CITY OF LODI
INFORMAL INFORMATIONAL MEETING
"SHIRTSLEEVE" SESSION
CARNEGIE FORUM, 305 WEST PINE STREET
TUESDAY, SEPTEMBER 11, 2001

An Informal Informational Meeting ("Shirtsleeve" Session) of the Lodi City Council was held Tuesday, September 11, 2001 commencing at 7:04 a.m.

A. **ROLL CALL**

Present: Council Members – Hitchcock (arrived at 7:05 a.m.), Howard, Land, Pennino and Mayor Nakanishi

Absent: Council Members – None

Also Present: City Manager Flynn, City Attorney Hays, and City Clerk Blackston

B. **CITY COUNCIL CALENDAR UPDATE**

City Clerk Blackston reviewed the weekly calendar (filed).

C. **TOPIC(S)**

C-1 "Water Fluoridation"

Public Works Director Prima reported that a state law was passed a few years ago that required cities to implement water fluoridation if funds were made available. In response, Public Works submitted a cost estimate to the state and they placed Lodi at approximately 65 on a list of cities. To institute water fluoridation, two of the City's wells would need additional property to install the necessary equipment. In addition, it would require more staff, training, and other procedural steps.

Doctor Clifford Bradshaw briefly reviewed his background. He stated that Assembly Bill 733 mandates that all cities implement water fluoridation to bring the level of fluoride up to an optimal level, which would decrease the decay rate by 60% and has minimal side effects. The mandate, however, is non-funded, so it is up to each individual community to develop the necessary resources. Funding sources are available through Proposition 10 funds, the California Endowment, and various private grants.

Doctor Matthew Stefanac reported that in the 1890s it was noted that people in Texas and southeast Colorado had small white and brown spots on their teeth. The cause was determined to be a high fluoride level of up to 12 parts per million. In the 1920s and 1930s it was also noted that individuals living in these areas had very little tooth decay. With time, it was determined that the correct level of fluoridation was approximately 1 part per million. Approximately 70% of Americans believe that water fluoridation is beneficial, 5% to 10% do not want government to add anything to their water, and 10% to 20% do not have an opinion on the subject. Nearly 70% of the treated water in the United States is fluoridated. In California, only 17% of the treated water is fluoridated. Fluoridation is accepted by the American Dental Association (ADA), American Medical Association, National Academy of Sciences, Center for Disease Control (CDC), and Poison Control. Dr. Stefanac stated that the research done by the anti-fluoridation group does not hold up to the scientific community. The group makes claims that fluoridation causes fractures in hips, cancer, diabetes, and causes fluorosis.

Doctor Judee Tippett-Whyte pointed out that fluoride is naturally occurring in water. There is some fluoride in Lodi's water, but it is an insignificant amount. Water fluoridation reduces dental decay by 38% to 60%. Children without access to dental care would benefit the greatest from water fluoridation. Employees who have less dental needs will have less time away from work. Studies have shown that in areas where there is water fluoridation, dental insurance rates are somewhat lower. Annually, it costs approximately

90 cents per person to fluoridate water. In a recent ADA news article, the CDC reported that approximately 60% (144 million people) of the United States' population have access to the oral health benefits of community water fluoridation. In 1999, the CDC reported that the average water fluoridation cost was 72 cents per person. Ms. Tippett-Whyte read the following quote from the ADA president, "It is our hope that the federal, state, and municipal governments will take their cue from the CDC and increase their efforts to bring water fluoridation to as many communities as possible."

Doctor Stefanac reported that it has been estimated that for every dollar put into fluoridation, $80 dollars is returned in terms of lower dental costs. Most of western Europe has fluoridated water, France has fluoridated salt, England is mostly fluoridated, and some of the Scandinavian countries are fluoridated through medication.

Doctor Michael Wong, pediatrician, stated that the CDC released a report on August 17 entitled, "Recommendations for using fluoride to prevent and control dental caries for the United States." A panel of 30 specialists stated that all persons should drink water with an optimal amount of fluoride concentration and brush their teeth twice daily with fluoride toothpaste. The ADA, the American Academy of Pediatric Dentistry, and the American Academy of Pediatrics all have guidelines for how much fluoride supplementation should be given to children on a daily basis according to the amount of fluoride in the water.

In answer to Mayor Nakanishi, Dr. Wong stated that fluoridating the water will not alter its taste.

Doctor Wong reported that in 1992, fluoridated water was reaching 56% of the United States' population. By 2000, 38 states and the District of Columbia were fluoridating their water. California and ten other states provide fluoridated water to less than 49% of their populations. The CDC reported that 80% of the dental caries in the permanent teeth of children ages 5 to 17, were found in 25% of the population. Those at increased risk for dental cavities are those with lower socioeconomic status, low level of parental education, those who do not seek regular dental care, and those without dental insurance or access to dental services. In 1994, an economic analysis reported that water fluoridation saved $39 billion in dental care expenditures in the United States between 1979 and 1989. Dr. Wong stated he was convinced that fluoridation of the community's water is the most equitable and cost effective method of promoting good dental health.

In reply to questions by Council Member Howard, Dr. Wong reported that temperature is no longer a determinant of how much fluoride should be put in water. Under that theory, the higher the average temperature of an area, the more water people would consume. If the recommended amount of fluoride were added to the water, fluorosis would be minimal and discoloration of teeth unnoticeable. Fluorosis does not mean that the teeth are weakened. In reference to Ms. Howard's concern about possible fluoride allergies, Dr. Wong pointed out that fluoride is a natural element in rocks and related allergies are unlikely. In regard to individuals on dialysis, tap water is not used, so the fluoridated water would have no effect. The recommended amount of fluoride for water is safe to the body. The salinity of the saliva helps the fluoride bond to the matrix of the teeth.

Sherrie Evans, Lodi Unified School District (LUSD), Regional Occupation Program (ROP) dental assisting instructor, reported that since 1997 her students have been teaching oral hygiene instruction at Lawrence and Heritage Elementary Schools, and will begin teaching at Joe Serna Charter School in the near future. Ms. Evans stated that she is the co-chair of the Lodi Area Dental Task Force formed in conjunction with the Healthy Start Program at Lawrence and Heritage Schools. The Task Force has identified that economics, access to dental treatment, language barriers, and lack of community water fluoridation are contributing factors to the poor dental health of many of Lodi's school age children. Ms. Evans presented the following statistics:

- 9,538 (64%) LUSD elementary students are on free or reduced lunches;

- A 2000-2001 random survey of school nurses in LUSD's Title I schools indicated that an average of 13 out of 20 students (65%) in each primary grade had obvious, untreated dental disease;
- At Joe Serna Charter School, 38 out of 119 Kindergarten to third grade students, required dental referrals;
- CDC has reported that 36.8% of poor children ages two to nine years have one or more untreated decayed primary teeth, compared to 17.3% of non-poor children;
- 29.2% of LUSD students come from limited English proficient, Hispanic and Asian families. The language barrier presents an obstacle to learning about oral health information.

Roberta Willams, LUSD school nurse, stated that for every dollar spent in prevention, $3 is saved in treatment. In 1999-2000 Ms. Williams screened all second graders at Lawrence Elementary School, of which 46% were referred to the dentist. In 2000-2001 she referred 20% of those screened to the dentist. A school nurse assigned to Heritage Elementary School screened two second grade classes and referred 55% and 75% respectively to the dentist. She referred 45% of a fourth grade class to the dentist. Ms. Williams stated that all these percentages average out to a 48% referral rate. School nurses believe that fluoridation of water is not only prevention and good health care, it is also cost effective in getting children to school, getting them to learn, and to eventually be productive citizens.

Mike Gilton, member of the California Fluoridation Task Force and American Water Works Fluoride Standards, explained that he was a staff engineer for the City of Modesto and designed its fluoride equipment. He reported that in the valley area, the fluoride level in the water is approximately .8 to 1 part per million. Referencing Ms. Howard's earlier question regarding equipment safety, Mr. Gilton stated that if the equipment is properly installed according to CDC guidelines, the equipment would alarm and automatically shut down if there was a malfunction. The operation and maintenance cost of fluoridating the City of Modesto's system, which has 100 wells and one water treatment plant, is approximately $500,000 a year. This equates to $2.50 per residence. Los Angeles has three water treatment plants, and its cost to fluoridate is 50 cents per capita. Modesto considered providing two liters of bottled water to each of its 30,000 Title 1 students; however, the cost was prohibitive at $3 to $5 million a year. Providing fluoride tablets is less effective. Mr. Gilton spoke with an engineer in Iowa who stated that they have not had a problem in the 50 years that they have been fluoridating their water. Approximately 30% of the water systems in California are fluoridated. Last week the Redding City Council voted to fluoridate its water.

Tom Bennett, representing Sierra Health Foundation, stated that they are one of the few private foundations that will fund fluoridation activities. He reported that the City of Redding received money from the County Public Health Department, Proposition 10 Commission. Funds are also available from the California Wellness Foundation, California Endowment, and the California Health Care Foundation. Sierra Health Foundation has set aside $1 million for community water fluoridation.

PUBLIC COMMENTS:

- David Phillips spoke in opposition to fluoridating the water system. He stated that the CDC has recently acknowledged that the mechanism of fluoride benefits are mainly topical and not systemic. According to medical information he had reviewed, when fluoride is ingested it remains in the body and only 50% is excreted. Fluoride is a cumulative poison that remains in the bones, glands, and tissues. It is one of the most toxic substances on earth and if three to five grams are consumed, fluoride is considered deadly. All the fluoride that is added to water systems is a byproduct of fertilizer, pesticide, and aluminum industries. Mr. Phillips asked the Council (if it is considering moving forward) to allow the community to vote on this issue at a regular general election.

Doctor Stefanac agreed that fluoride has a great topical effect; however, studies have also shown that there is a significant reduction in tooth decay from the ingestion of fluoride. He pointed out that many things are considered poisonous if ingested in large quantities, e.g., caffeine, chlorine. Dr. Stefanac stated that typically 50% of the community will vote against fluoridating water because they are confused about the issue. He encouraged the Council to make the decision for the community.

Mayor Pro Tempore Pennino stated that he was unsure of the role of the City Council regarding this issue and believed that more research should be done to bring forward additional information including: Public Works cost estimate and procedural steps to implement water fluoridation, legal and medical issues, equipment safeguards, statistics on dental insurance costs decreasing, and additional input from citizens.

Mayor Nakanishi agreed that additional study and information should be sought prior to making a decision.

Discussion ensued regarding potential costs for fluoridating Lodi's water system.

Council Member Hitchcock noted that a 35 to 45 member Environmental Quality Committee of the League of California Cities has studied the issue of water fluoridation. She agreed that additional information should be obtained regarding research, costs, and potential grants. Addressing City Manager Flynn, she stated that the issue of water fluoridation should be placed on a regular City Council agenda within the next two to three months.

Mayor Pro Tempore Pennino and Council Member Howard favored having another Shirtsleeve Session on the topic prior to placing it on a regular City Council agenda.

City Manager Flynn believed that the cost to fluoridate the City's water would be minimal compared to the benefits. He agreed with Mr. Prima's estimate of $500,000 for capital costs.

D. COMMENTS BY THE PUBLIC ON NON-AGENDA ITEMS

None.

E. ADJOURNMENT

No action was taken by the City Council. The meeting was adjourned at 8:40 a.m.

ATTEST:

Susan J. Blackston
City Clerk

Mayor's & Council Member's Weekly Calendar

WEEK OF SEPTEMBER 11, 2001

Tuesday, September 11, 2001

7:00 a.m.	Shirtsleeve Session 1. Water Fluoridation
8:30 a.m.	ADESA Golden Gate's ground breaking ceremony for its new auction site in Tracy, Schulte Road at Stanford Road, Tracy.
11:30 a.m.	**Nakanishi.** United Way Kick-Off Luncheon, Stockton Civic Auditorium.
7:00 p.m.	Library Facilities Master Plan Town Hall Meeting II, Lodi Public Library ~ Bud Sullivan Community Room.

Wednesday, September 12, 2001

Reminder	**Hitchcock, Land, and Pennino.** LCC Annual Conference, Sacramento, 9/12 - 15.
6:00 - 8:30 p.m.	San Joaquin County Superior Court's "Continuing Conversations with the Court: Past, Present, and Critical Issues for the Future of the Justice System," UOP ~ McCaffery Center Theater.
10:30 a.m.	Child Abuse Prevention Council's ground breaking ceremony for the site of the new First Step Children's Center, 540 N. California Street, Stockton.
6:30 p.m.	**Nakanishi, Hitchcock, Howard, Land, and Pennino.** Dinner with LCC Conference attendees, Morgan's Central Valley Bistro in the Sheraton Hotel.

Thursday, September 13, 2001

Reminder	**Hitchcock, Land, and Pennino.** LCC Annual Conference, Sacramento, 9/12 - 15.
Reminder	Grape Festival begins and runs through Sunday, 9/16.

Friday, September 14, 2001

Reminder	**Hitchcock, Land, and Pennino.** LCC Annual Conference, Sacramento, 9/12 - 15.

Saturday, September 15, 2001

Reminder	**Hitchcock, Land, and Pennino.** LCC Annual Conference, Sacramento, 9/12 - 15.
Reminder	Kiddie's Parade, Downtown Lodi.

Sunday, September 16, 2001

11:00 a.m.	Grape Festival Parade Brunch, Odd Fellows Hall, 6 S. Pleasant Avenue.
12:30 p.m.	Grape Festival Parade.

Monday, September 17, 2001

Disclaimer: This calendar contains only information that was provided to the City Clerk's office

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City of Lodi
Fluoridation Cost Estimate

Item (Each Well Site)	Cost
Fluoride Saturator w/ Metering Pump, Softener	$4,000
Fluoride Analyzer	$3,500
Subtotal	$7,500
Backflow Device	$500
Instrumentation	$1,000
Level Control	$1,000
Safety Facilities	$1,000
Subtotal	$3,500
Grading/Excav.	$1,000
Yard Piping	$1,000
Enclosure/Vault	$5,000
Sub Total	$7,000
Subtotal per Well (1)	$18,000
Subtotal 26 Wells	$468,000
Design & Construction Management	$101,000
Cost Inflation/Contingencies @ 20% (2)	$114,000
Total:	$ 683,000
Annual Fluoride & Parts	$45,000
Annual Labor O&M (1.5 FTE)	$89,000
Annual Total:	$134,000

Notes:
1. Costs based on State of California Estimates, 1996.
2. Acquisition of additional property will be necessary at Wells 2 and 12.

Cavities used to be a fact of life. But over the past few decades, tooth decay has been reduced dramatically. The key reason: fluoride. Research has shown that it reduces cavities up to 60 percent in baby teeth and 15-35 percent in adult teeth. It also helps repair the early stages of tooth decay even before the decay becomes visible. Unfortunately, many people continue to be misled about fluoride and water fluoridation. To help you learn more about the important oral health benefits of fluoride, the American Dental Association (ADA) has prepared this informational brochure.

We encourage you to talk to your dentist about this and other oral health issues. Your health is our first priority and we are pleased to provide you the FACTS ABOUT FLUORIDE.

Children living in communities without fluoridated water can still enjoy the benefits of fluoride.

TRUE! In such communities, dentists and physicians may prescribe fluoride tablets or drops for children to take daily, or fluoride may be added to the school water supply. Children also may benefit from fluoride mouthrinses at home or school, or the application of fluoride solutions or gels in the dental office.

All bottled water contains the adequate amount of fluoride needed to prevent tooth decay.

FALSE! All water contains some fluoride naturally. However, unless the fluoride content is printed on the label, don't assume bottled water contains adequate fluoride to prevent tooth decay. It may be necessary to contact the manufacturer to obtain this information.

American Dental Association
Division of Communications
211 East Chicago Avenue
Chicago, Illinois 60611-2678

W102

Facts About Fluoride

There are numerous benefits of fluoride.

TRUE! Fluoride, when added to community water supplies, is the single most effective public health measure we have to prevent tooth decay and improve oral health for a lifetime. Also, products containing fluoride stop the growth of newly formed cavities AND can prevent formation of cavities on the roots of teeth.

Fluoride is available from a number of sources.

TRUE! All water contains some fluoride naturally, in amounts greater or lesser than that needed to contribute to oral health benefits. Water fluoridation is the process of adjusting the natural level of fluoride to the concentration necessary for protection against tooth decay. Another way to receive fluoride is by using oral care products such as toothpastes, mouthrinses and gels. In fact, about 90 percent of toothpastes and many mouthrinses contain fluoride. Both systemic fluoride (fluoride that comes from eating foods and drinking liquids) and topical fluoride (fluoride that is applied to the surfaces of the teeth) work together to keep teeth strong.

Fluoride is only beneficial to children.

FALSE! Fluoride benefits people of all ages. For example, when children are young and their teeth are still forming, fluoride works by making tooth enamel harder and more resistant to the acid that causes tooth decay. In fact, studies indicate that people who drink optimally fluoridated water from birth will experience approximately 35 percent less decay over their lifetimes.

For adults, the benefits are just as great. Fluoride helps repair the early stages of tooth decay even before they become visible in the mouth, a process known as remineralization. And for older adults who experience problems with root caries (decay along the gumline), fluoride has been effective in decreasing this condition.

Water fluoridation is expensive.

