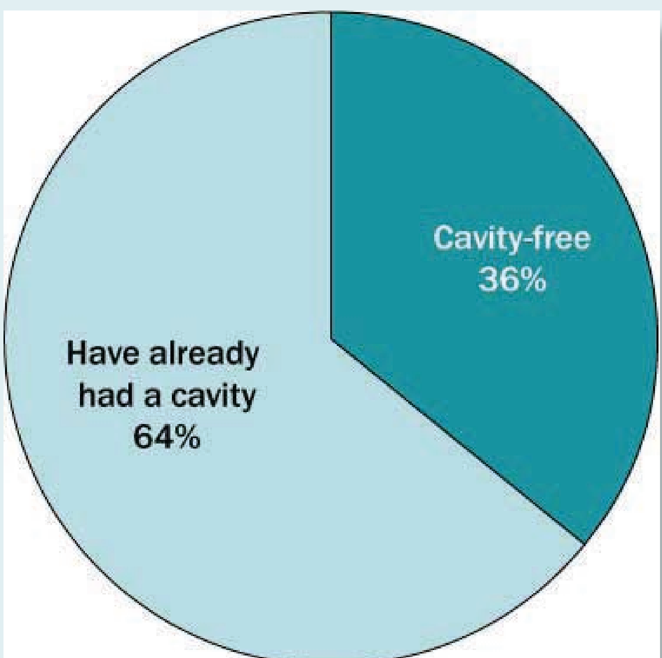
Dental decay remains a significant public health problem for Oregon's children

In 2007 …

Nearly two in three children in first, second and third grades, **representing 80,000 Oregon school children**, have already had a cavity.*

One of every five children in this age group, **representing more than 24,000 Oregon youngsters**, have rampant decay, meaning decay in seven or more teeth

Nearly one in six youngsters in this age category – **representing more than 21,000 Oregon children** – have already had cavities in their permanent, 'adult' teeth. Decay in a permanent tooth requires a lifetime of re-treatment, often including larger fillings over the years, and perhaps a crown or an extraction. Decayed teeth also are not suitable for sealants, a highly effective, low-cost method for preventing cavities. (See page 11 for dental sealant rates.)



Cavities are 100% preventable.

Many children get their first cavity before they lose their first tooth.

* Includes children who have active decay, a previous filling or premature tooth extraction

Many children in Oregon do not receive the dental care they need

More than one in three children in grades one, two and three, **almost 44,000 children**, need treatment for tooth decay.

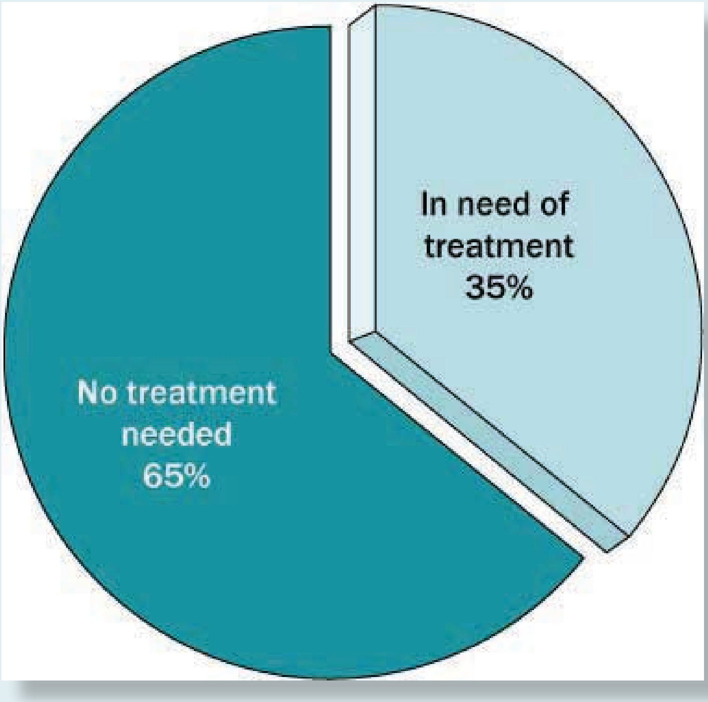
Every day, nearly one in 20 school children need urgent care due to pain or infection. On any given day, more than 5,000 children in Oregon are in school and suffering from dental pain or infection.

More than one in four Oregon school children in this age group, **more than 34,000 youngsters**, have not been to a dentist in the past year.

An estimated 9 percent of all first-graders in Oregon, **about 4,000 youngsters, have never been to a dentist.** National recommendations call for all children to see a dentist by the child's first birthday.