FALSE! Not only is fluoridation an oral health benefit, it's also economical! The average cost for a community to fluoridate its water is estimated to be less than 50 cents a year, per person. Over a person's lifetime, that's less than the price of having one cavity treated. In light of increasing health care costs, fluoridation is presently the most cost-effective way we have to prevent tooth decay.

Water fluoridation is safe.

TRUE! Since the 1930s, hundreds of carefully conducted scientific studies have shown that water fluoridation, at the concentrations recommended for good oral health, has no harmful effects. Fluoridation of community water supplies is recognized as a beneficial public health measure by the ADA, the World Health Organization, the U.S. Public Health Service, the American Medical Association and the American Cancer Society.

Parents should monitor their children's tooth brushing habits.

TRUE! The ADA encourages parents to take an active role in their children's oral health and one way to do so is to supervise their brushing habits. Children should be told to use only a small amount of toothpaste and not to swallow toothpastes and mouthrinses.

Fluoride is all that's needed to prevent tooth decay.

FALSE! While it is true that fluoride is instrumental in preventing tooth decay, fluoride alone cannot prevent dental disease. To help, the ADA recommends brushing twice a day, flossing daily and eating well-balanced meals. Regular dental check-ups also are recommended.

Mild dental fluorosis does not affect health or tooth function.

TRUE! Dental fluorosis is usually a mild cosmetic condition unnoticeable to most people. It is characterized by lacy white lines or specks in the teeth. In fact, teeth with fluorosis are more resistant to decay.

Drinking optimally fluoridated water (0.7-1.2 ppm) will not cause dental fluorosis in children.

TRUE! Drinking optimally fluoridated water and properly using products containing fluoride will not cause moderate or severe dental fluorosis. Dental fluorosis occurs when the natural fluoride content is too high and children drink this water when their permanent teeth are forming. Drinking water fluoridated at the recommended level will not cause moderate or severe fluorosis (unsightly stained teeth).

There is no link between fluoride and cancer.

TRUE! The U.S. Public Health Service completed an extensive study of the benefits and risks of fluoride. Their report concluded that "optimal fluoridation of drinking water does not pose a detectable cancer risk to humans." The report went on to say that fluoride's "benefits are great and easy to detect."

SJDS

Encompassing the Counties of CALAVERAS, SAN JOAQUIN, AND TUOLUMNE

7849 N. Pershing Ave. • Stockton, CA 95207 • (209) 951-1311 • FAX (209) 951-1321

July 6, 2000

Matthew Stefanac, DDS
Chairman
Coalition for Healthy Smiles
San Joaquin Dental Society
4661 Precissi Lane
Stockton, CA 95207

Dear Dr. Stefanac:

On behalf of the Board of Directors the San Joaquin Dental Society resoundingly supports community water fluoridation and urges the City of Stockton to bring what the Center for Disease Control has named one of the top ten public health measures of the last century to our community.

In 1994 the first ever statewide oral health needs assessment revealed that dental disease is the most prevalent disease plaguing California children, affecting them at twice the rate of the national average.

Water fluoridation, in place for more than 50 years in many parts of the country presents the most safe, economical, effective, preventive measure for reducing decay in both adults and children. Decreasing significantly the risk and incidence of decay provides the potential for tremendous savings in both time and treatment costs to public and private sectors. Community fluoridation is estimated to cost about 50 cents per person annually - the California Department of Health Services estimates every dollar invested in fluoridation saves $140 in dental care. This is the type of healthcare reform we need most . . . prevention.

According to the 1994 needs assessment, children in California communities currently providing fluoridated water already have an average of 36-54 percent fewer cavities. Over 60% of the U.S. population benefits from fluoridation, a measure supported by every U.S. Surgeon General since its inception over 50 years ago. With community water fluoridation available to less than 30% of its population, California lags far behind in this process, in spite of the State's 1995 fluoridation mandate.

As dentists, it's our responsibility to educate our patients and our community on dental health, which includes encouragement and support of water fluoridation. We urge you to help us serve the people of Stockton by bringing this vital public health measure to our community.

Sincerely,

San Joaquin Dental Society

Nick Veaco, DDS
President

c: Judee Tippett-Whyte, DDS, Coalition for Healthy Smiles
Cindy Lyon, DDS, President

American
Dental
Association

211 East Chicago Avenue
Chicago, Illinois 60611-2678
312: 440-2500
Fax (312) 440-7494

DATE: August 1998

TO: Officers and Members of the Board of Trustees

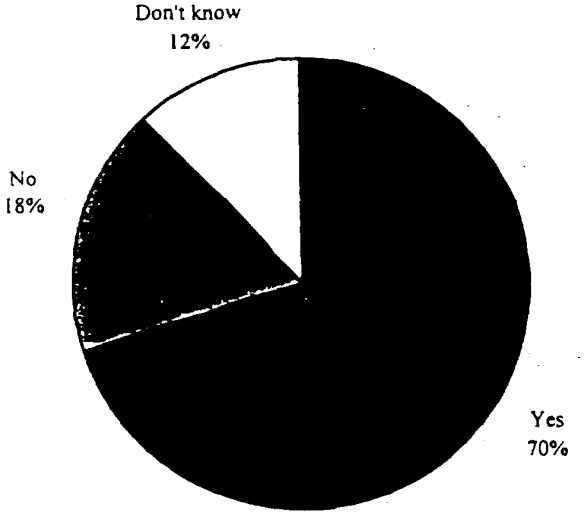
FROM: Karen Schaid Wagner, Director
Survey Center

SUBJECT: 1998 *Consumers' Opinions Regarding Community Water Fluoridation*

The Survey Center has just released the 1998 *Consumers' Opinions Regarding Community Water Fluoridation*. The Gallup Organization conducted a national random telephone study of 1003 adults, 18 years of age or older, in June 1998. Respondents were surveyed on a variety of health and non-health related issues. For the American Dental Association, one specific topic addressed was community water fluoridation.

Specifically, respondents were asked: "Do you believe community water should be fluoridated?". A majority of the respondents (70%) indicated *yes*. Eighteen percent of the respondents said they were opposed to community water fluoridation, while the response for the remaining 12% was *don't know*. (See the figure below.) This report also summarizes the similarities and/or differences across gender, age, U.S. Census Region, educational attainment, and annual household income regarding this issue.

Consumers' Opinions on Whether Community Water Should Be Fluoridated



Source: ADA, Survey Center, 1998 Consumers' Opinions Regarding Community Water Fluoridation.

DEPARTMENT OF HEALTH AND HUMAN SERVICES

Office of the Secretary

Assistant Secretary for Health
Office of Public Health and Science
Washington D.C. 20201

OCT 19 1998

Timothy R. Collins, D.D.S., M.P.H.
Chairman
California Fluoridation Task Force
4340 Redwood Highway #319
San Rafael, California 94903

Dear Dr. Collins:

I have just become aware of the decision by the City of Los Angeles to initiate fluoridation of their drinking water by the end of the year. This is indeed a great public health advancement. As you know, oral diseases and their prevention remain a high priority for the Department, and I am in the process of completing the first Surgeon General's report on oral health. Fluoridation was included in our National Healthy People 2000 objectives and has been proposed for retention in the objectives for 2010.

Fluoridation remains an ideal public health measure based on the scientific evidence of its safety and effectiveness in preventing dental decay and its impressive cost-effectiveness. Further, one of my highest priorities as Surgeon General is reducing disparities in health that persist among our various populations. Fluoridation holds great potential to contribute toward elimination of these disparities.

I am pleased to join previous Surgeons General in acknowledging the continuing public health role for community water fluoridation in enhancing oral health protection for Americans. Congratulations to you, the task force, and the health organizations that are supporting your efforts. Your success in Los Angeles and other California communities in need of fluoridation will make a significant contribution toward achieving our national goal.

Sincerely yours,

David Satcher, M.D., Ph.D.
Assistant Secretary for Health and
Surgeon General

American Medical Association
Physicians dedicated to the health of America

James S. Todd, MD
Executive Vice President

515 North State Street
Chicago, Illinois 60610

312 464-5000
312 464-4184 Fax

March 10, 1995

John S. Zapp, D.D.S.
Executive Director
American Dental Association
211 East Chicago Avenue
Chicago, Illinois 60611

Dear Dr. Zapp:

This letter is to inform the American Dental Association of a resolution adopted in 1994 by the American Medical Association (AMA) regarding the fluoridation of community drinking water supplies.

The continued concern of physicians for improving state drinking water fluoridation programs is indicated in recent AMA policies. In 1986, the AMA adopted as policy:

> "The AMA urges state health departments to consider the value of requiring statewide fluoridation (preferably a comprehensive program of fluoridation of all public water supplies, where these are fluoride deficient), and to initiate such action as deemed appropriate." (AMA policy no. 440.972)

In 1991, the AMA encouraged physicians and medical societies to become involved with this issue:

> "Local and state medical societies and individual physicians have the opportunity to become involved in correcting the problem of fluoride underfeeding by (1) ascertaining whether municipal water supplies are optimally fluoridated and (2) working with the public health agencies to take corrective action if suboptimal fluoridation is found." (AMA policy no. 440.945)

Most recently, at the June 1994 Annual Meeting, the AMA House of Delegates adopted a resolution for improving the operation and maintenance of water fluoridation systems:

> "The AMA encourages state medical societies to urge state health departments to appoint water fluoridation engineers/specialists as the best protection for assuring optimally fluoridated community water supply programs." (AMA policy no. 440.923)

DEPARTMENT OF HEALTH & HUMAN SERVICES Public Health Service

May 1, 1989

National Institutes of Health
Bethesda, Maryland 20892

Contact: Brent Jaquet
(301) 496-4261

NIDR Affirms Effectiveness of Water Fluoridation

Claims that water fluoridation does not reduce tooth decay in American children are false, say federal health officials. The claims are being made by anti-fluoridation activist Dr. John Yiamouyiannis, who obtained raw data from a government survey through a Freedom of Information Act request.

Officials of the government's National Institute of Dental Research are taking the unusual step of refuting specific anti-fluoridation claims because of fears that in this case the claims could be misinterpreted as having come from the Institute.

NIDR conducted a survey during the 1986-87 school year in which dental examinations were performed on almost 40,000 schoolchildren across the country. The results showed a sharp decline--36 percent--in tooth decay since 1980. That decline followed a similar drop during the 1970s. By 1987, half of all Americans aged 5 to 17 had never had a cavity.

As part of its survey, NIDR collected information on the residential history of each participant and on the child's use of topical and supplemental fluorides, such as drops, tablets, treatments in the dental office, and school-based fluoride programs. By matching this with information about public water supplies, NIDR epidemiologists were able to determine whether a child had always, sometimes, or never lived in an area with community water fluoridation.

Children who had always lived in fluoridated areas had about 18 percent less tooth decay than children who had never lived in a fluoridated community, they found. When some of the effects of topical fluorides were taken into account, the difference rose to 25 percent. These results were presented at an international scientific symposium in March and have been submitted for publication in a scientific journal.

There are many unanswered questions about the reasons for the continued downward trend in tooth decay in American children since the advent of water fluoridation some 40 years ago. But there is little doubt, say NIDR officials, that fluoride-based prevention is necessary to maintain this decline. To ensure optimum delivery of fluoride and to minimize costs, water fluoridation must continue to be the major component of this effort in the United States, they say.

Position Statement
on
Community Water Fluoridation

As the dean of a California dental school, I would like to state my personal and professional position on the need to fluoridate California's community water systems. Community water fluoridation, without a doubt, is the greatest public health benefit related to decay prevention. It is a safe, effective and cost effective way to make this preventive measure available to everyone in a community. Quite simply, it is a measure which I would advocate to my family, friends and colleagues without question or concern.

The need to fluoridate California's community water systems is obvious. California currently ranks 48th in the nation related to community water system fluoridation. This translates to only 17 percent of Californians benefiting from perhaps the most safe, efficient and cost effective means of preventing tooth decay. Recent studies indicate the decay rate of California school children to be as much as 50 percent higher than the national average. Sixty percent of Californians mistakingly think that their water is already optimally fluoridated. Fluoride is a naturally occuring element found in trace amounts in most water systems. It has been scientifically proven that by adjusting the concentration of fluoride in community water systems the therapeutic effect for decay prevention will be achieved. Years of studies in communities with naturally occurring optimal levels of fluoride as well as those communities with adjusted levels have proven to be safe and effective. Many communities have voluntarily fluoridated for over forty years with no adverse health effects.

With the passage of AB 733 (Speier) in 1995, California was given a tremendous opportunity to act positively regarding this public health measure. This legislation, however, is currently an unfunded mandate. The political will of a community to support fluoridation is important. Community water fluoridation is estimated to cost about 50 cents per person annually. By comparison, a single filling costs between $50-$100. This means that for every dollar spent on fluoride a savings of $100 in dental care would be realized. This also means that fewer anxiety-provoking visits to the dentist for fillings or other treament would be needed.

Many communities across the nation have been studied for the decay-reducing effects of water fluoridation, and it is apparent that this public health measure is beneficial. Studies conducted by the National Institute of Dental Research and the Centers for Disease Control indicate a 30-60 percent reduction in tooth decay after implementation of community water fluoridation. Dental decay (caries) is, in fact, a disease that can be prevented or minimized by consuming drinking water that is fluoridated at an optimal level. This optimal level is monitored by state-of-the-art equipment and highly trained water engineers within a community's water system.

Extensive research has been conducted on the safety of community water fluoridation. When present at optimum levels in community water systems, fluoridation is indeed safe. The American Dental Association, the U.S. Public Health Service, the National Institute of Dental Research and independent university research have shown that, although a few individuals continue to object to fluoridation, there is no scientific basis for doubting the medical safety, effectiveness and practicality of community water fluoridation as a public health measure for preventing dental decay.

Best wishes for better dental health,

Charles N. Bertolami, DDS, D.Med.Sc.
Dean, School of Dentistry
University of California, San Francisco

Arthur A. Dugoni, DDS
Dean, School of Dentistry
University of the Pacific

Charles J. Goodarce, DDS, MSD
Dean, School of Dentistry
Loma Linda University

Howard M. Landesman, DDS
Dean, School of Dentistry
University of Southern California

No-Hee Park, DMD, PhD
Dean, School of Dentistry
University of California at Los Angeles

MMWR Weekly April 02, 1999 / 48(12);241-243

Ten Great Public Health Achievements -- United States, 1900-1999

During the 20th century, the health and life expectancy of persons residing in the United States improved dramatically. Since 1900, the average lifespan of persons in the United States has lengthened by greater than 30 years; 25 years of this gain are attributable to advances in public health (1). To highlight these advances, MMWR will profile 10 public health achievements (see box) in a series of reports published through December 1999.

Many notable public health achievements have occurred during the 1900s, and other accomplishments could have been selected for the list. The choices for topics for this list were based on the opportunity for prevention and the impact on death, illness, and disability in the United States and are not ranked by order of importance.

The first report in this series focuses on vaccination, which has resulted in the eradication of smallpox; elimination of poliomyelitis in the Americas; and control of measles, rubella, tetanus, diphtheria, Haemophilus influenzae type b, and other infectious diseases in the United States and other parts of the world.

Ten Great Public Health Achievements – United States, 1900-1999

- Vaccination
- Motor-vehicle safety
- Safer workplaces
- Control of infectious diseases
- Decline in deaths from coronary heart disease and stroke
- Safer and healthier foods
- Healthier mothers and babies
- Family planning
- Fluoridation of drinking water
- Recognition of tobacco use as a health hazard

Future reports that will appear in MMWR throughout the remainder of 1999 will focus on nine other achievements:

- Improvements in motor-vehicle safety have resulted from engineering efforts to make both vehicles and highways safer and from successful efforts to change personal behavior (e.g., increased use of safety belts, child safety seats, and motorcycle helmets and decreased drinking and driving). These efforts have contributed to large reductions in motor-vehicle-related deaths (2).
- Work-related health problems, such as coal workers' pneumoconiosis (black lung), and silicosis --

common at the beginning of the century -- have come under better control. Severe injuries and deaths related to mining, manufacturing, construction, and transportation also have decreased; since 1980, safer workplaces have resulted in a reduction of approximately 40% in the rate of fatal occupational injuries (3).

- Control of infectious diseases has resulted from clean water and improved sanitation. Infections such as typhoid and cholera transmitted by contaminated water, a major cause of illness and death early in the 20th century, have been reduced dramatically by improved sanitation. In addition, the discovery of antimicrobial therapy has been critical to successful public health efforts to control infections such as tuberculosis and sexually transmitted diseases (STDs).
- Decline in deaths from coronary heart disease and stroke have resulted from risk-factor modification, such as smoking cessation and blood pressure control coupled with improved access to early detection and better treatment. Since 1972, death rates for coronary heart disease have decreased 51% (4).
- Since 1900, safer and healthier foods have resulted from decreases in microbial contamination and increases in nutritional content. Identifying essential micronutrients and establishing food-fortification programs have almost eliminated major nutritional deficiency diseases such as rickets, goiter, and pellagra in the United States.
- Healthier mothers and babies have resulted from better hygiene and nutrition, availability of antibiotics, greater access to health care, and technologic advances in maternal and neonatal medicine. Since 1900, infant mortality has decreased 90%, and maternal mortality has decreased 99%.
- Access to family planning and contraceptive services has altered social and economic roles of women. Family planning has provided health benefits such as smaller family size and longer interval between the birth of children; increased opportunities for preconceptional counseling and screening; fewer infant, child, and maternal deaths; and the use of barrier contraceptives to prevent pregnancy and transmission of human immunodeficiency virus and other STDs.
- Fluoridation of drinking water began in 1945 and in 1999 reaches an estimated 144 million persons in the United States. Fluoridation safely and inexpensively benefits both children and adults by effectively preventing tooth decay, regardless of socioeconomic status or access to care. Fluoridation has played an important role in the reductions in tooth decay (40%-70% in children) and of tooth loss in adults (40%-60%) (5).
- Recognition of tobacco use as a health hazard and subsequent public health anti-smoking campaigns have resulted in changes in social norms to prevent initiation of tobacco use, promote cessation of use, and reduce exposure to environmental tobacco smoke. Since the 1964 Surgeon General's report on the health risks of smoking, the prevalence of smoking among adults has decreased, and millions of smoking-related deaths have been prevented (6).