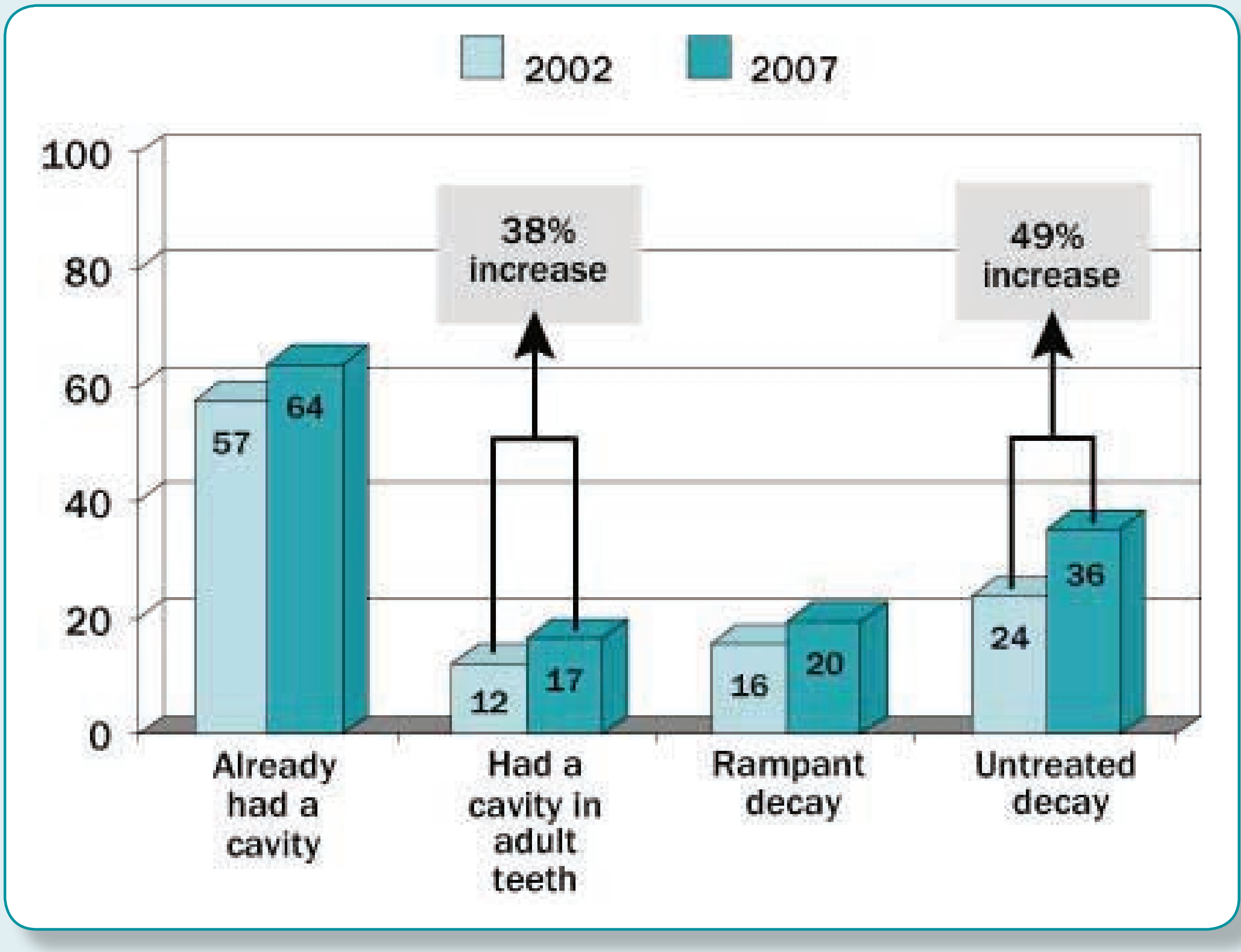
Almost one in four, **more than 30,000 Oregon school children**, have no dental insurance.

Access to professional care can be a challenge.



From 2002 to 2007: Survey results show Oregon's oral health is headed in the wrong direction

The 2007 Smile Survey reports the oral health of Oregon's school children worsened in every major measurement from 2002, the year the study was first conducted.



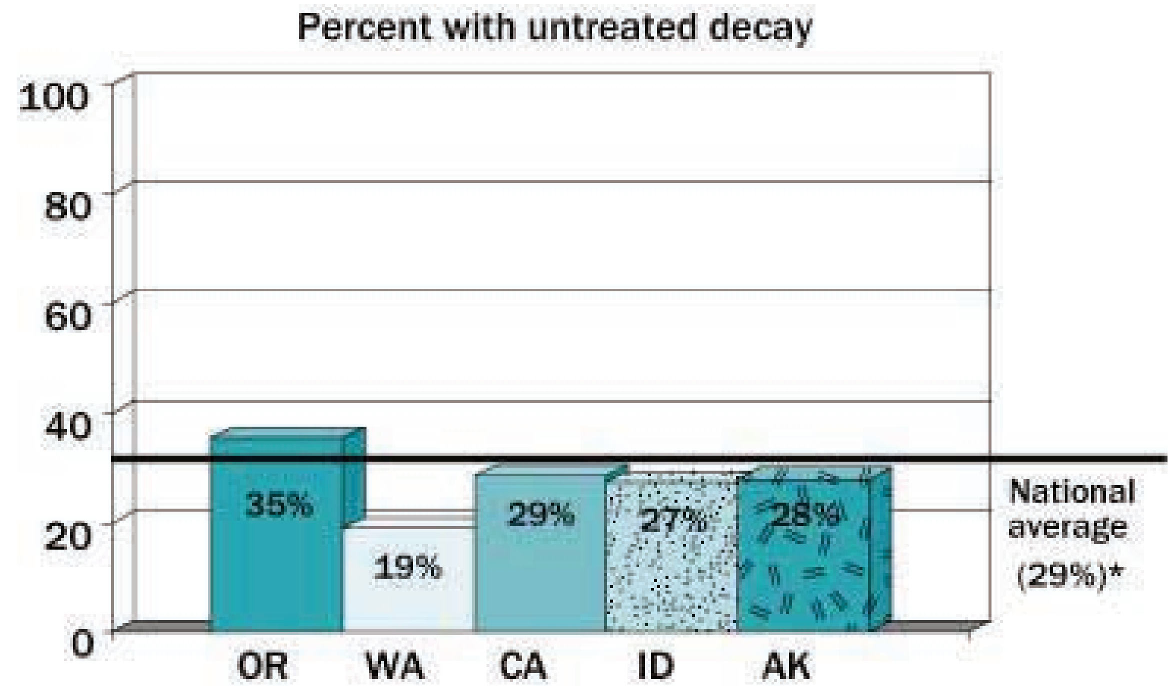
Rampant decay is past or present decay in seven or more teeth.

For a complete description of the methods and a comparison of the results by grade, go to http://www.oregon.gov/DHS/ph/oralhealth/index.shtml.

Nationally, Oregon ranks 25th – seventh from the bottom – in the percent of school children with untreated decay.*

The oral health of Oregon's school children is poorer than that of children in neighboring states

Compared with neighboring states, Oregon has a higher rate of untreated decay among school children. In Oregon, almost two out of three first- through third-graders have already had a cavity. Furthermore, **more than half of those children have untreated decay**.



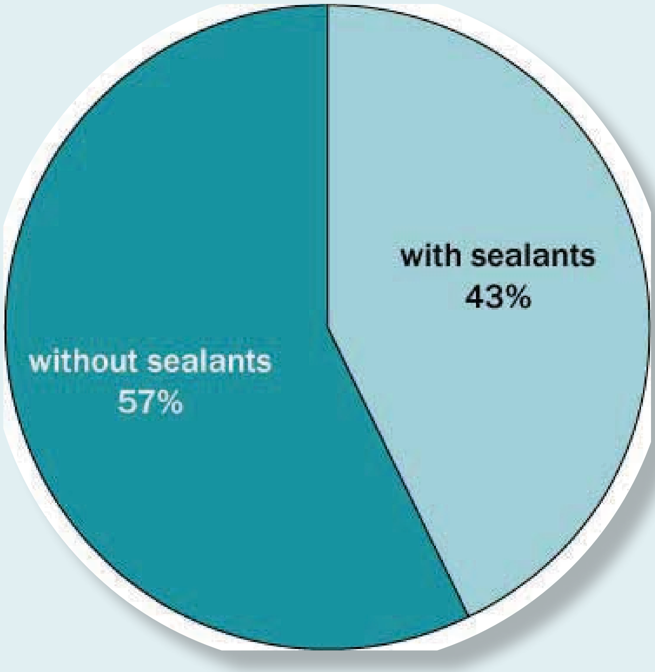
Preventing disease is always better than treating it. When dental decay occurs, prompt treatment is important. Left untreated, dental cavities can lead to severe pain or bacterial infection, which can cause additional tooth loss and other problems. The infection can become life-threatening if it spreads elsewhere in the body.

* Of the 32 states that report data using a similar method.

Fewer than half of all third-graders in Oregon have dental sealants*

Only 43 percent of Oregon's third-graders have sealants, leaving more than 24,000 third-graders without this highly effective, safe, and low-cost weapon against cavities.

What is a sealant? Dental sealants are thin plastic coatings applied to the chewing surfaces of the back adult molars. The coatings flow into the deep pits and grooves to seal out decay-causing bacteria. Eighty-five percent of tooth decay occurs in grooves or pits.