The list of achievements was developed to highlight the contributions of public health and to describe the impact of these contributions on the health and well being of persons in the United States. A final report in this series will review the national public health system, including local and state health departments and academic institutions whose activities on research, epidemiology, health education, and program implementation have made these achievements possible.

Reported by: CDC.

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Return To: 

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Page converted: 04/01/99

Giants close the gap

Bonds' homer helps tighten race with 2-1 win over Dodgers

▶ SPORTS F1

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Founded 1857
Volume 282

THURSDAY
September 18, 1997

The Sacramento Bee

FINAL
46¢

Many state kids are 'walking dental disasters,' study finds

By Pamela Martineau
Bee Staff Writer

Nearly three times as many California elementary school students have tooth decay as their peers across the nation, prompting public health officials to launch an aggressive dental hygiene program in the state's schools.

That troubling statistic and others culled from the state's first-ever assessment of children's dental health have prompted the kickoff today of a $2.1 million Children's Dental Health Initiative to bring dentists and dental hygienists out to schools across the state.

The study, released today, chronicles the dental woes of California's preschoolers through high school students. It found that youths are failing to get adequate dental care and have much higher incidences of tooth decay than their peers across the nation. Supported by public funds, the survey was conducted by the Dental Health Foundation, a nonprofit research and advocacy group.

"Kids in California are walking dental disasters," said Bob Isman, a dentist and director of the newly formed Children's Dental Health Initiative. "Kids covering their mouths when they smile because they have terrible teeth is a terrible thing to bring on a child."

Dental officials, supported by the findings, believe that California's kids aren't receiving enough preventive dental care and the lack of prevention is exacerbated by an increasing number of children who are not covered by dental insurance.

The oral health research was conducted during the 1993-94 school year and used teams of dental examiners to assess 6,643 children in 156 schools in the state, including Prairie Elementary, Grant Union High and Valley High in Sacramento.

The $620,000 study, funded by the California Department of Health Services and the California Wellness Foundation, found markedly high incidences of tooth decay in the state's students, particularly its 6- to 8-year-olds.

Tooth decay among California's children in the 6-to-8 age group is nearly

Please see DENTAL, back page, A18

Galt foiled in Congress

U.S. says no to pact

ate $690,000 to the 1996 presidential

that one of them has since left the agency and gone on Tamraz's pay-

president.

"Mr. Fowler called me," Heslin

son, he will not be called as a witness, the lawyers said.

Bee photograph/Bryan Patrick

gher than the assessed value of their homes, an t the agency overseeing the project has denied.

er,' mayor says

er is- o me- reluc- ies to if the sling, ornia over- com- using er of com- tense nder or 80 Agri- and lying and build mise s ex- hose DA to is or- llow truc-

tion of shabbily built homes.

"The quality of the work they have put in is a problem and people are paying top dollar for shabby work."

De La Cruz also said she wants the USDA to investigate charges she heard from some homeowners that their loans were higher than the assessed value of their homes.

Keasling bristled at such allegations, calling them an outright fabrication and challenging De La Cruz to provide proof.

As for charges of poor workmanship, he said, "The homes all have to pass inspection by Galt housing inspectors, so I guess she is saying that her own city is inept."

Before Wednesday's decision in Congress, Galt had filed an unsuccessful lawsuit in federal court challenging Grizzly Hollow.

Some new homeowners in the development accused the city of discriminating against them.

"I guess they think we are going to steal from them," said Claudia Espinoza, who, along with her farm worker husband Raul, spends each afternoon and weekend building her "sweat equity" home in Galt.

Until there are talks between Galt and Keasling's group, Keasling said construction of homes will continue.

"People have a right to own their own home," Keasling said. "And we are going to help people achieve that dream."

Dental: Study says 21% of 10th-graders require urgent care

Continued from page A1

three times as high as for children of comparable age nationally, according to researchers.

A National Health and Nutrition Examination survey conducted on the nation's 5- to 11-year-olds between 1988 and 1991 found that 26 percent of those children had treated or untreated tooth decay. California's study conducted in the 1993-94 school year found that 73 percent of 6- to 8-year-olds had treated or untreated decay.

"A lot of other states have more preventative programs," said Isman, adding there are no current statistics on children's dental health on average in the United States today and national studies conducted in the past did not break down the data by region.

The new California study said that 21 percent of 10th-graders in the state are in urgent need of dental care for extensive decay, pain or infection.

Twenty-six percent of preschoolers, 28 percent of kindergarten through third-graders, and 44 percent of high school students in California had no dental insurance coverage, researchers found.

The findings prompted dental health officials to form an advisory committee of public health experts and children's groups to push for better dental health among the state's schoolchildren. The group hopes to develop a plan to increase the use of dental sealants on children, having them applied to kids at school by mobile dental units.

Sealants are plastic coatings that are applied to the chewing surfaces of the back teeth to protect against decay.

Isman said the committee will look at ways to counsel communities against baby bottle tooth decay – the rotting of children's teeth due to overuse of feeding bottles – and to increase the use of fluoride toothpastes and flossing.

The committee also hopes to encourage more health insurers to offer dental coverage.

"Oral diseases affect not only the teeth, gums and the rest of the mouth," said Jared Fine, a dentist and chairman of the Dental Health Foundation, "they can also lead to more serious general health problems."

Health care officials working to improve the dental health of California's kids also hope to raise money to pay for the fluoridation of the state's public drinking water systems and to lobby for such fluoridation.

The study found that only 16 percent of the state's population drinks fluoridated water, which has been found to decrease tooth decay. That figure ranks California 47th among the 50 states in the percentage of its population drinking fluoridated water.

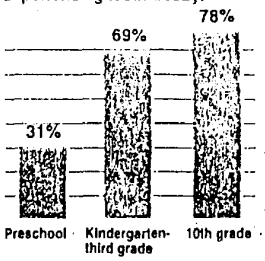
Isman said the low rate of fluoridation and a lack of public dental programs place California's kids at risk for dental disease.

California children and dental care

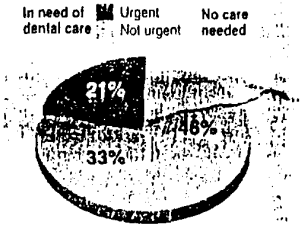
Dental Health Foundation study conducted during the 1993-94 school year.

Tooth decay

Percentage of California children experiencing tooth decay:



California 10th-graders in need of dental care



Steps to improve children's dental health

- Don't put children to bed with a bottle.
- Have children visit the dentist by age 1, and every six months after that.
- Use flouride toothpaste and mouth rinses.
- Floss and brush teeth regularly. Cut down on candies and sweets.
- Ask dentist to apply dental sealants.
- Encourage children to use mouthguards during sports.

Source: Dental Health Foundation

Bee graphic

on: Devastated by TV show's cancellation

page A1

/incennes, Ind., on

week to $7,500," he said.

He debuted on radio and on

Sciences at the Emmy Awards show, he told the audience: "I

once said: "I don't want to be

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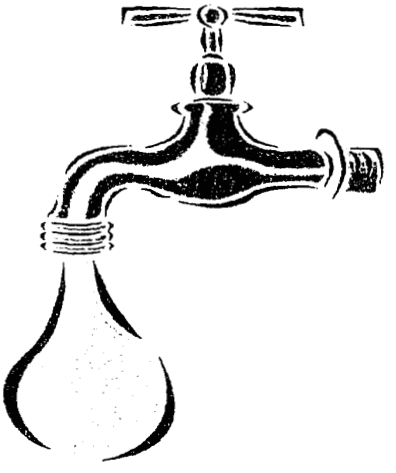
California Fluoridation Implementation Project

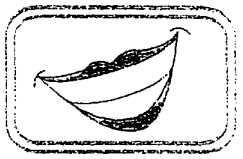


Prepared by the California Department of Health Services
Office of Oral Health
In Cooperation with the California Dental Association,
California Fluoridation Taskforce, and The Dental Health Foundation

70% of Californians Support Fluoridation

FLUORIDATION PREVENTS TOOTH DECAY

- ✓ **Baby teeth have 60% less tooth decay**
- ✓ **Adult teeth have 35% less tooth decay**



Recent survey data shows Californians want this inexpensive, medically proven to be safe means of preventing tooth decay

Fluoride is SAFE Fluoride SAVES $

- ✓ Current scientific research shows fluoride is safe
- ✓ Fluoride does not cause cancer, bone disease, kidney disease, genetic diseases, impaired intelligence
- ✓ Fluoride from water, food, and tooth-paste combined does not create health risks
- ✓ Every dollar invested in fluoridation saves $140 in dental bills
- ✓ By preventing just one cavity in each child, California's taxpayers would save more than $385 million within five years
- ✓ The cost to provide fluoridated water to one person for a lifetime, at 54 cents a year, is less than the cost of a single dental filling

MAJOR HEALTH ORGANIZATIONS SUPPORT FLUORIDATION :

The National Cancer Institute, Centers for Disease Control and Prevention, American Academy of Pediatrics, California Department of Health Services, American Pharmacological Association, National Academy of Sciences, Institute of Medicine, World Health Organization, American Public Health Association, American Hospital Association, American Medical Association, American Dental Association, California Dental Association, California Dental Health Foundation, (just a partial list)

Fluoridated Water is One of the 10 Great Public Health Achievements of the 20th Century

California Department of Health Services

What is Dental Fluorosis?

- Dental fluorosis is defined as chalky white spots on the teeth. Dental fluorosis is a minor cosmetic effect and is not considered to be harmful to health. It may occur when children drink water, which is high in natural fluoride content as the enamel of their permanent teeth, is forming. If children exhibit fluorosis, it is usually a very mild form and often unnoticeable. In most cases, only a trained dentist can detect dental fluorosis. The benefits received from community water fluoridation far outweigh the risk of mild dental fluorosis.

- Fluorosis can be prevented through appropriate use of fluoride-containing products. Children take dietary fluoride supplements only when the home water supply is known to be deficient in fluoride and the children are not consuming fluoridated water from other sources (e.g., school, daycare). Children under the age of six should be supervised when using fluoride toothpastes to avoid excessive swallowing. It is recommended that a pea-size amount of toothpaste be used when brushing.

Who Supports Water Fluoridation?

- The National Cancer Institute, American Academy of Pediatrics, National Academy of Sciences, Institute of Medicine, World Health Organization, American Dental Association, American Medical Association are just some organizations supporting fluoridation of community water supplies.

- Over 100 major, state, national, and international health related organizations support fluoridation. The MMWR published by CDC just listed the fluoridation of drinking water as one of the 20th Century's **"Ten Great Public Health Achievements."**

- Every Surgeon General of the U.S., for the past 50 years, has supported community water fluoridation.

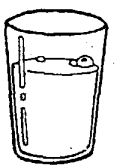
For further information and for more copies, please call the California Department of Health Services, Office of Oral Health, at (916) 323-0852

Community Water Fluoridation

One of the 20th Century's Ten Great Public Health Achievements

The benefits of public water fluoridation are well known. Since its introduction over 50 years ago, fluoridation has been primarily responsible for improving the public's oral health status. No other issue in public health has been as widely studied as community water fluoridation, and has been proven to be safe and effective. The amazing results from its use continue.

What is Fluoride?



Fluoride is a naturally occurring element. Fluoride is nature's cavity fighter. It is abundant in the earth's crust and is found in minerals that are in rocks and soil everywhere. Small amounts of fluoride are present naturally in all water sources, and varying amounts of fluoride are found in all foods and beverages.

What is Water Fluoridation?

- Water fluoridation is the process of adjusting the natural level of fluoride to a sufficient concentration for protection against tooth decay, a range of from 0.7 parts per million to 1.2 parts per million depending on average air temperature.

- Fluoridation of community water supplies is the single most effective measure for preventing tooth decay and improving dental health.
- Over 144 million U.S. residents in more than 10,000 communities are now served by water supplies in which the fluoride concentration has been adjusted to an optimal level (134.6 million residents).

Is Water Fluoridation Effective?

- The average cost to the consumer for the protection of fluoridated water is estimated at 51 cents a year per person. Over a lifetime, that is less than the cost of having one cavity treated. Studies show that water fluoridation can reduce the amount of cavities children get in their baby teeth by as much as 60 percent; and can reduce tooth decay in permanent adult teeth by nearly 35 percent.
- For optimal protection against decay, children and adults need both systemic and topical fluoride sources. Systemic fluoride is obtained by drinking fluoridated water or by the use of fluoride supplements such as drops or tablets for children. Topical fluoride is applied to the surfaces of teeth using toothpaste, mouthrinse and gels.
- Fluoride reduces tooth decay in many ways. It is incorporated into the enamel of developing teeth, making them more resistant to decay. Fluoride also markedly decreases decay that forms along the gum line which is seen in older people.

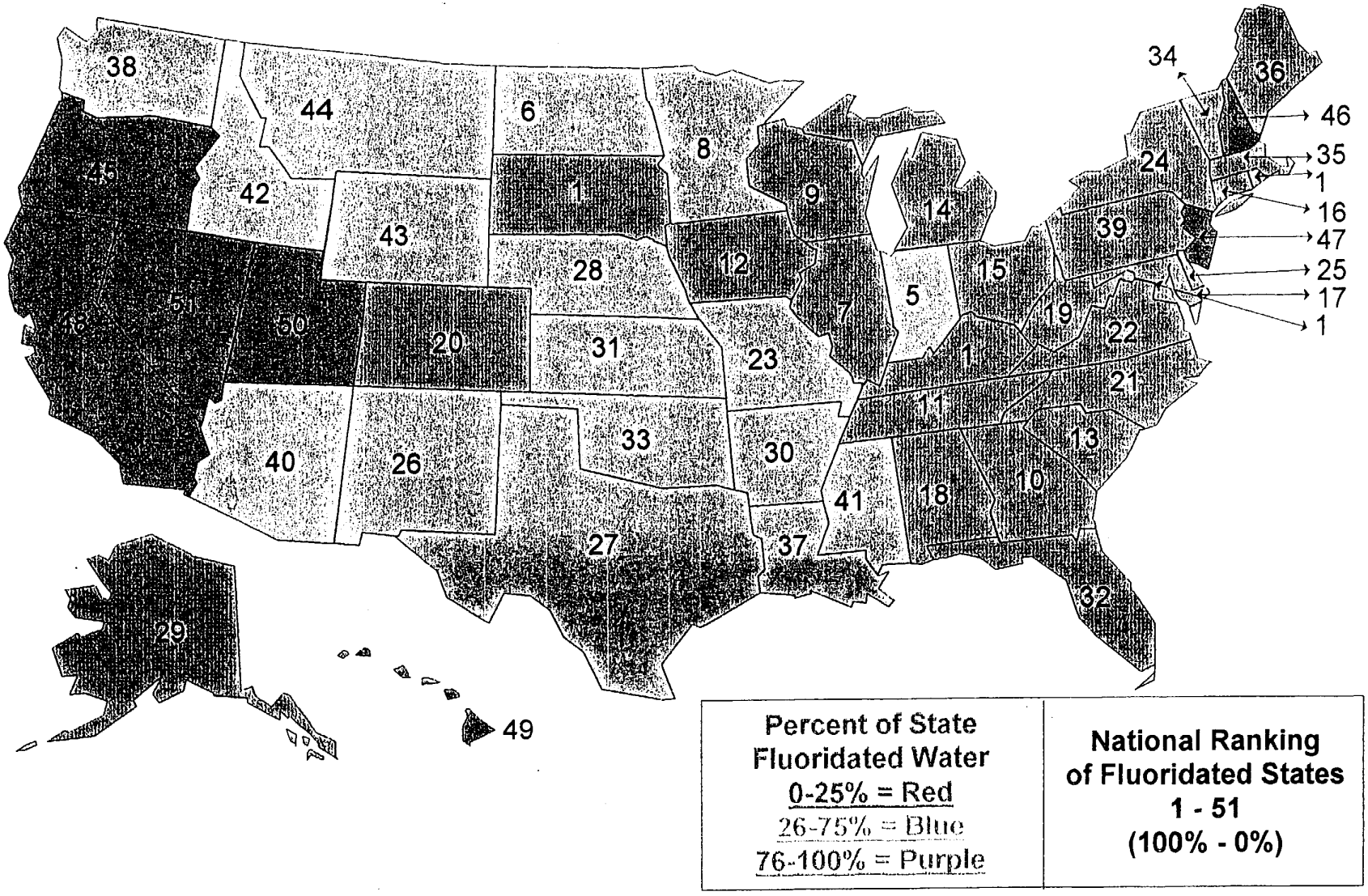
Why Should California Fluoridate?