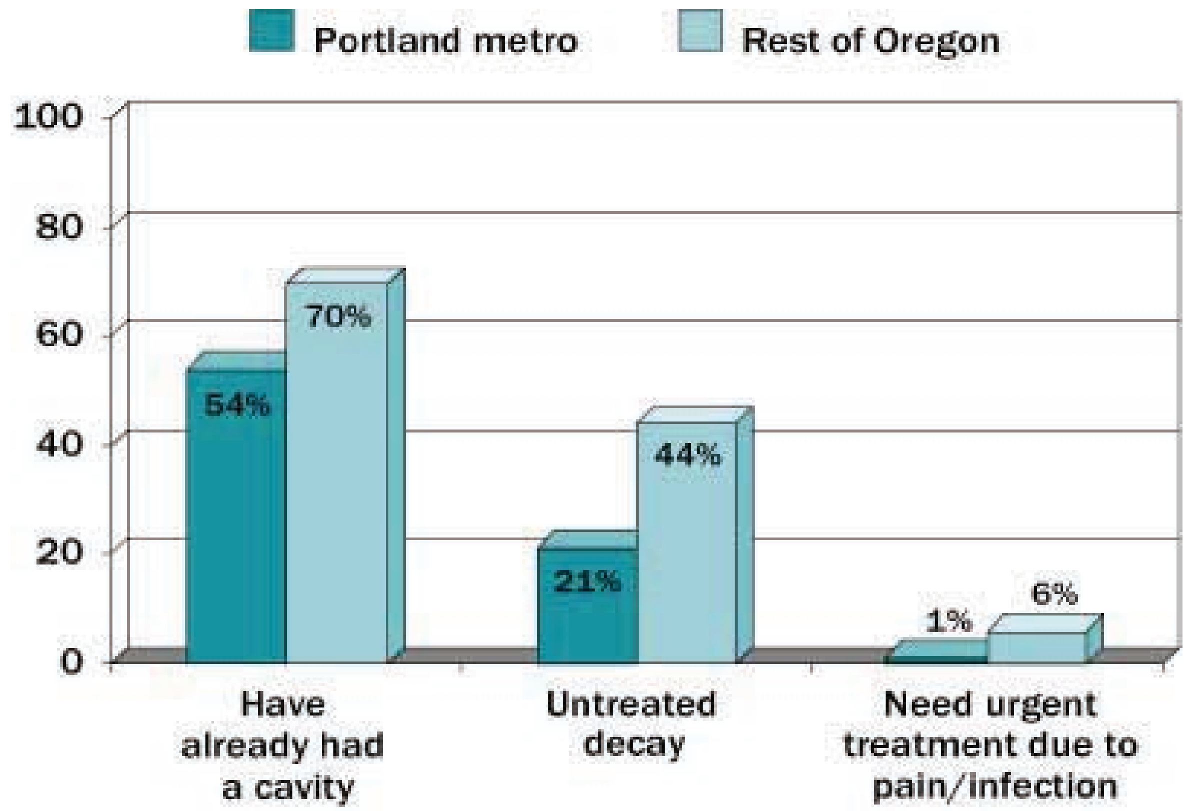
According to the 2007 Smile Survey, third-graders who had seen a dentist in the previous year were twice as likely to have sealants.

* Why is third grade the benchmark? Most children get their first adult molars during the first and second grade. The third grade is a good time to check all children for sealants. National surveys use third-grade figures for reporting.

Children living outside of metropolitan Portland* suffer from poorer oral health

Children in the Portland metropolitan area have less untreated tooth decay, are less likely to have ever had a cavity and are less likely to need urgent dental treatment.

In the metropolitan area, one in 100 students require urgent care due to pain or infection. Outside of the metropolitan area, one in 17 students need urgent care.



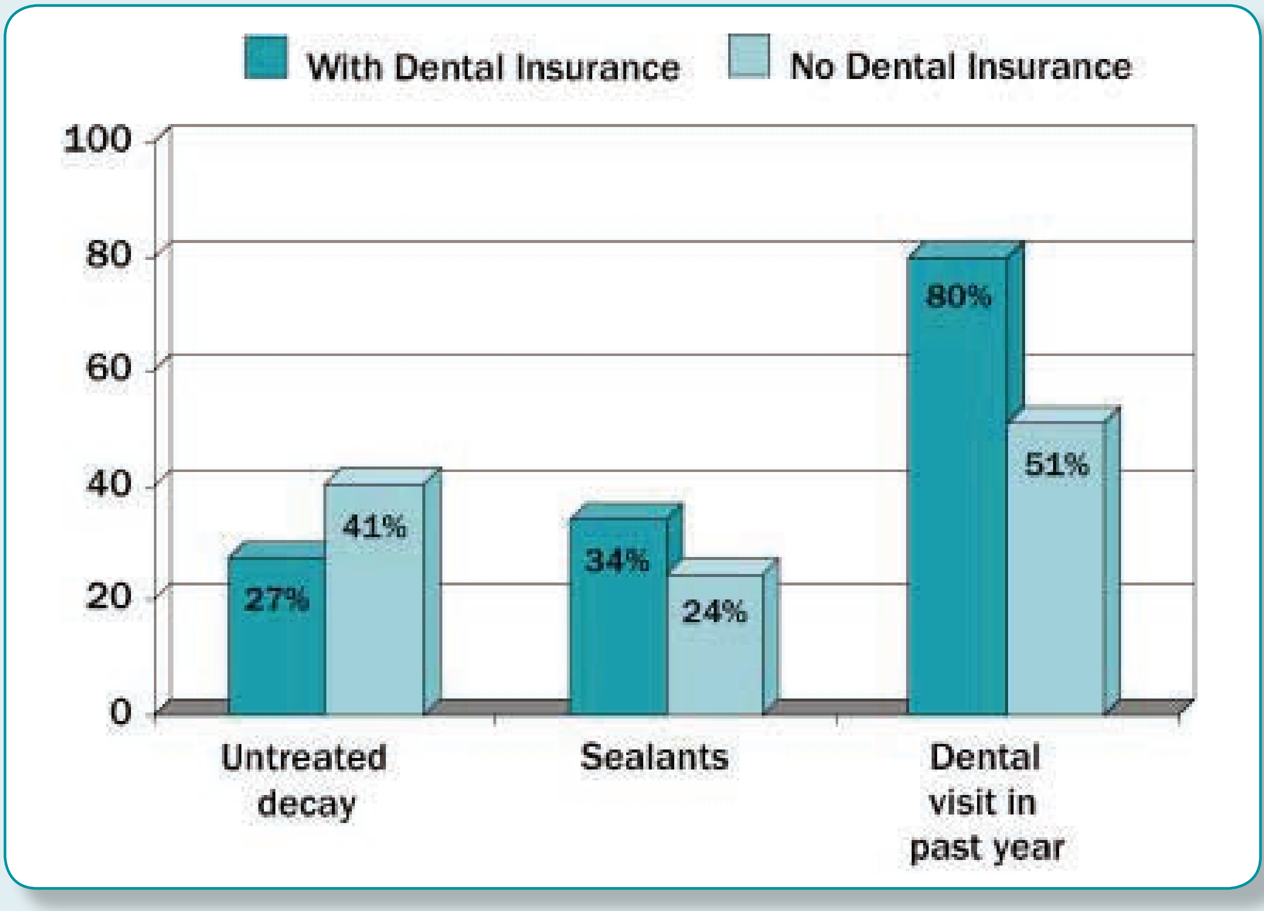
In the Portland metropolitan area, more than half of third-graders – 51 percent – have sealants. Slightly less than a third of third-graders who live outside of the metropolitan area have sealants.

* This report defines the Portland metropolitan area as Multnomah, Washington and Clackamas counties.

Children with dental insurance* have better oral health and access to care

One in four children do not have dental insurance. Oral disease and the care received for children with dental insurance compared to those without is strikingly different.