- Community water fluoridation benefits the entire community regardless of education or income, especially people without access to regular dental care.
- There are 152 cities in the U.S. with a population over 50,000 that are not fluoridated. Of these, 87 are in California. These include Los Angeles, San Diego, San Jose, Sacramento, Santa Ana, Anaheim, and Stockton.
- A national health objective for the year 2000 is to increase to at least 75 percent the proportion of persons served by community water systems providing optimal levels of fluoride. To achieve this objective, an additional 30 million persons must receive optimally fluoridated water from public water supplies. In California, only 17.0 percent of the population is served by fluoridated water, giving California a ranking of 48th in the country in terms of the proportion of people served by fluoridated water.
- California taxpayers could save as much as $385 million in dental care costs after five years of community water fluoridation.

Is Water Fluoridation Safe?

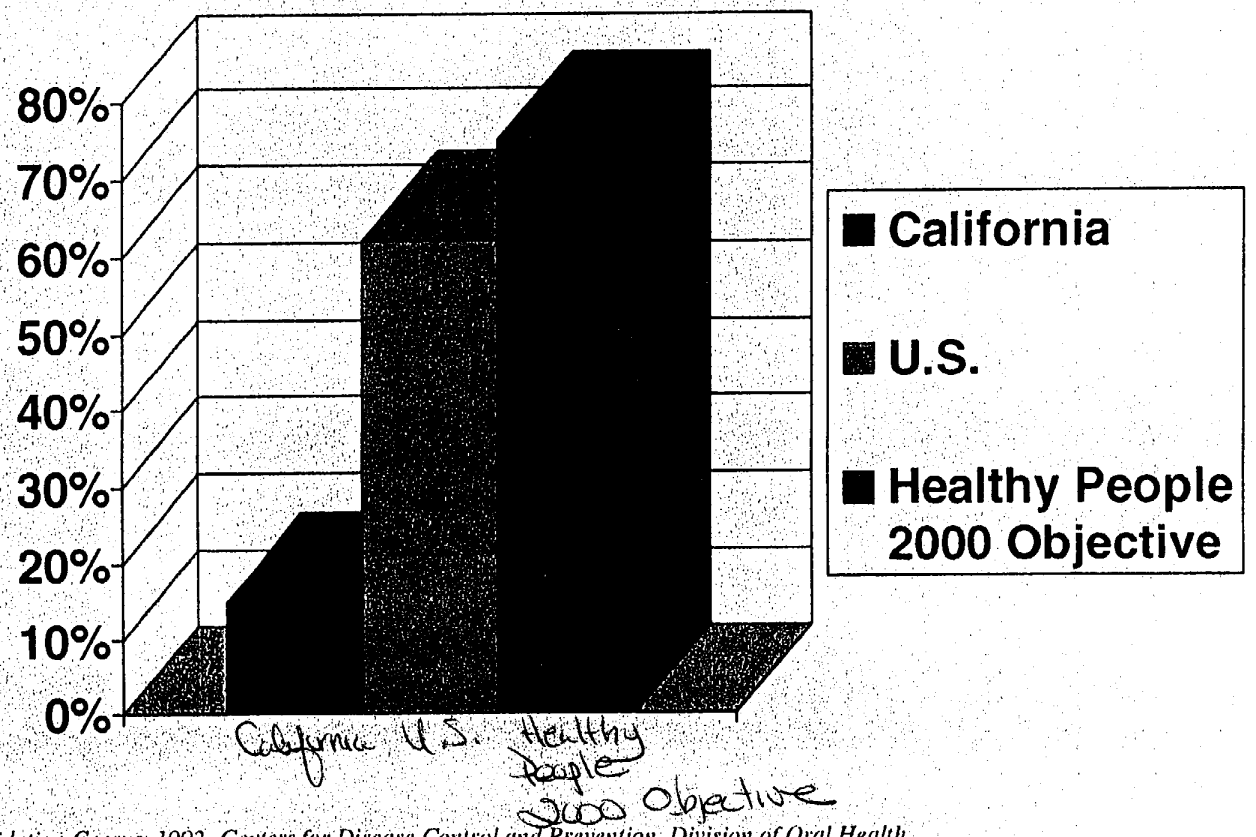
- Studies over the past 50 years have repeatedly confirmed the safety of water fluoridation at optimal levels and its effectiveness in preventing dental decay.
- There is no cancer risk associated with drinking water. A National Academy of Sciences study concluded "the weight of the evidence from more than 50 epidemiological studies does not support the hypothesis of an association between fluoride exposure and increased cancer risk in humans."
- The National Cancer Institute has stated repeatedly that "Water fluoridation applied for the purpose of dental caries prevention does not pose a detectable risk of cancer to humans."
- Consumption of optimally fluoridated water along with proper use of topical fluoride products is not harmful because most of the fluoride is excreted from the body.

Percent of Population Using Fluoridated Water and State Ranking



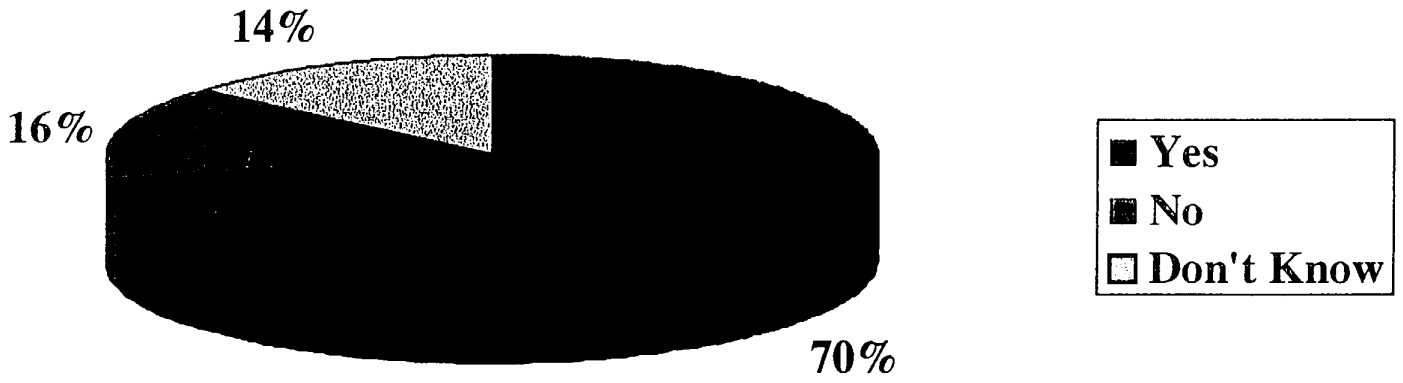
Source: Centers for Disease Control and Prevention, Division of Oral Health

Percentage of Persons Whose Water is Fluoridated



Source: *Fluoridation Census, 1992, Centers for Disease Control and Prevention, Division of Oral Health.*
Healthy People 2000, U.S. Department of Health and Human Services

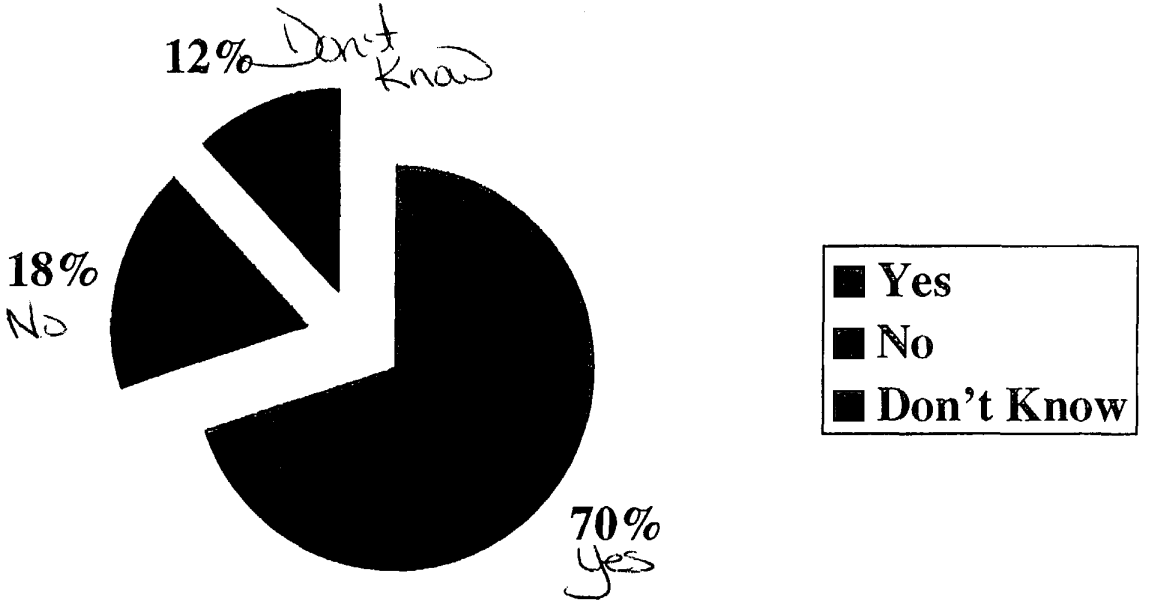
Public Support for Water Fluoridation in California, 1991-94



Source: California Behavioral Risk Factor Surveillance System
California Department of Health Services

Consumers' Opinions
on Whether Community Water Should Be Fluoridated

When asked "Do you believe community water should be fluoridated?", a majority of the respondents (70%) indicated 'yes'



Source: American Dental Association Survey Center 1998 Consumers' Opinions' Regarding Water Fluoridation

WHY COMMUNITY WATER FLUORIDATION IS GOOD FOR CALIFORNIA'S CHILDREN

- ✓ Children with poor dental health suffer from pain, discomfort and the social embarrassment of having unsightly or missing teeth. Community water fluoridation will substantially reduce ill effects on children's emotional and physical well being.

- ✓ Since water fluoridation began in the U.S. 50 years ago, continuous scientific research shows a reduction of 20 percent to 40 percent in tooth decay for children growing up in communities with fluoridated water. A reduction of up to 60 percent is seen in children with all their deciduous ("baby") teeth.

- ✓ Despite the commercial availability of topical fluorides and fluoride toothpaste, a huge number of California children do not have access to regular dental care and/or cannot afford to buy these products. The only way millions of California children will receive the benefit of fluoride is through community water fluoridation.

- ✓ Even for children who have access to a dentist or to fluoride products, "noncompliance" is a big problem (just as it is regular flossing and brushing). Research shows that even when parents are educated and highly motivated in the use of fluoride supplements, most are unable to maintain the daily schedule needed to achieve effectiveness comparable with water fluoridation. The best way to assure the benefits of fluoride is through community water fluoridation.

- ✓ Fluoridation plays a lifetime protective role as children become adults, by reducing root cavities. This is a benefit to older citizens even when exposure to fluoridated water begins in adulthood.

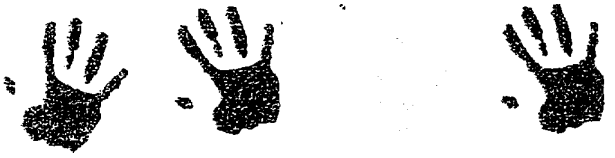
- ✓ Many thousands of scientific studies have carefully examined fluoridation and found it to be safe and effective. Enamel fluorosis can be controlled by appropriate use of fluoridated toothpaste and fluoride supplements during early childhood.

- ✓ Compared to the national average, twice as many six-to-eight year old children in California have tooth decay.

- ✓ A 1994 California statewide survey found that children in non-fluoridated areas, grades K-3, had 43 percent more tooth decay, and 10th graders had 53 percent more tooth decay, than children living in fluoridated areas.

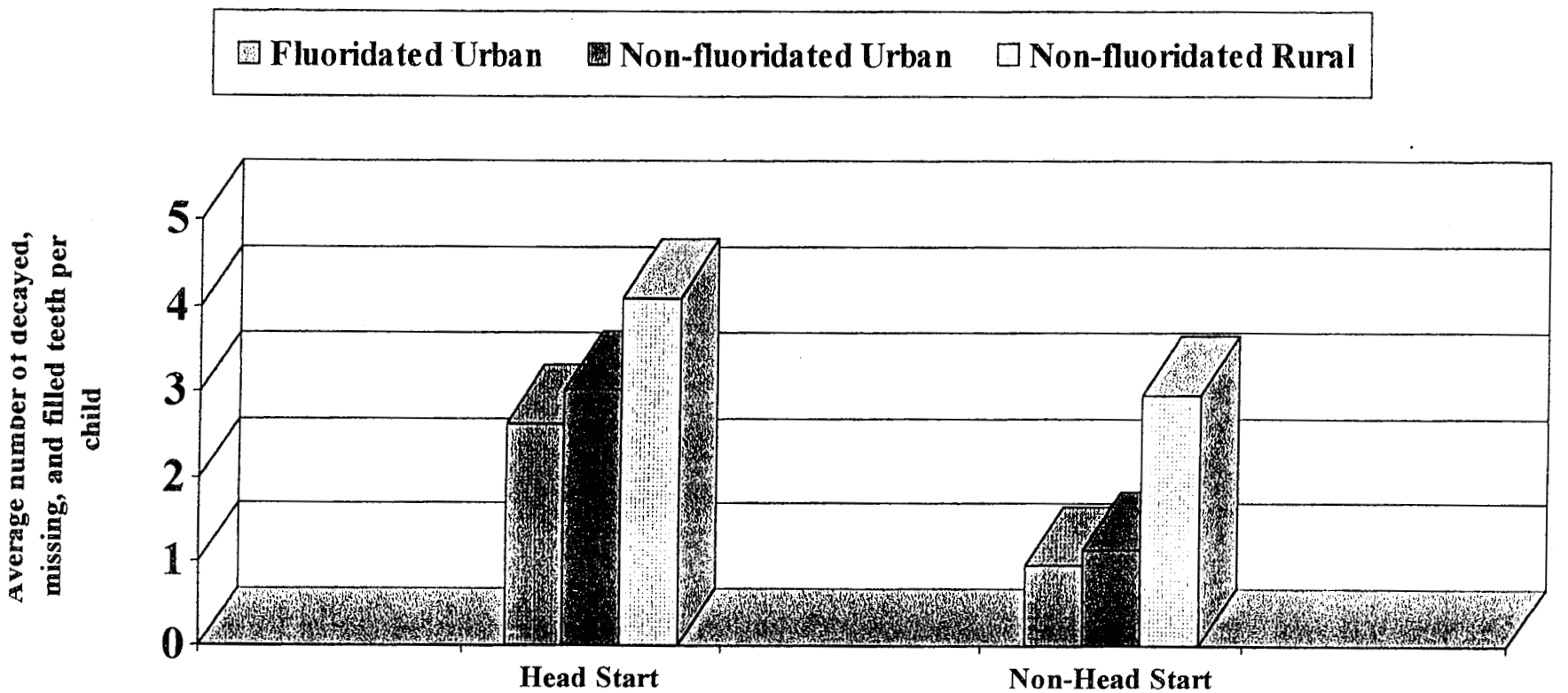
- ✓ Preventing just one cavity in each school-age child in California will save taxpayers an estimated $385 million over the first five years of statewide fluoridation.

CHILDREN SHOULD NOT HAVE TO SUFFER FROM PREVENTABLE DENTAL DISEASE



California Children's Oral Health Needs Assessment

Preschool Children: Dental Decay

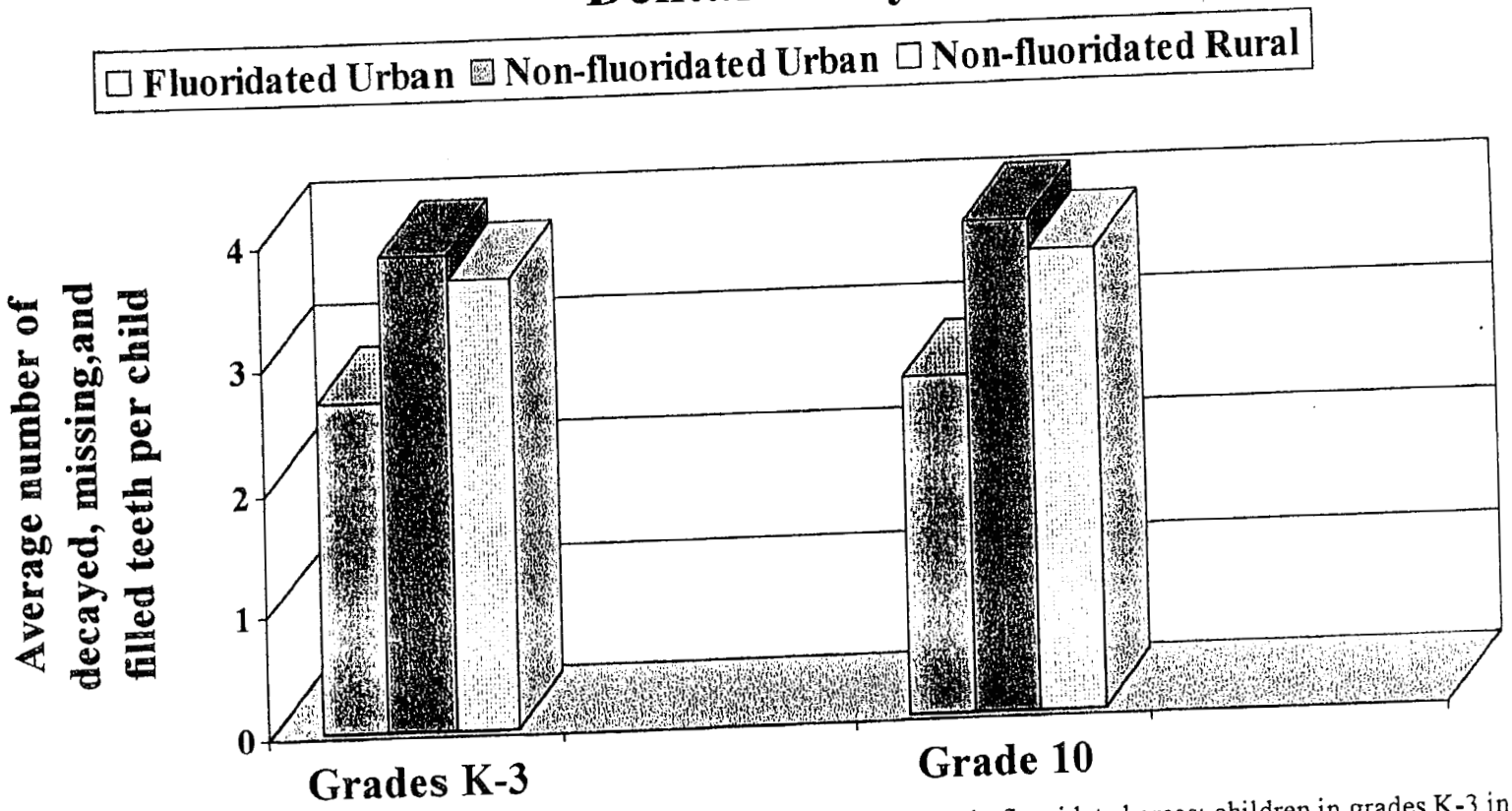


The California Oral Health Needs Assessment Survey, 1993-94, found that children in fluoridated urban areas had less tooth decay than those in non-fluoridated urban and rural areas.