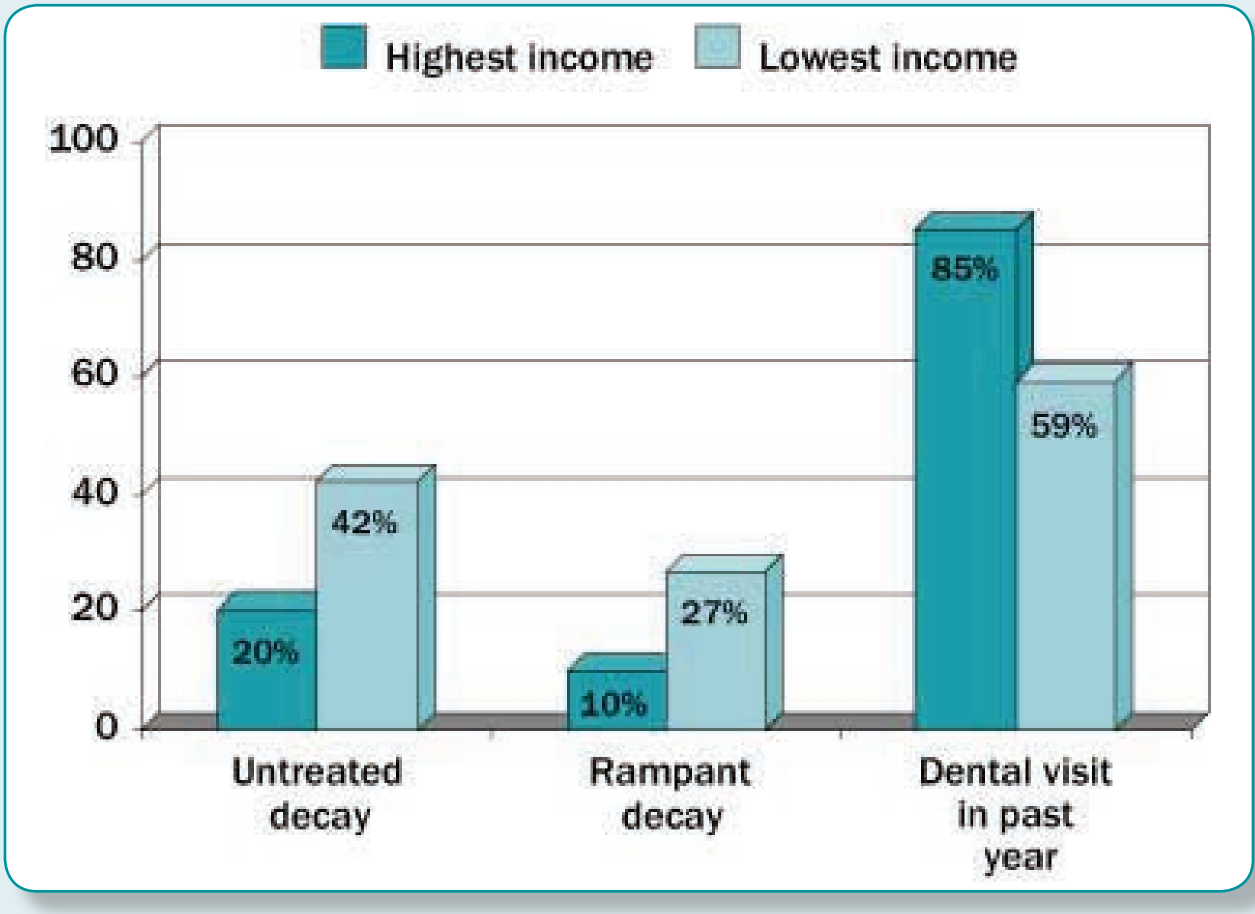
Insured school children have less untreated decay, are more likely to have sealants, and are more likely to have visited a dentist in the previous year.



* Data on dental insurance was extrapolated from questionnaires returned by 1,972 parents.

Low-income* children suffer from poorer oral health and have less access to care

The lowest income children, compared with the highest income, are more than twice as likely to have untreated decay, almost three times as likely to have rampant decay, and see the dentist annually 30 percent less of the time.



Information on household income was not collected in this survey. A proxy for income was used instead – the percent of children in a school that participate in the Federal Free and Reduced Lunch Program. Schools fell in to one of four categories:

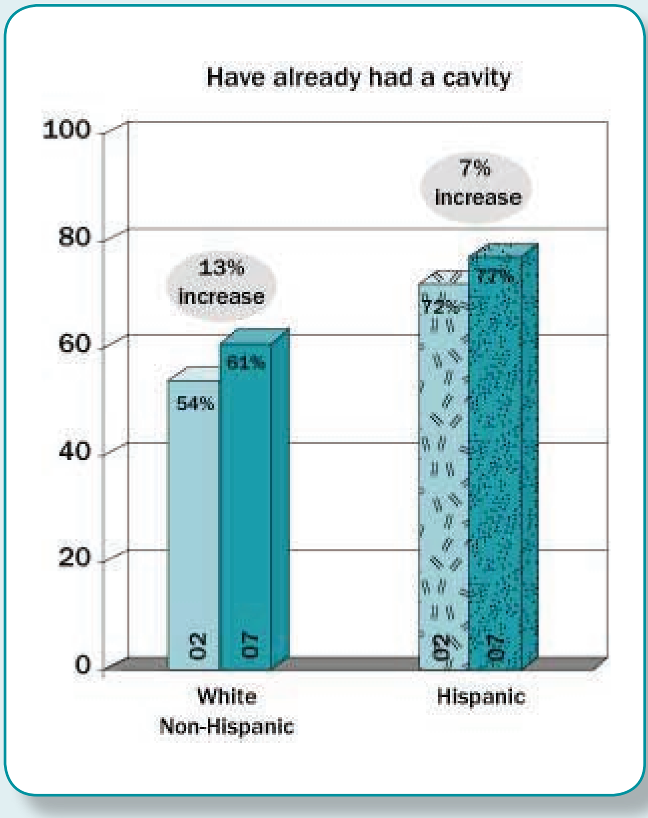
- Higher income < 25 percent
- 25.0 – 49.9 percent
- 50.0 – 74.9 percent
- Lower income is ≥ 75 percent