Source: *California Oral Health Needs Assessment Survey, 1993-1994*
Research Project of the Dental Health Foundation, December 1994

California Children's Oral Health Needs Assessment

Dental Decay



Children in grades K-3 in non-fluoridated areas had 45 percent more tooth decay than in fluoridated areas; children in grades K-3 in rural areas had 36 percent more tooth decay than those students in fluoridated areas. Grade 10 students in non-fluoridated areas had 54 percent more tooth decay than in fluoridated areas; grade 10 students in rural areas had 36 percent more tooth decay than those students in fluoridated areas.

Source: *Report of the California Oral Health Needs Assessment, 1993-1994*
Research Project by The Dental Health Foundation, December 1994

CALIFORNIA CONSUMERS' GUIDE TO COMMUNITY WATER FLUORIDATION:

A QUESTION AND ANSWER GUIDE FOR CITIZENS, PUBLIC OFFICIALS, AND THE MEDIA

© Michael W. Easley, D.D.S, M.P.H., President & Chief Executive Officer,
International Health Management & Research Associates; and
Director, National Center for Fluoridation Policy & Research

Publication Prepared for:
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California Department of Health Services, Sacramento

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from the Centers for Disease Control and Prevention.

TABLE OF CONTENTS

INTRODUCTION

Community water fluoridation has been utilized for more than half a century as the principle public health measure to prevent the ravages of a common disease known as dental decay. Also known as dental caries, dental decay is a disease that ultimately results in the formation of dental cavities and can lead to dental infections (abscesses), loss of teeth, massive general (systemic) infections, and occasionally death. The treatment of dental decay also results in substantial direct and indirect costs to individuals, employers, insurance companies, consumers, and taxpayers. Community water fluoridation is one of the safest, most effective, and most economical programs that public officials can provide for their constituents in order to prevent the pain, suffering, and costs of dental decay.

Community water fluoridation is generally easy and inexpensive to implement - costing public water systems, on average, about 50 cents per person per year to operate[1-2]. The return on investment is tremendous - more than $80 in dental treatment costs being avoided for each dollar invested in community water fluoridation[2]. Few health activities, and even fewer publicly financed programs, result in such a large amount of savings to consumers, taxpayers, insurance companies, and employers. Moreover, fluoridation has proven to be a safe, effective, efficient, economical, and environmentally sound means to prevent dental decay in children and adults. The implementation of community water fluoridation by public and private water systems serves as an excellent example of good public policy at work. Former U. S. Surgeon General C. Everett Koop has frequently stated that, ***"Fluoridation is the single most important commitment a community can make to the oral health of its children and to future generations."***

Coalition for Healthy Smiles

Why would dentists, who earn their livelihood fixing decayed teeth be recommending fluoridation of local water supplies? The answer is simple. Adding fluoride to the water supply is the right thing to do for our patients and our community. Many communities throughout the United States have been fluoridating their water for over 50 years. Currently, 62% of Americans with access to community water systems benefit from fluoridation's continuous protection against dental decay. "Data consistently has indicated that water fluoridation is the most cost effective, practical and safe means for reducing tooth decay in a community" states the Surgeon General of the United States. In the May 2000, Oral Health of America: Report of the Surgeon General, David Satcher MD, PhD, says "Community water fluoridation remains one of the greatest achievements of public health in the twentieth century-an inexpensive means of improving oral health that benefits all residents of a community, young and old, rich and poor alike." Studies conducted by the National Institute of Dental Research and the Center of Disease Control indicate a 30-60% reduction in tooth decay after implementing community water fluoridation.

Water fluoridation is the process of adjusting the natural level of fluoride to a sufficient concentration for the prevention of tooth decay. Community water fluoridation is estimated to cost about 50 cents per person annually! Over a lifetime this amounts to about $42.00, less than 1/2 the cost of a filling. The benefits reach to all people of our community, but especially the poor and under served. It has been estimated the California taxpayers will save as much as $385 million in the Denti-Cal program alone after only 5 years of water fluoridation. We vaccinate our children to prevent diseases such as chickenpox and measles, however, only 17% of California water sources are fluoridated, nature's cavity fighter!

The water in the City of Stockton and outlying areas is not fluoridated. Despite the commercial availability of topical fluorides and fluoride toothpaste, a significant number of children and adults do not have access to regular dental care and/or cannot afford to buy these products. It is estimated that 35% of the population of our community do not have access to dental care. Daily, children miss school and adults work due to toothache pain. Recent research findings have pointed to possible links between oral infection and diabetes, heart and lung disease, stroke and low-birth-weight and premature infants. Through water fluoridation, we can provide the single most effective public health measure to prevent tooth decay and improve TOTAL health for a lifetime.

Through a collaborative campaign, the San Joaquin Dental Society, San Joaquin County Health Care Services-Family Preservation of Oral Health Initiative, San Joaquin County Public Health Services and community members are working toward the goal of fluoridating the drinking water of the City of Stockton. In 1995, The California Fluoridation Act, AB 733, was passed that directed cities with 10,000 water connections or more to supplement the water to optimal fluoride levels. Since this is a non-funded mandate, it is up to each community to develop resources for funding and implementation of water fluoridation. Funding resources are now available and potential sources include Prop 10 funds, the California Endowment and various private grants.

It is most apparent that everyone wins with fluoridation. Fluoridation ultimately promotes: lower health care costs; lower insurance costs; lower tax supported costs for public service programs; decreases costs for employers; and lowers costs for consumer goods and services. Most importantly, all individuals, young or old, wealthy or poor, will benefit through their lifetime from improved oral health.

Ultimately, optimizing the public's oral health through community water fluoridation will require a concerted effort by public officials, health professionals and the public. It's time to fluoridate Stockton's water now! We hope your organization will support our efforts. Enclosed are some fluoridation fact sheets and literature from the American Dental Association that will answer question you may have regarding this important community benefit. Also included for your convenience is a sample letter of support that can be transferred to your letterhead, signed and mailed in the postage paid envelope provided. For more information you may contact:

Dr. Matt Stefanac 478-2252
Dr. Judee Tippett-Whyte 957-8940

Thank you in advance for your support!

Sincerely,

Dr. Judee Tippett-Whyte
Coalition for Healthy Smiles

Dr. Matt Stafanac

Return Address

PLACE
STAMP
HERE

Coalition for Healthy Smiles
c/o San Joaquin Dental Society
7849 North Pershing Ave.
Stockton, CA 95207-1749

To Whom It May Concern:

Yes, we realize the significance of water fluoridation and endorse the efforts of the Coalition for Healthy Smiles to bring water fluoridation to the Stockton community water supply. Studies conducted by the Center for Disease Control and the National Institute for Health indicate a 30-60 percent reduction in tooth decay after implementation of water fluoridation.

We feel confident in the medical safety, effectiveness and practicality of community water fluoridation as a public health measure for preventing dental decay.

Please add our endorsement of this proposal for community water supply.

Sincerely,

What Is Fluoride And Why Is It Necessary?

Fluoride is a naturally occurring substance that is present in virtually all sources of drinking water in the United States. It serves as an essential trace element necessary for the proper development of teeth and bones, and for the protection of teeth once they have erupted into the mouth. Therefore, fluoride not only benefits children before their teeth have come in, but it also protects the teeth of children and adults after all of their teeth are present in the mouth. Those fortunate enough to have had access to community water fluoridation experience 40-60% fewer dental cavities[3].

What Is Community Water Fluoridation And Why Is It Important?

Community water fluoridation is the precise adjustment of the existing naturally occurring fluoride levels in drinking water to a safe level that has been determined to be ideal for the prevention of dental cavities in children and adults. As previously mentioned, virtually all sources of drinking water in the United States contain some fluoride naturally. There are even some locations in the United States where naturally occurring fluoride levels are adequate for the prevention of dental cavities - these communities do not have to fluoridate their drinking water. However, most communities in the U. S. have insufficient levels of fluoride for effective prevention of dental decay. Therefore, these communities with insufficient naturally-occurring fluoride in their water require the addition of very small amounts of fluoride to achieve the optimal level for good health.

Community water fluoridation mimics a naturally occurring process and can be considered to be a form of enrichment or supplementation of the drinking water. Moreover, the concept of fluoridation as a measure to prevent dental decay is very similar to the supplementation of: milk and breads with Vitamin D to prevent rickets; fruit drinks with Vitamin C to prevent scurvy; table salt with iodine to prevent goiter; breads and pastas with folic acid to prevent certain birth defects; and cereals with many different vitamins and minerals in order to provide for proper human development and to promote good health.

Why Use The Public Water System To Provide Fluoride?

First of all, public water systems have been used for the purpose of preventing diseases in the United States since the 1840's. The original reason for the establishment and widespread use of community water systems by cities and villages was to prevent the outbreak of serious diseases like cholera, hepatitis A, and typhoid fever. Many other diseases, including dental cavities, are prevented through the treatment of drinking water. Water treatment for disease prevention is considered to be a primary public health activity and is essential for the control of many diseases that would otherwise plague modern society.

Don't We Have Other Ways Of Getting Fluoride?

There are other ways to provide fluoride, but none are as effective as community water fluoridation for the prevention of dental decay in children and adults[4-9]. Fluoride benefits teeth in two general ways - there are (1) systemic benefits and (2) topical benefits.

(1) Systemic Benefits of Fluoride: Systemic benefits are gained when one drinks water and eats foods that contain fluoride. Systemic benefits can also be obtained by taking fluoride tablets or vitamins with fluoride that have been prescribed by a family's physician or dentist. More permanent in nature, the fluoride obtained from systemic sources actually becomes part of the tooth structure as baby teeth and permanent teeth develop under the gums of infants and children[4]. These teeth are then considerably stronger and resist dental decay much better once they have erupted into the mouth. This protection, gained from getting fluoride from systemic sources, generally stays with the teeth throughout life.

Systemic sources of fluoride also benefit older children and adults[4-5]. Fluoride from food and drink eventually ends up in a person's saliva. The fluoride in the saliva constantly bathes the teeth so that the teeth are protected continuously with low amounts of fluoride. For those older children and adults fortunate enough to live in fluoridated communities, this constant protection of the teeth by saliva containing small amounts of fluoride is substantial[5]. The fluoride from saliva not only prevents some cavities from ever starting, but it also repairs early dental decay through a process called remineralization[5]. With remineralization, some very small cavities are not only prevented from getting larger, they actually can "heal" or repair themselves because of the action of low levels of fluoride present in the saliva[5].

It should be noted that community water fluoridation is much more effective, much safer, and much more economical than the use of prescribed fluoride supplements (fluoride tablets or fluoride vitamins)[4-9]. Community water fluoridation is always the best choice to prevent dental decay in children and adults, not only because it is safer, more effective, and more economical, but because it benefits all people using the public water system, regardless of age, race, ethnic background, or socioeconomic status[4-9].

Fluoride tablets or vitamins with fluoride can and should be used in the absence of community water fluoridation, but are meant only as a temporary substitute until a community's water system can be fluoridated. Because they must be prescribed by a physician or a dentist, fluoride tablets or vitamins with fluoride often are only available to people fortunate enough to be able to afford regular visits to a family dentist or physician.

(2) Topical Benefits of Fluoride: Topical benefits, on the other hand, are temporary benefits that are gained when fluoride from external sources comes into direct contact with the surfaces of the teeth[4,8]. Topical benefits can be

obtained through use of such things as fluoride toothpaste, fluoride mouthrinses, and fluoride treatments that are provided in dentists' offices.

Fluoride toothpaste do a great job in helping to prevent dental decay, but only provide a temporary topical benefit to the tooth surfaces. Fluoride toothpaste, by themselves, also do not prevent decay as well as fluoride from the previously mentioned systemic sources[3-4,6-8]. Readily available from grocery stores, drug stores, and other commercial establishments, fluoride toothpaste are safe and should be used according to directions on their labels. Fluoride toothpaste can be used by children and adults in areas served by fluoridated community water systems and do provide additional protection to teeth.

Fluoride mouthrinses are effective in preventing dental decay, but also only provide a temporary benefit and are not as effective as fluoride from systemic sources[3-4,6-8]. They are available over the counter (grocery stores, drug stores, etc.) or by prescription from dentists and physicians. Fluoride mouthrinses may be used at the same time that people are getting fluoride from systemic sources (community water fluoridation or fluoride tablets/vitamins with fluoride), however fluoride mouthrinses should only be used in these situations after consulting with the family's dentist or physician.

Fluoride treatments from a family's dentist also provide a temporary topical benefit to the tooth surface[4, 6-8]. These topical fluoride treatments may be used at the same time that an individual is receiving fluoride from systemic sources, but only if the dentist has determined that there is a need for a fluoride treatment because of the level of decay present in that individual.

It is important to remember that fluoride from topical sources, while effective in preventing dental decay, is not nearly as effective as fluoride from systemic sources[4,8]. Moreover, fluoride from topical sources should never be considered to serve as an adequate substitute for fluoride from systemic sources. The gold standard for dental disease prevention is community water fluoridation[4,8]. Community water fluoridation should be implemented whenever it is technically feasible. Fluoride tablets are meant to be used as a temporary substitute for community water fluoridation only until a community water system can be fluoridated. Topical sources of fluoride (fluoride toothpaste, fluoride mouthrinses, and fluoride treatments provided in dental offices) are only meant to be used as adjuncts to systemic sources of fluoride.

How Much Fluoride Is Added To The Drinking Water?

Only a very small amount of fluoride is added to the drinking water to achieve the desired maximum benefits. The existing natural fluoride levels in drinking water supplies are adjusted slightly in order to raise them to between 0.7 and 1.2 parts per million[10]. This very small amount of fluoride being added is considered to be a trace amount. The precise level of fluoride calculated to be appropriate for each individual community is determined based on that

community's annual average daily temperature[11]. Depending on the precise calculation, each community's water fluoride levels will be adjusted to either 0.7, 0.8, 0.9, 1.0, 1.1, or 1.2 parts per million depending on where the community is located and what type of climate it has[11].

Whichever level of fluoride is determined to be the correct level for an individual community, it bears repeating that only a very small amount of fluoride is ultimately added to the drinking water. It also is important to remember that the optimal amount of fluoride in fluoridated drinking water has been calculated to take into account the fluoride the people get from other sources, like food and drink. Fluoridated drinking water provides only about one-third to one-half the amount of fluoride that an individual should be getting on a daily basis[12].

Is The Amount Of Fluoride In Fluoridated Water Systems Safe?

The amount of fluoride present in fluoridated community water systems is miniscule and has been determined to be safe for all individuals, regardless of age, race, gender, or health status[13]. In other words, community water fluoridation is safe for infants, children, teenagers, young adults, mature adults, and senior citizens[13]. It is safe for everyone, even those with chronic diseases[13]. Community water fluoridation harms no one and it is also effective in preventing dental decay in people of all ages, races, ethnic groups, or socioeconomic backgrounds[13].

Fluoride is like many substances that are required to sustain life and promote health; it is beneficial in small amounts and harmful in large amounts. Such common substances as vitamins, minerals, table salt, food, even water, are helpful in the correct amounts and harmful in excessive amounts. For example, fluoride levels in fluoridated water are so low that an adult would have to consume 660 gallons of fluoridated water in a 2 to 4 hour period in order to get a toxic level of fluoride that would cause death[14]. It is physically impossible for an adult to ever consume that amount of water - the adult would die of other causes long before they were able to accumulate enough fluoride to cause a problem[14]. Likewise, a 12-18 month old child would have to drink 85 gallons of fluoridated water in a 2 to 4 hour period in order to get a toxic level of fluoride that would cause death, again a physical impossibility[14].

In order to suffer chronic skeletal effects of too much fluoride, an adult would have to consume roughly 6 to 14 gallons of fluoridated water every day for 10 to 20 years - again physically impossible for virtually all adults[14]. Most adults drink far less than 1 gallon of water or other liquids a day. Children consume even much lower amounts of liquids than do adults on a daily basis.

A lifetime of drinking water fluoridated at the optimum level (0.7 to 1.2 parts per million) results in **NO** adverse effects to any individual or group of individuals[13]. Thousands of scientific studies have been completed which looked at individuals and groups who used water with optimum levels of fluoride their

entire lives[13]. Lifetime exposure to fluoridated water caused no diseases, no disabilities, nor any other adverse conditions for any group or individuals[13]. Lifetime exposure to fluoridated water only resulted in benefits - lower rates of dental decay and lower health care bills[13].

How Widespread Is The Practice Of Community Water Fluoridation In the United States?

Currently 135 million Americans are benefiting from community water fluoridation[15]. Another 10 million Americans are fortunate enough to live in communities with adequate levels of naturally occurring fluoride[15]. That means that over 62 percent of Americans with access to community water systems currently benefit from fluoridation's continuous protection against dental decay[15]. Unfortunately, only 17 percent of Californians currently enjoy the same decay-preventive benefits of fluoridation, ranking California 47th of 50 states[15].

The 145 million Americans benefiting from fluoridation live in more than 10,500 communities that are served by over 14,300 water systems[15]. In addition, 43 of the 50 largest cities in the United States are currently fluoridating their water systems[15]. With Los Angeles and Sacramento planning to begin fluoridation in 1999, that means that 45 of the 50 largest cities in the U. S. will be fluoridated by year's end. It also means that California, a state whose fluoridation efforts have lagged considerably behind the rest of the nation, will begin to move up in the rankings.

It is also important to remember that communities in the United States have been fluoridating their public water systems since 1945, many since the 1950's and 1960's. We have over 54 years experience adjusting fluoride levels in community water systems.

California Recently Passed Legislation Requiring Fluoridation of Some Community Water Systems. Do Any Other States Require Fluoridation?

Many states have passed legislation requiring community water systems to provide the benefits of water fluoridation for their customers. In addition to California, the states of Connecticut, Delaware, Georgia, Illinois, Minnesota, Nebraska, Nevada, Ohio, and South Dakota require certain communities to fluoridate their public water systems[16,17]. Several other states are currently considering legislation similar to that enacted in California. Both the Commonwealth of Puerto Rico and the District of Columbia have also legislatively mandated fluoridation[16]. Additionally, Kentucky requires statewide fluoridation by administrative regulation[18]. Moreover, many local governments have required fluoridation through laws, regulations, and ordinances.

Who Benefits From The Cost Savings That Result From Fluoridation?

The total cost to the nation for dental treatment services reported in 1997 was $50.6 billion - a substantial amount usually paid for by individuals, employers, government agencies, and insurance companies[19]. California's Denti-Cal program, just one taxpayer supported program that provides dental services to indigent Californians, regularly costs almost $700 million per year. There are a number of ways in which individuals and groups benefit from the costs savings brought on by community water fluoridation, costs which are avoided because of the need for less dental treatment.

For example, taxpayers benefit because public programs paying for dental care for disadvantaged populations require fewer local, state, and federal tax dollars for each person covered by the program[20]. It has been estimated that California taxpayers will save as much as $385 million in the Denti-Cal program alone after only 5 years of fluoridation. Employers benefit because their costs for prepaid dental care fringe benefits for their employees are lower[20]. Employers also avoid the extra costs required when their employees are absent from work due to personal or family visits for dental care[20].

Consumers benefit because they pay lower costs for consumer goods since employers costs for insurance and employee absences is lower[20]. In other words, the cost of doing business in a fluoridated community is lower for employers.

Additionally, all patients benefit in several ways. First, their overall health care bills and insurance premiums are lower in fluoridated communities because there are fewer expensive hospital emergency room visits for dental emergencies, costs of which are usually passed on to everyone able to pay through their health care bills and insurance premiums[20]. Secondly, patients in fluoridated communities avoid having to pay higher health care bills, dental bills, and insurance premiums that often result from the need for physicians, dentists, and hospitals to pass on their extra costs for uncompensated care to those who can pay[20].

It is most apparent that everyone wins with fluoridation. Not only do individuals benefit because of their improved oral health, but they benefit greatly because cost savings resulting directly and indirectly from a community's decision to fluoridate. Fluoridation ultimately promotes: lower health care costs; lower insurance costs; lower tax-supported costs for public programs; lower business costs for employers; and lower costs for consumer goods and services[20].

What Other Impact Is Water Fluoridation Having On Consumer Or Taxpayer Costs?

The extensive use of community water fluoridation in the United States has contributed substantially to decreasing consumer and taxpayer costs for supporting dental education. Because of lower levels of dental decay in the U. S. population, fewer dentists are needed to care for those currently in the health care system. As a result, seven dental schools have ceased operations since 1985[21]. In addition since 1980, enrollment reductions in the remaining dental schools have been equivalent to the closure of another 20 average size dental schools[21].

Community water fluoridation has also had an impact on the costs of dentists' malpractice insurance. Dentists practicing in fluoridated communities pay significantly lower malpractice insurance premiums than dentists practicing in non-fluoridated communities[22]. These lower malpractice insurance rates occur for several reasons. First, since the population suffers from much less decay in fluoridated communities, dentists do not spend as much time providing complicated procedures and therefore are less likely to run into complications. Secondly, dentists also do less general anesthesia and other forms of premedication in fluoridated communities because there are fewer cases of rampant decay in young children.

Who Supports Community Water Fluoridation?

Most legitimate organizations of health professionals and scientists strongly support community water fluoridation. Table 1 provides a list of just a few of the hundreds of organizations that support fluoridation, their year of establishment, and the number of members they represent[23].

Table 1: Examples of Scientific, Technical, and Professional Organizations that Support Community Water Fluoridation[23]

Professional Organization	Established	Membership
American Medical Association	1847	296,000
American Dental Association	1859	141,000
American Dental Hygienists' Association	1923	100,000
American Osteopathic Association	1897	43,000
American Dietetic Association	1917	70,000
American Academy of Pediatrics	1930	49,000
American Academy of Family Physicians	1947	84,000
American Public Health Association	1872	50,000
American Nurses Association	1893	180,000
National Academy of Sciences	1863	2,200**
American Water Works Association	1881	52,000

** The 2,200 Members of the National Academy of Sciences include more than 160 Nobel Prize Winners.

Some other well-known organizations and agencies supporting community water fluoridation include the National Academy of Sciences (established 1863), the U. S. Public Health Service (established 1798), the National Institutes of Health (established 1891), the U. S. Centers for Disease Control (established 1946), and the World Health Organization (established 1946)[23]. These and many additional scientific and professional organizations that recognize the public health benefits of community water fluoridation are listed in the Appendix.

It is important to note that these broadly based organizations represent millions of health practitioners, scientists and other professionals. These credible and respected organizations have also been working to improve the lives of Americans for many years. They are organizations and agencies with established administrative offices, some with state and local chapters, and many whom publish peer-reviewed scientific journals.

Community water fluoridation has also been repeatedly shown to have wide support of the American public[24-25]. Most recently, a national scientific poll taken by the prestigious Gallup Organization documented that 70% of Americans thought community water systems should be fluoridated, 12% did not know, and only 18% thought that community water systems should not be fluoridated[24].

Who Opposes Community Water Fluoridation?

While there is a small, very vocal, minority of the population that opposes the implementation of community water fluoridation, no credible national scientific or professional organization opposes the practice[16,26]. Individuals whom oppose fluoridation are often called 'antifluoridationists.' Most groups that claim to oppose fluoridation have few members, have no history because they have been organized for relatively short periods of time, have no established offices because they often operate out of individuals' homes, and have unfamiliar names and spokespersons[16,26]. These groups have been granted no professional credibility or scientific standing by the scientific or health care communities, publish no accepted scientific journals, and frequently use multiple names in order to appear to have more support for their position than actually exists[16,26-31]. Most of the groups lack any stability, disbanding and reforming periodically as interest in their movement periodically increases or subsides[16,26-31]. The antifluoride groups often publish pseudoscientific propaganda pieces which, when vigorously reviewed and investigated, lack any basis in science[16, 26-31]. Many of these organizations operate exclusively though the Internet where there is little in place to protect consumers from their scientifically invalid claims and their extensive propaganda[29-31].

What Are Some of the Claims Against Fluoridation that are Being Made by Antifluoridationists?

Bone Health: Antifluoridationists often claim that the fluoride from community water systems is bad for bones, that it causes osteoporosis, that it is responsible for increased hip fractures in senior citizens, and that it causes bone cancer. Not only have such claims never been demonstrated in legitimate scientific studies, just the opposite has been shown to be true.

Most studies show no differences in the prevalence of osteoporosis or hip fractures for those people living in fluoridated communities when compared to those living in non-fluoridated communities[32-37]. A recent study actually demonstrated that populations living in fluoridated communities had fewer hip fractures than those living in non-fluoridated communities[37]. An additional study even demonstrated the significant benefits of using fluoride to treat osteoporosis of the spinal column in post-menopausal women[38]. Regarding the allegation that fluoridation causes bone cancer, studies indicate otherwise - that fluoridation is not related to bone cancer[13, 39-40].

Adult Dental Health: Antifluoridationists repeatedly claim that community water fluoridation is only effective in preventing decay in young children. Thankfully, this antifluoridationists' claim is incorrect. Fluoridation benefits people of all ages, whether they are infants, children, adolescents, young adults, middle-aged adults, or the elderly. It is quite clear that adults exposed to fluoridated water experience much less tooth decay than their counterparts who do not have access to fluoridated water[41]. Moreover, substantial benefits to older persons have been documented repeatedly in studies that show a significant decrease in root decay in older Americans[41-45]. Root decay occurs in adults for two reasons. First as people age, the gum tissue recedes so that soft root surfaces become exposed to decay-causing foods in the mouth[41-45]. Secondly as people age or as they become dependent on certain types of medications used to manage chronic health conditions, the flow of saliva tends to become diminished, resulting in what has been termed "dry mouth"[46]. Dry mouth can result in a substantial increase in the likelihood that teeth will decay[46]. Root decay is a serious problem in older Americans and has been shown to be a significant reason for loss of teeth after age 55[47].

Total Fluoride Intake in Children and Adults: Antifluoridationists make a number of bogus claims about total fluoride intake in children and adults. Those few individuals opposed to fluoridation often try to claim that children and adults in the United States routinely get too much fluoride or that fluoride intake for children and adults is somehow increasing. Nothing could be further from the truth. Fluoridation levels for communities have been calculated so as to factor in the amount of fluoride that children and adults get from other sources[4,12,48-52]. Moreover, fluoride consumption for both children and adults in the United States has repeatedly been demonstrated to fall well within a wide margin of safety[12,48-53].

Dental Fluorosis: Antifluoridationists frequently claim that children and adults living in fluoridated communities suffer from an increased amount of dental fluorosis. Again, there are a number of significant problems with these allegations by the antifluoride minority. Firstly, dental fluorosis is a relatively rare occurrence and describes a range of conditions which mostly do not occur in the United States[13]. Fluorosis occurs when children consume more than optimal amounts of fluoride during tooth development[13,54]. Antifluoridationists often exhibit photographs of children living in other countries where serious industrial pollution causes teeth to have permanent brown stains. These brown stains are examples of moderate and severe fluorosis, a condition directly related to industrial pollution and almost never seen in the United States[13,54-55].

The types of fluorosis seen occasionally in the United States are the questionable, very mild, and mild forms[13,55]. Questionable and very mild fluorosis result in changes in teeth so subtle that only trained dental examiners are likely to discover them[13,55]. Mild fluorosis is characterized by a subtle white lacy appearance of the teeth, barely discernable by someone looking closely at the teeth[13,55]. None of these minor forms of fluorosis (questionable, very mild, or mild fluorosis) are considered abnormal or of any health consequence[12-13,55]. Questionable, very mild, and mild fluorosis usually result from very young children swallowing too much fluoride toothpaste or from the inappropriate supplementation with prescription fluoride products (such as (1) when physicians and dentists independently prescribe fluoride supplements or (2) when physicians and dentists prescribe fluoride supplements without checking the fluoride content of the child's water supply so that, in either case, a child gets a "double" dose of fluoride on a daily basis)[12,56-62]. Dental fluorosis also can occur when children consume water with high levels of naturally-occurring fluoride from private wells or community water systems with higher than optimum natural fluoride levels. Community water fluoridation plays almost no role in the development of any of the forms of fluorosis and certainly plays no role in the development of moderate or severe fluorosis.

Secondly, adults cannot get fluorosis[13,56,63]. Fluorosis is caused when high levels of fluoride are consumed during the time that children's teeth are developing under the gums[13,56]. Once all of the permanent teeth have fully formed in children and erupted into the mouth (usually between ages 14-18), fluorosis cannot occur[13,56,63].

Thirdly, the various forms of fluorosis that occasionally occur in the United States are not considered to be any sort of adverse health effect[13]. They are not precursors to any diseases, despite the claims by antifluoridationists, nor are they of any concern other than as a minor issue of esthetics[13]. Moreover, because of the additional fluoride incorporated into the enamel of teeth with questionable, very mild, or mild fluorosis, they are likely to be much more resistant to decay.

Skeletal Fluorosis: Allegations by antifluoridationists that long term consumption of fluoridated water causes skeletal fluorosis are untrue. Skeletal fluorosis occurs after long term consumption (10 years or more) of very high levels of fluoride, amounts which far exceed what one would consume with lifetime exposure to community water fluoridation[12-13]. Extensive studies looking at thousands of lifetime residents who routinely drank water with natural fluoride levels of 4-8 parts per million yielded only 23 cases of an extremely mild condition known as osteosclerosis and no cases of skeletal fluorosis[53,64]. Advanced skeletal fluorosis has not been demonstrated to occur even when people spend their entire lives drinking water with naturally occurring fluoride levels of as much as 20 parts per million[12-13,53,64-65]. Advanced skeletal fluorosis is so rare in the United States that only 5 cases have been confirmed in the last 35 years[12-13]. These 5 cases of advanced skeletal fluorosis were related to industrial exposures of extremely high amounts of fluoride chemicals that occurred over a long period of time and in no way was related to community water fluoridation[12-13].

Reproduction, Infertility, Birth Rates, Genetics, and Sudden Infant Death Syndrome (SIDS): Using the laundry list approach, antifluoridationists allege that fluoride from fluoridated water systems interferes with reproduction, lowers birth rates, causes genetic damage, and is responsible for sudden infant death syndrome (SIDS). Researchers have looked at each of these allegations in depth and have concluded that the allegations are not true[13,53,57,64-85]. Despite scientific evidence to the contrary, antifluoride zealots persist in repeating these false allegations.

Cancer, Heart Disease, Kidney Disease, AIDS, Mental Deficit, and Alzheimers' Disease: Using the same laundry list approach, antifluoride activists also attempt to induce panic in the public by claiming that fluoride from fluoridated water causes such dreaded diseases as cancer, heart disease, kidney disease, AIDS, and Alzheimers' Disease. These claims have resulted in the conduction of a substantial amount of scientific research, all of which demonstrates that the antifluoridationists' claims are without substance[12-13,53,84-97]. Again, as with the previously mentioned laundry list of alleged diseases attributed to community water fluoridation, scientific evidence counters the false allegations of the antifluoride minority.

Fluoride Status in Europe: Antifluoridationists often claim that "only the United States fluoridates its community water supplies," or that "98% of Europe is fluoride free," or even that "Europe has banned fluoride." All three of these claims are false. The World Health Organization strongly recommends the use of community water fluoridation where ever it is technologically feasible[23,98]. The phrase "technologically feasible" means that the country has one or more public water systems: (1) that are capable of adding fluoride to the drinking water; (2) has drinking water systems that are usable, safe, and dependable; and (3) that the country's water systems employ qualified water plant operators who can ensure that optimum levels of fluoride will continue to be maintained.

Currently approximately 60 countries practice community water fluoridation, providing the benefits of optimally fluoridated drinking water to more than 360 million people[98-99]. While many of these countries which fluoridate their community water systems are in Europe, some European countries provide their populations with fluoride through alternative means. For example, France and Switzerland add fluoride to table salt to ensure that adequate amounts of fluoride are made available to all of their populations, although one community water system in Switzerland is fluoridated. Salt fluoridation was chosen because of inherent difficulties in using water fluoridation in communities with extremely complex water distribution systems.

Other countries, especially Norway, Sweden, Finland, Denmark, and the Netherlands utilize their extensive national health care systems to deliver fluoride supplements to all children, as well as to provide routine topical fluoride applications in their public clinics. Many Eastern European community water systems have stopped fluoridation (some have even shut down their water treatment plants altogether) only because of their current financial difficulties and will likely be resuming fluoridation once their economies permit upgrading of worn out and outdated facilities. Not a single European country has "banned" fluoridation as alleged by America's antifluoride minority.