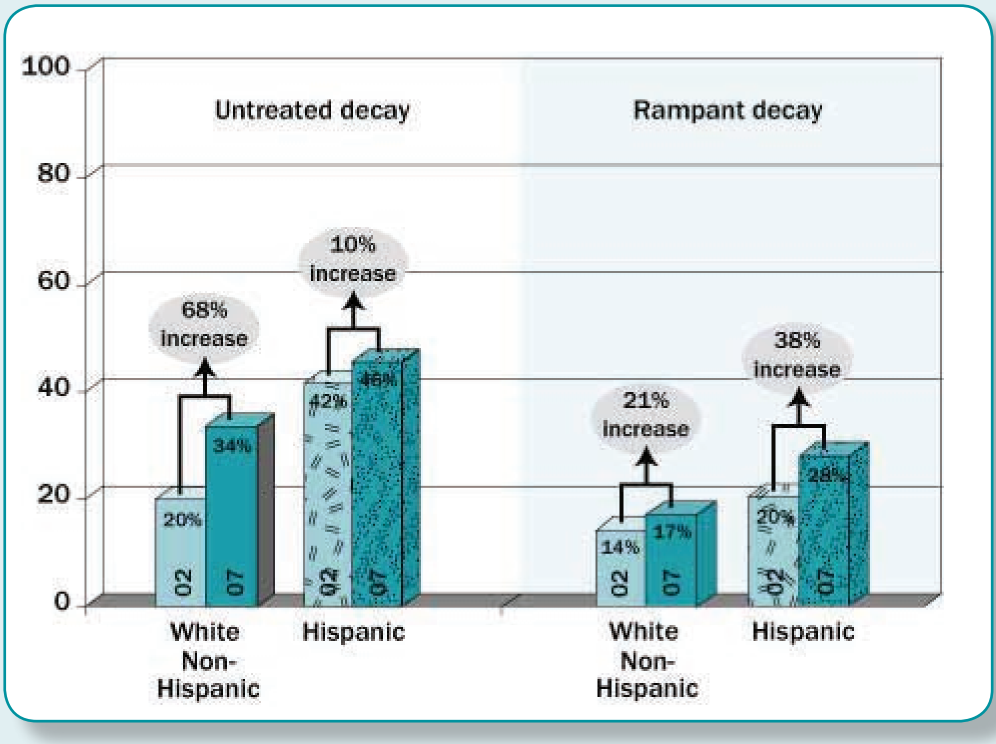
* Eligibility for the Free and Reduced Lunch Program is a household income at or below 130% (Free) and between 130–185% (Reduced) of the federal poverty level.

Racial and ethnic disparities ease

Comparing the 2007 Smile Survey results with those of 2002, there is evidence that oral disease disparities are easing to some degree.

- Oral disease increased for school children in every race/ethnicity category.
- Hispanic school children have a disproportionately higher rate of oral disease than White, non-Hispanic school children.
- The rate of increase for some types of oral disease increased more slowly among Hispanic children than among White, non-Hispanic school children.





Recommendations

Dental public health professionals have long championed the practice of disease prevention and health promotion on the part of individuals, health care providers and the community at large. The simple reason is these thoughtful approaches can significantly improve oral health. When efforts by individuals, providers and the community at large join to form partnerships, the outcome is even further enhanced. The Oregon Public Health Division recommends the following strategies that focus on public-private partnerships to address the issue of dental disease in children.

- Improve the oral health of infants, children and adolescents by setting guidelines for prevention and care.
- Improve the partnerships between dental professionals and other health professionals to promote the oral health of children.
- Create partnerships between dental care professionals and families to promote an understanding of the importance of oral health care.
- Create partnerships between dental care professionals and public health professionals.
- Promote a seamless system of care that includes community-based health education and preventive interventions.

There are four community-based preventive measures that have been proven effective in reducing tooth decay through partnerships between public health and the professional.

- Community water fluoridation
- Early-childhood cavities prevention programs
- School-based fluoride supplement programs
- School-based dental sealant programs

Community water fluoridation

Water fluoridation is the controlled addition of a fluoride compound to a public water supply to achieve a concentration optimal for tooth decay prevention. The practice of community water fluoridation has been recognized as one of the great public health achievements of the 20th century because of its impressive record of safety and effectiveness. Nearly 70 percent of U.S. citizens on public water supplies drink fluoridated water compared with less than 20 percent of Oregon residents. This ranks Oregon 48th out of 50 states. The Public Health Division advocates the fluoridation of community water supplies to reduce tooth decay.

Early-childhood cavities prevention

Dental treatment for pregnant women plus preventive care beginning as early as age one has been shown to reduce tooth decay in young children. The Public Health Division in partnership with dental and medical care providers supports early-childhood cavity prevention programs.

School-based fluoride supplement programs

For communities without community water fluoridation, participation in school-based fluoride supplement programs is recommended. The Public Health Division, partnering with elementary schools around the state, recommends and implements a school-based fluoride supplement program.