U. S. Environmental Protection Agency: Some antifluoridationists have claimed that the U. S. Environmental Protection Agency (USEPA) has banned fluoridation in the United States. This allegation serves as yet another example of the use of false and misleading statements by the antifluoride minority. First of all, the USEPA continues to support the use of community water fluoridation in public water systems in the United States, all of which fall under the Agency's regulations. As recently as 1997, a USEPA spokesperson reconfirmed that "recent reviews of the available toxicity data by the Department of Health and Human Services (1991) and the National Research Council (1993) support EPA's policy and the use of optimal fluoridation"[100]. An official letter from the USEPA that is included in the current Code of Federal Regulations further emphasizes that "fluoride in children's drinking water at levels of approximately 1 mg/l [1 part per million] reduces the number of dental cavities"[101].

Toothpaste Warning Label: Recently, warning labels have been showing up on fluoride-containing toothpastes. Although unrelated in any way to community water fluoridation, there are several reasons why this has happened. First of all, most toothpastes sold in the United States contain fluoride at levels that are between 1,100 and 1,600 parts per million. Since toothpaste fluoride levels are more than 1,000 times higher than fluoride levels in community water systems, very young children swallowing substantial amounts of toothpaste could end up with mild to moderate fluorosis[58]. Mild to moderate fluorosis, while not being an adverse health effect, could result in some slightly stained permanent teeth[58]. As discussed previously, older children and adults can not get fluorosis, although they are less likely to swallow large amounts of toothpaste anyway[13,56,63]. While there is the hypothetical possibility that a very small child

could intentionally swallow enough fluoride toothpaste to become acutely ill, there are other chemical constituents in toothpaste that would likely cause the child to vomit long before they swallowed enough fluoride to be harmful[102].

In the U. S., any consumer products companies making health claims for their products, even if their products are sold over the counter, come under the regulatory authority of the U. S. Food and Drug Administration (FDA)[102]. The FDA requires that all over-the-counter products include warning labels for every such product to explain to the public what might happen if the product is consumed in larger quantities than recommended by the manufacturer[102]. While the FDA began enforcing this requirement a number of years ago by selectively imposing the regulation on various categories of consumer products, they only recently began enforcing the requirement on toothpastes[102]. It is important to note that there never has been a documented case of serious injury or death from children swallowing toothpaste[102]. Furthermore, the statewide California Poison Control System confirms that NO child has ever been referred to a hospital for toothpaste related illness as a result of a call to one of California's regional poison control centers[102]. The Director of the San Diego Division, California Poison Control System, himself a board certified applied toxicologist, stated:

> ***Equally convincing are the numerous studies that have shown that fluoridation of drinking water is safe. From a toxicological perspective, many epidemiologic studies have been performed that show convincingly that fluoridation of drinking water produces no harmful effects.***[103]

SUMMARY AND CONCLUSIONS

Community water fluoridation has served the American public extremely well as the cornerstone of dental caries prevention activities for more than 54 years. The dental health and general health benefits associated with the consumption of water-borne fluorides have been documented for over 100 years. Ongoing research, often conducted in response to the repeated allegations by those opposed to fluoridation, continues to confirm the safety, effectiveness, efficiency, cost-effectiveness, and environmental compatibility of community water fluoridation.

Fluoridation also continues to be acclaimed as an important contributor to the health of the nation, most recently being named as one of the 20th Century's ten greatest public health achievements[104]. Dr. David Satcher (currently the Assistant Secretary for Health and the Surgeon General of the United States) recently reconfirmed the support of his office for community water fluoridation[105]. Dr. Satcher's comments were included in a congratulatory letter to the chair of California's Fluoridation Task Force regarding the positive decision of the City of Los Angeles to initiate fluoridation[105]. Moreover, the deans of California's five

dental schools recently issued a signed Position Statement on Community Water Fluoridation (1999) that stated in part:

> ***As the dean of a California dental school, I would like to state my personal and professional position on the need to fluoridate California's Community water systems. Community water fluoridation, without a doubt, is the greatest public health benefit related to decay prevention. It is a safe, effective and cost effective way to make this preventive measure available to everyone in a community. Quite simply, it is a measure which I would advocate to my family, friends and colleagues without question or concern."***[106]

The adoption of community water fluoridation by local communities and state legislatures represents an excellent example of good public policy. Communities throughout the United States continue to exhibit sound decision-making and evidence their continued trust and faith in science and the health professions by adopting fluoridation. The acceptance of community water fluoridation by public officials ensures that all citizens of a community, regardless of age, race, ethnic background, religion, gender, educational status, or socioeconomic level, receive the same substantial dental disease prevention benefits currently available to the 145 million Americans on fluoridated water systems.

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APPENDIX I: National & International Organizations that Recognize the Public Health Benefits of Community Water Fluoridation for Preventing Dental Decay*

*[From: *Fluoridation Facts*, © 1999, American Dental Association]

Academy of Dentistry International
Academy of General Dentistry
Academy of Sports Dentistry
Alzheimer's Association
American Academy of Allergy, Asthma & Immunology
American Academy of Family Physicians
American Academy of Oral & Maxillofacial Pathology
American Academy of Pediatrics
American Academy of Pediatric Dentistry
American Academy of Periodontology
American Association for the Advancement of Science
American Association for Dental Research
American Association of Community Dental Programs
American Association of Dental Schools
American Association of Endodontists
American Association of Oral & Maxillofacial Surgeons
American Association of Orthodontists
American Association of Public Health Dentistry
American Cancer Society
American College of Dentists
American College of Physicians
American Society of Internal Medicine
American College of Prosthodontists
American Council on Science & Health
American Dental Assistants Association
American Dental Association
American Dental Hygienists' Association
American Dietetic Association
American Federation of Labor / Congress of Industrial Organizations
American Hospital Association
American Medical Association
American Nurses Association
American Osteopathic Association
American Pharmaceutical 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
American Student Dental Association
American Veterinary Medical Association
American Water Works Association
Association for Academic Health Centers
Association of Maternal & Child Health Programs
Association of State & Territorial Dental Directors
Association of State & Territorial Health Officials
British Dental Association

British Fluoridation Society
British Medical Association
Canadian Dental Association
Canadian Dental Hygienists Association
Canadian Medical Association
Canadian Nurses Association
Canadian Paediatric Society
Canadian Public Health Association
Chocolate Manufacturers Association
Consumer Federation of American
Delta Dental Plans Association
European Organization for Caries Research
FDI World Dental Federation
Federation of Special Care Organizations in Dentistry
Academy of Dentistry for Persons with Disabilities
American Association of Hospital Dentists
American Society for Geriatric Dentistry
Health Insurance Association of America
Hispanic Dental Association
International Association for Dental Research
International Association for Orthodontics
International College of Dentists
Institute of Medicine
National Academy of Sciences
National Alliance for Oral Health
National Association of County & City Health Officials
National Association of Dental Assistants
National Confectioners Association
National Council Against Health Fraud
National Dental Assistants Association
National Dental Association
National Dental Hygienists' Association
National Down Syndrome Congress
National Down Syndrome Society
National Foundation of Dentistry for the Handicapped
National Kidney Foundation
National PTA
National Research Council
Society of American Indian Dentists
The Dental Health Foundation (of California)
U.S. Department of Defense
U.S. Department of Veterans Affairs
U.S. Public Health Service
U.S. Centers for Disease & Prevention (CDC)
U.S. Health Resources & Services Administration (HRSA)
U.S. Indian Health Service (IHS)
National Institute of Dental & Craniofacial Research (NIDCR)
World Federation of Orthodontists
World Health Organization

APPENDIX II: Partial List of California Organizations and Agencies that Recognize the Public Health Benefits of Community Water Fluoridation for Preventing Dental Decay**

**[From California Dental Association and California Department of Health Services]

American Academy of Pediatrics - California Division
California Chamber of Commerce
California Children NOW
California Conference of Local Health Officers
California Department of Health Services
California Dental Association
California Dental Hygienists' Association
California Fluoridation NOW
California Fluoridation Task Force
California Medical Association
California Public Health Association - North
California Rural Indian Health Board
California Schools of Dentistry
- University of California, San Francisco
  - Dr. Charles N. Bertolami, Dean
- University of the Pacific
  - Dr. Arthur A. Dugoni, Dean
- Loma Linda University
  - Dr. Charles J. Goodarce, Dean
- University of Southern California
  - Dr. Howard M. Landesman, Dean
- University of California at Los Angeles
  - Dr. No-Hee Park, Dean

Delta Dental Plan of California
Dental Health Foundation (of California)
Los Angeles Citizens for Better Dental Health
Older Women's League
Sacramento District Dental Society
Southern California Public Health Association

APPENDIX III: BIBLIOGRAPHY (Suggested Readings)

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APPENDIX IV: SELECTED WORLD WIDE WEBSITES WITH SCIENTIFICALLY VALID FLUORIDATION INFORMATION

CALIFORNIA SITES:

California Dental Association
http://www.cda.org/public/index.html

California Fluoridation Now
http://www.deltadentalca.org/flo/flo_spr98.html

Delta Dental Plans of California
http://www.deltadentalca.org/sub/sub_fluor.html

Dental Health Foundation (of California)
http://www.dentalhealthfoundation.org/

Los Angeles Citizens for Better Dental Health
http://www.dhs.co.la.ca.us/phps/phwpost/watrflrd.htm

Sacramento District Dental Society
http://www.sdds.org/fluorida.htm

OTHER STATES' SITES:

Washington State Children's Alliance
http://www.childrensalliance.org/teeth/fluorida.htm

Washington State Dental Association
http://www.wsda.org/public/consumers/factsheets2.cfm?id=34

Washington State Oral Health Coalition
http://www.childrensalliance.org/teeth/washingt.htm

NATIONAL SITES:

American Academy of Family Physicians
http://www.aafp.org/policy/50.html

American Dental Association
http://www.ada.org/consumer/fluoride/fl-menu.html

American Society for Nutritional Sciences and the American Society for Clinical Nutrition
http://www.faseb.org/ain/fluoridation.html

National Center for Fluoridation Policy & Research
http://fluoride.oralhealth.org/

U. S. Centers for Disease Control, Division of Oral Health
http://www.cdc.gov/nccdphp/oh/

U. S. National Institutes of Health, National Center for Dental & Craniofacial Research
http://www.cyberdentist.com/fluoride.htm#Q1
http://www.nidr.nih.gov/flouride.htm

U. S. Public Health Service (Report on Fluoride Benefits & Risks)
http://www.cda.org/public/pubhsrvc.html

INTERNATIONAL SITES:

British Fluoridation Society
http://www.derweb.ac.uk/bfs/index.html

Calgary (Alberta, Canada) Regional Health Authority
http://www.crha-health.ab.ca/pophlth/hp/fluoride/

APPENDIX V: STATEMENT FROM THE CALIFORNIA POISON CONTROL SYSTEM

From: California Poison Control System
Anthony S. Manoguerra, Pharm.D., ABAT
Director, San Diego Division, California Poison Control System
Professor of Clinical Pharmacy & Pediatrics
Diplomate, American Board of Applied Toxicology

To: To Whom It May Concern

Date: March 30, 1989

What Follows is the Transcribed Contents of Dr. Manoguerra's Letter:

As with nearly all substances, fluoride is toxic in large doses and safe and therapeutic in small doses. I have reviewed the evidence for the safety of fluoridation of water along with poison center data relative to fluoride ingestions in children. The California Poison Control System has established a threshold of 10 mg/kg of fluoride as the acute dose that a child must ingest before a referral to a health care facility is necessary. This amounts to approximately 100 sodium fluoride tablets (1 mg fluoride per tablet), 90 to 100 grams (3 ounces or more) of fluoride-containing toothpaste or 100 liters of fluoridated water. These amounts are so large that they are rarely, if ever, ingested. Chronic ingestion of fluoride in the quantities found in fluoridated water plus typical food and beverage sources and toothpaste are not associated with adverse health effects. There is no evidence that fluoride ingestion is related to an increased incidence of cancer.

There is strong and convincing evidence that fluoridation decreases the incidence of dental caries in children. Recent studies have shown that California children suffer an excess of dental caries because of inadequate fluoridation programs. This results in substantial and unnecessary dental work and the resultant costs associated with the repair of children's teeth. Equally convincing are the numerous studies that have shown that fluoridation of drinking water is safe. From a toxicologic perspective, many epidemiologic studies have been performed that show convincingly that fluoridation of drinking water produces no harmful effects.

I appreciate the opportunity to provide this input and ask that if you have any questions, please contact me.

Sincerely,

s/ Anthony S. Manoguerra, Pharm. D., ABAT

APPENDIX VI: STATEMENT FROM DR. DAVID SATCHER, ASSISTANT SECRETARY FOR HEALTH AND SURGEON GENERAL OF THE UNITED STATES REGARDING THE FLUORIDATION OF LOS ANGELES

From: David Satcher, M.D., Ph.D., Assistant Secretary for Health and Surgeon General of the United States

To: Timothy R. Collins, D.D.S., M.P.H., Chairman, California Fluoridation Task Force

Date: October 19, 1998

What Follows is the Transcribed Contents of Dr. Satcher's Letter:

I have just become aware of the decision by the City of Los Angeles to initiate fluoridation of their drinking water by the end of the year. This is indeed a great public health advancement. As you know, oral diseases and their prevention remain a high priority for the Department, and I am in the process of completing the first Surgeon General's report on oral health. Fluoridation was included in our National Healthy People 2000 objectives and has been proposed for retention in the objectives for 2010.

Fluoridation remains an ideal public health measure based on the scientific evidence of its safety and effectiveness in preventing dental decay and its impressive cost-effectiveness. Further, one of my highest priorities as Surgeon general is reducing disparities in health that persist among our various populations. Fluoridation holds great potential to contribute toward elimination of these disparities.

I am pleased to join previous Surgeons General in acknowledging the continuing public health role for community water fluoridation in enhancing oral health protection for Americans. Congratulations to you, the task force, and the health organizations that are supporting your efforts. Your success in Los Angeles and other California communities in need of fluoridation will make a significant contribution toward achieving our national goal.

Sincerely yours,

s/ David Satcher, M.D., Ph.D.

APPENDIX VII: POSITION STATEMENT ON COMMUNITY WATER FLUORIDATION (FROM THE DEANS OF CALIFORNIA'S FIVE DENTAL SCHOOLS)

From: Charles N. Bertolami, D.D.S., D.Med.Sc.
Dean, School of Dentistry; University of California, San Francisco

Arthur A. Dugoni, D.D.S.
Dean, School of Dentistry; University of the Pacific

Charles J. Goodarce, D.D.S., M.S.D.
Dean, School of Dentistry; Loma Linda University

Howard M. Landesman, D.D.S.
Dean, School of Dentistry; University of Southern California

No-Hee Park, D.M.D., Ph.D.
Dean, School of Dentistry; University of California at Los Angeles

What Follows is the Transcribed Contents of the Deans' Position Statement:

As the dean of a California dental school, I would like to state my personal and professional position on the need to fluoridate California's community water systems. Community water fluoridation, without a doubt, is the greatest public health benefit related to decay prevention. It is a safe, effective and cost effective way to make this preventive measure available to everyone in a community. Quite simply, it is a measure which I would Advocate to my family, friends and colleagues without question or concern.

The need to fluoridate California's community water systems is obvious. California currently ranks 48th in the nation related to community water system fluoridation. This translates to only 17 percent of Californians benefiting from perhaps the most safe, efficient and cost effective means of preventing tooth decay. Recent studies indicate the decay rate of California school children to be as much as 50 percent higher than the national average. Sixty percent of Californians mistakingly (Sic) think that their water is already optimally fluoridated. Fluoride is a naturally occurring element found in trace amounts in most water systems. It has been scientifically proven that by adjusting the concentration of fluoride in community water systems the therapeutic effect for decay prevention will be achieved. Years of studies in communities with naturally occurring optimal levels of fluoride as well as those communities with adjusted levels have proven to be safe and effective. Many communities have voluntarily fluoridated for over forty years with no adverse health effects.

With the passage of AB 733 (Speier) in 1995, California was given a tremendous opportunity to act positively regarding this public health measure. This legislation, however, is currently an unfunded mandate. The political will of a community to support fluoridation is important. Community water fluoridation is estimated to cost about 50 cents per person annually. By comparison, a single filling costs between $50-$100. This means that for every dollar spent on fluoride a savings of $100 in dental care would be realized. This also means that fewer anxiety-provoking visits to the dentist for fillings or other treatment would be needed.

Many communities across the nation have been studied for the decay-reducing effects of water fluoridation, and it is apparent that this public health measure is beneficial. Studies conducted by the National Institute of Dental Research and the Centers for Disease Control indicate a 30-60 percent reduction in tooth decay after implementation of community water fluoridation. Dental decay (caries) is, in fact, a disease that can be prevented or minimized by consuming drinking water that is fluoridated at an optimal level. This optimal level is monitored by state-of-the-art equipment and highly trained water engineers within a community's water system.

Extensive research has been conducted on the safety of community water fluoridation. When present at optimum levels in community water systems, fluoridation is indeed safe. The American Dental Association, the U. S. Public Health Service, the National Institute of Dental Research and independent university research have shown that, although a few individuals continue to object to fluoridation, there is no scientific basis for doubting the medical safety, effectiveness and practicality of community water fluoridation as a public health measure for preventing dental decay.

Best wishes for better dental health,

s/ Charles N. Bertolami, D.D.S., D.Med.Sc.
s/ Arthur A. Dugoni, D.D.S.
s/ Charles J. Goodarce, D.D.S., M.S.D.
s/ Howard M. Landesman, D.D.S.
s/ No-Hee Park, D.M.D., Ph.D.