School-based dental sealant programs

A dental sealant is a plastic coating applied to the chewing surfaces of molar teeth for the purpose of preventing tooth decay. School-based dental sealant programs have been shown to be a best practice in decay prevention. The Public Health Division, in partnership with communities, elementary schools, and dental care professionals, promotes and implements a school-based dental sealant program.

Oregon Department of Human Services
Public Health Division
Oral Health Program
800 NE Oregon Street, Suite 825
Portland, Oregon 97232
www.oregon.gov/DHS/ph/oralhealth/

Portland, Oregon

FINANCIAL IMPACT and PUBLIC INVOLVEMENT STATEMENT
For Council Action Items

(Deliver original to Financial Planning Division. Retain copy.)

1. Name of Initiator	2. Telephone No.	3. Bureau/Office/Dept.
Stu Oishi	503.823.3005	Commissioner of Public Safety

4a. To be filed (date):	4b. Calendar (Check One)	5. Date Submitted to Commissioner's office and FPD Budget Analyst:
September 6, 2012	Regular ☐ Consent ☐ 4/5ths ☐	

6a. Financial Impact Section:	6b. Public Involvement Section:
X Financial impact section completed	X Public involvement section completed

1) Legislation Title:

Authorize and direct the Portland Water Bureau to fluoridate the City of Portland's public drinking water supply to the optimal levels beneficial to reduce tooth decay and promote good oral health as recommended by the Oregon Health Authority. (Ordinance)

2) Purpose of the Proposed Legislation:

Authorize and direct the Portland Water Bureau to fluoridate the City of Portland's public drinking water supply to the optimal levels beneficial to reduce tooth decay and promote good oral health as recommended by the Oregon Health Authority.

3) Which area(s) of the city are affected by this Council item? (Check all that apply—areas are based on formal neighborhood coalition boundaries)?

X City-wide/Regional ☐ Northeast ☐ Northwest ☐ North
☐ Central Northeast ☐ Southeast ☐ Southwest ☐ East
☐ Central City
☐ Internal City Government Services

FINANCIAL IMPACT

4) Revenue: Will this legislation generate or reduce current or future revenue coming to the City? If so, by how much? If so, please identify the source.

No.

5) <u>Expense</u>: What are the costs to the City related to this legislation? What is the source of funding for the expense?

The project is estimated to cost up to $5 million. Funding for effort during FY 2012-13 will be requested with the Fall BuMP adjustments and will be submitted with the Requested Budget for the subsequent years. This project will be included in the Treatment Program that now contains $2.6 million in the 5-year CIP adopted budget. This project budget currently has a low confidence rating.

6) <u>Staffing Requirements:</u>

- **Will any positions be created, eliminated or re-classified in the current year as a result of this legislation?** No.

- **Will positions be created or eliminated in *future years* as a result of this legislation?** No.

(Complete the following section only if an amendment to the budget is proposed.)

7) <u>Change in Appropriations</u> > No changes.

[Proceed to Public Involvement Section — REQUIRED as of July 1, 2011]

PUBLIC INVOLVEMENT

8) Was public involvement included in the development of this Council item (e.g. ordinance, resolution, or report)? Please check the appropriate box below:

X YES: Please proceed to Question #9.
☐ **NO**: Please, explain why below; and proceed to Question #10.

9) If "YES," please answer the following questions:

a) What impacts are anticipated in the community from this proposed Council item?

Based on established research, it is anticipated that this proposal would reduce dental decay by at least 25% for the population that drinks fluoridated water. It would also reduce dental costs by at least $19 per person per year, and would decrease Medicaid dental costs by an estimated 50%.

b) Which community and business groups, under-represented groups, organizations, external government entities, and other interested parties were involved in this effort, and when and how were they involved?

The proposal was developed and brought forward by a diverse coalition called the "Everyone Desérves Healthy Teeth" coalition. The coalition had over 200 meetings, and identified 75 organizations that endorse the proposal. These include the coalition of communities of color, public health organizations, children's advocacy groups, and major health systems. The coalition also launched a website with downloadable materials for the public on a variety of issues related to dental health and water fluoridation. The coalition also met with organizations that have historically been neutral or opposed to fluoridation including environmental groups and others.

c) How did public involvement shape the outcome of this Council item?

This proposal came before the council because of a strong community-driven coalition to raise awareness about dental health, and to partner with city commissioners.

d) Who designed and implemented the public involvement related to this Council item?

The Everyone Deserves Healthy Teeth coalition engaged in public involvement with suggestions from Commissioner Leonard.

e) Primary contact for more information on this public involvement process (name, title, phone, email):

Raquel Bournhonesque, Co-Director, Upstream Public Health,
Phone: 503-284-6390
Email: Raquel@upstreampublichealth.org

10) Is any future public involvement anticipated or necessary for this Council item? Please describe why or why not.

No. There have been significant meetings with relevant parties.

Commissioner Randy Leonard

BUREAU DIRECTOR (Typed name and signature)