Fluoridation

Statewide Survey of California Voters

Conducted by the Charlton Research Company, March 23-27, 1995
600 interviews statewide with a margin of error of 4 percent

1. Do you agree or disagree that fluoride is an effective tool in the fight against tooth decay?

Agree	**80%**
Disagree	8%
Unsure	12%

2. Do you agree or disagree that having fluoride in your local water supply is a good way to help fight tooth decay?

Agree	**69%**
Disagree	15%
Unsure	16%

3. Do you believe that your local water supply contains fluoride?

Agree	**48%**
Disagree	22%
Unsure	30%

4. Would you be more or less likely to favor a state law requiring fluoride be put in all communities' water supplies if you knew that the cost of providing fluoridated water over one's lifetime is usually less than the cost to repair just one cavity?

More likely	**62%**
Less likely	18%
Unsure	20%

5. Would you be willing to accept a ten-cent to fifty-cent increase in your monthly water bill to fluoridate your local water supply?

Yes	**58%**
No	34%
Unsure	8%

CDA.
1201 K Street, 14th Floor, Sacramento, California 95814

AMERICAN ALBUM

Fluoridation: a shining public health success

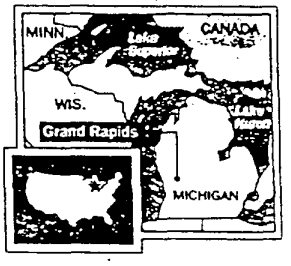
Unfounded qualms aside, the pioneering 1945 test and later studies confirm that cavities decline when drinking water is treated.

By MARLENE CIMONS
TIMES STAFF WRITER

Fifty years ago this week, public health history was made in Grand Rapids, Mich.

On Jan. 25, 1945, Grand Rapids became the first city in the world to fluoridate its water. In doing so, it launched a program destined to become what dental professionals and others have called one of the most successful public health experiments ever.

"One of the most exciting experiences of my career was observing firsthand the benefits of fluoridation in the people of Grand Rapids," said Dr. David Scott, former director of the National Institute of Dental Research and one of the researchers. The study was sponsored by the Public Health Service, the University of Michigan and the city of Grand Rapids.



Results came early: After 11 years of what was a planned 15-year study of tooth decay among the city's 30,000 schoolchildren, scientists announced that the rate of cavities had plunged by 60%.

Subsequent studies have solidly confirmed fluoride's benefits.

From 1971 through the mid-1980s, three national surveys of children's oral health showed a continued decline in cavities attributed to the use of fluoride, according to the dental institute, which is part of the National Institutes of Health.

National Institute of Dental Research

Dr. David Scott examines one of the 30,000 children in the Grand Rapids, Mich., fluoridation study of the late '40s and '50s.

The most recent survey, taken in 1986-87, found that American children had 36% fewer cavities than they did at the beginning of the 1980s, a decline similar to one shown during the 1970s.

Today, half of the children entering first grade have never had a cavity thanks to fluoridation, according to the American Dental Assn. Moreover, fluoride also can reduce cavities by 15% to 35% in adults, the ADA said.

More than 144 million Americans in about 10,500 communities drink fluoridated water. Put another way, about 70% of U.S. cities with populations of more than 100,000 add the mineral to their water, according to the federal Centers for Disease Control and Prevention. About 26 million Americans live in areas without central water systems, such as those who drink water from private wells.

In California, the cities of Los Angeles, San Diego and San Jose do not fluoridate their water; San Francisco, Long Beach, Oakland and Fresno do.

Experts give several reasons why the number of cities participating isn't greater. These include costs and inertia on the part of some local governments—which run the water systems—to make the decision to fluoridate. Perhaps more significantly, there has been a lingering public unease in some quarters about adding anything to the community water supply.

The latter attitude has been fueled over the years by isolated anti-fluoridation drives, where opponents have attacked fluoridation as a Communist plot and a violation of civil liberties, or claimed that the substance promotes everything from cancer, birth defects and sickle cell anemia to heart disease and AIDS. Several studies in recent years have shown no evidence that fluoride poses any health risks.

Despite its critics, the practice has been endorsed by the American Dental Assn., the American Medical Assn., the World Health Organization, the American Cancer Institute, the CDC and the Public Health Service.

In recent years, fluoride also has been added to toothpaste and mouth rinse. Other sources include drinks made with fluoridated water, fluoride drops or tablets and topical application in the dentist's office.

In addition to preventing decay, water fluoridation has been shown to "remineralize," or rebuild, enamel layers in teeth at spots affected by early stages of decay, the ADA said.

Scientists are also examining other possible therapeutic uses of fluoride. A study published in the April, 1994, Annals of Internal Medicine by researchers at the Texas Southwestern Medical Center showed that a regimen of fluoride and calcium supplements appeared to prevent new spinal fractures and helped to rebuild bone loss in post-menopausal women suffering from a major form of osteoporosis.

Experts call fluoridation a real bargain.

It costs an average of 51 cents per person per year, and about $38.25 over a lifetime—less than the average cost of about $42 for one dental filling, the dental institute said. Every dollar invested in community fluoridation programs saves about $80 in dental bills, the ADA says.

Research on fluoride and its effects on tooth enamel began in the early 1930s under Dr. H. Trendley Dean, a dentist at what was then the National Institute of Health, after scientists observed low decay rates among people whose drinking water contained high levels of naturally occurring fluoride.

By the early 1940s, dental scientists concluded that water containing 1 part per million of fluoride would protect teeth from decay, and decided to test their theory by adding the mineral to the almost fluoride-free Grand Rapids water supply.

"The most important historical feature of water fluoridation was that this public health measure simply replicated what had already been demonstrated in nature," Scott said.

Exactly how fluoride prevents cavities is not fully understood, but scientists do know that fluoridated water most helps those who drink it from birth "and the protection holds throughout life for persons who continue to live in fluoridated communities," the dental institute said.

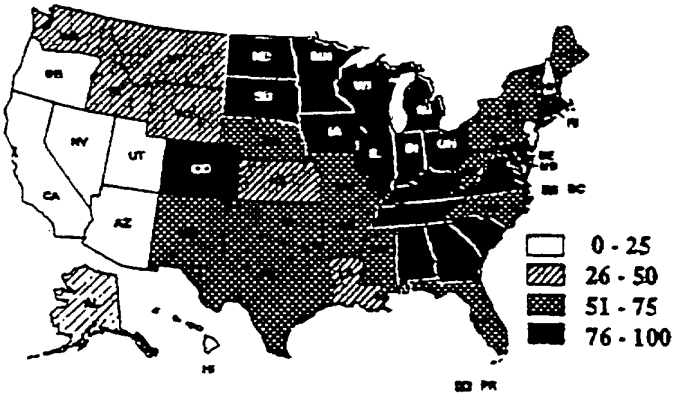
CDC BRIEFS
CENTERS FOR DISEASE CONTROL
"Current Issues in Preventive Health"
SEPTEMBER 1992

Fluoride: It's in the Water

Tooth decay (also known as dental caries) was a virtually inevitable fact of life for most persons, until the middle of this century. The disease often meant many visits to the dentist to have painful or damaged teeth repaired. Still, a few persons escaped this condition, and a small number of these experienced dental fluorosis, "mottled teeth," because of exposure to fluoride, naturally present in the drinking water. Fluorosis is a change in the color of teeth in persons exposed during the developmental phase of life while adult teeth are forming. These people also seemed to retain their teeth for longer than average, however.

Studies in the 1930s confirmed a reduced rate of tooth decay in persons whose drinking water contained a threshold level of fluoride. Since almost all water contains some fluoride, adjusting the fluoride level of the water supply is an inexpensive and easy way to improve public oral health. Based on observations in communities, an optimal fluoride concentration was established, whereby teeth remained white and incidence of dental caries decreased. A new prevention strategy was realized.

Studies in the 1950s conclusively showed that when fluoride was added to drinking water, a marked decline of dental caries followed among consumers. Currently, over 126 million U.S. residents are supplied with water containing added or adjusted fluoride, provided by over 9,400 community water systems.



Percentage of states' population on community water systems who receive fluoridated drinking water - U. S., 1989 - Source: *CDC, Div. of Oral Health*

Other methods of delivering fluoride have been developed over the last half century, including toothpastes, mouth rinses, and dietary supplements. These require a conscious decision to use, however, and are more expensive than water fluoridation. The nationwide distribution of fluoride containing products and fluoridation of drinking water has resulted in a reduction of dental caries throughout the population of the United States.

No evidence of adverse effects resulting from deliberate water fluoridation has been confirmed since this prevention strategy was first initiated. Some studies have examined the relationship between fluoride consumption and bone/teeth development; cost/benefits ratio in providing public fluoridation; the increase in local dental caries after a community ceases to add fluoride to drinking water, and effects of overconsumption of fluoridated water and products.

Healthy People 2000 is the U.S. Department of Health and Human Services plan which sets health objectives for the nation. The objective in the area of fluoridation calls for 75 percent of those served by community water systems to receive optimal levels of fluoride in their drinking water, by the year 2000. (The current level is 62 percent.) To reach this goal, approximately 30 million more people need to be added to the roster of fluoridated water consumers.

Prepared by: John P. Anderton
CDC, Office of Public Affairs

Questions and Answers about... *Water Fluoridation*

Q. Is public water fluoridation safe?
A. Yes. Extensive research conducted over the past 45 years has shown time and time again that fluoridation of public water supplies is a safe and effective way to reduce the incidence of dental caries. A recent, comprehensive Public Health Service review of the benefits and potential risks confirmed the value and safety of water fluoridation.

Q. Are there alternative methods of fluoride delivery?
A. Yes. Available with a prescription are dietary supplements for children during the years teeth are forming. In addition, non-prescription tooth pastes and mouth rinses containing fluoride are available for topical use.

Q. What does it cost to fluoridate the water?
A. Nationally, the average cost to provide fluoridated water to an individual for one year is $0.51.

Q. Is public water fluoridation cost effective?
A. Yes. It is estimated that $34 billion (5 percent of 1990 U.S. expenditures for health care) is spent for dental services. The national average cost to restore one cavity with dental amalgam is $40; that amount is the same as the cost of water fluoridation for a person's lifetime.

Q. Has incidence of dental caries decreased, since public water fluoridation began?
A. Yes. In 1945 and 1946, independent studies followed four communities experimentally testing water fluoridation. After 15 years, dental caries in these communities declined an average of 56 percent, compared to demographically similar communities whose water did not contain additional fluoride.

In a more recent study, concluding in 1987, caries levels were 26 to 30 percent lower in fluoridated communities because of wide use of fluoride in other forms. In communities which at one time fluoridated their water supplies and then ceased to do so, cases of dental caries increased, further substantiating the findings of other studies.

Q. What is the current prevalence of dental caries in the United States?
A. The most recent national study, in 1987, showed that 50 percent of persons between 5 and 17 years of age had experienced caries in permanent teeth. By age 17, 84 percent of persons had experienced some dental decay in permanent teeth.

For more information contact:
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The Effectiveness of Community Water Fluoridation in the United States

Herschel S. Horowitz, DDS, MPH

Abstract

Grand Rapids, the first city in the world to implement controlled water fluoridation, has served as a model for thousands of other communities. Fluoridation is one of the greatest public health and disease-preventive measures of all time. Its advantages include effectiveness for all, ease of delivery, safety, equity, and low cost. Today, nearly 56 percent of the US population lives in fluoridated communities (62% of those on central water supplies). Previously observed caries reductions of one-half to two-thirds are no longer attainable in the United States because other fluoride methods and products have reduced the caries prevalence in all areas, thus diluting the measurement of effectiveness, and because benefits of fluoridation are dispersed in many ways to persons in nonfluoridated areas. Water fluoridation itself, however, remains as effective as it ever was among groups at high risk to dental caries. Contrary to early beliefs that stressed the importance of preeruptive fluoride exposure, fluoridation also provides an important source of topical fluoride and facilitates remineralization. Although data on effectiveness and safety are compelling, future progress of water fluoridation will be affected by economic, political, and public perception factors. [J Public Health Dent 1996;56(5):253-8]

Key Words: water fluoridation, fluoridation statistics, diffusion and dilution effects of fluoridation, preeruptive and posteruptive effects of fluoridation, fluorosis, future of water fluoridation.

Although the subject of my presentation is the effectiveness of community water fluoridation in the United States, I cannot resist or ignore the opportunity this forum provides to congratulate Grand Rapids, Michigan, for its innovative implementation of community water fluoridation in 1945, and to extol the attributes and benefits of the procedure. By adjusting the fluoride concentration of its water supply to one part fluoride to 1 million parts of water (1 ppm), Grand Rapids led the way to developing a public health method for the prevention of dental caries, a disease that was a scourge at the time among Americans. Grand Rapids, by being the first city in the world to fluoridate its water supply, provided an example for many other cities in the United States to fluoridate their own water supplies. Approximately 10,000 communities in the United States now are adjusting the concentrations of fluoride in their drinking water (1). Another 3,700 US communities have drinking water sources that naturally contain sufficient concentrations of fluoride (1). Controlled water fluoridation is practiced in some 40 other countries as well, some of which use this health promotional method for essentially all of their populations—e.g., the city-states of Hong Kong and Singapore—or for major proportions of their populations—e.g., Australia, Canada, Ireland, Malaysia, and New Zealand (2).

Although abundant epidemiologic evidence existed from studies done in the 1930s and 1940s showing that children who consumed water with approximately 1 ppm fluoride had remarkably fewer cavities than did children who consumed water with negligible concentrations of fluoride (3-6), it nevertheless required courage and foresight for decision makers in Grand Rapids more than 50 years ago to agree to participate in a venturesome investigation that would determine the effectiveness and safety of a brand new intervention for health—community water fluoridation.

This is not my first chance to congratulate Grand Rapids for its major contribution to public health. On April 21, 1988, I took part in a symposium here in Grand Rapids to honor the 43rd anniversary of the city's fluoridation, sponsored by the National Institute of Dental Research. I quote from my remarks at that time (7):

> Grand Rapids started something remarkable in 1945. The city has served for many years as a model for public health workers. Certainly, all dental public health personnel in the world and most dentists in the United States know that Grand Rapids was the pioneer in community water fluoridation.

Advantages of Water Fluoridation

With respect to community water fluoridation itself, it is difficult to restrain myself from delivering a paean of praise and exultation for this great public health procedure, which was characterized by Dr. William H. Stewart, surgeon general of the Public Health Service from 1965–69, as one of the great disease prevention measures of all time, along with the pasteurization of milk, the purification of water, and immunization against diseases (8).

There are compelling advantages to a public health approach to disease prevention. The characteristics that make community water fluoridation a great public health and disease prevention measure are its safety, effectiveness in preventing dental decay, ease of administration, low cost, and its equity (9). The entire community benefits from the procedure regardless of age, socioeconomic status, educational attainment, or other social

Dr. Horowitz is consultant for dental research and public health. He currently resides at 6307 Herkos Court, Bethesda, MD 20817. Reprints will not be available from the author.

variables. With community water fluoridation in place, automatic benefits accrue to everyone who consumes the water directly, who consumes foods and beverages cooked or prepared with the water, or who consumes manufactured foods and beverages processed with the water. A conscious, cooperative effort or direct action on the part of the population is not required for benefits to be derived. Benefits do not depend on the availability of professional dental services or the ability to afford them. The benefits continue for a lifetime if consumption of the water continues. Lifetime consumption of fluoridated drinking water has been associated with a lower prevalence of root surface caries in older adults (10). The unique attributes of water fluoridation make it the fundamental base for community caries prevention.

Water fluoridation is eminently safe. Because opponents have continued a barrage of allegations against water fluoridation, no other disease-preventive method has been studied as extensively for safety. Fluoridation has received close and continuing scrutiny (11,12). Aside from direct basic research on safety considerations, disease incidence and prevalence findings and data on morbidity and mortality have been assessed and reassessed. Each new study or analysis has reaffirmed the safety of community water fluoridation (11,12).

The fact that a conscious effort or action is not required to benefit from fluoridation has led to a certain complacency in the population. For example, most of my nondental friends assume that the entire United States is fluoridated and has been for many years. The public must be kept aware of the benefits of fluoridation so that a constituency of public support for the measure is maintained or, in some geographic areas, is created.

Effectiveness of Water Fluoridation in Preventing Dental Caries

Newburgh, NY, and Brantford, Ontario, also began to fluoridate their water supplies in 1945, and Evanston, IL, in 1947 (13). Early findings of reduced dental decay in children were so profound (14–17) that water fluoridation grew rapidly as a public health measure. The findings of most of the evaluations of water fluoridation related that dental decay in permanent teeth of children who grew up drinking fluoridated water declined by about 50 percent to 70 percent compared with children in the same communities before fluoridation was initiated or in similar control communities without fluoridated water (18,19). Caries-protection of primary teeth in studies reported between 1956 and 1979 were only slightly less substantial than for permanent teeth; the majority of reductions ranged from 40 percent to 60 percent (18,19). Other comparisons showed that more than six times as many school-aged children were caries free in fluoridated communities, that benefits were particularly profound in approximal and smooth surfaces of teeth (as great as 95 percent in approximal surfaces of maxillary incisors) and that the number of first molars requiring extractions was reduced by 75 percent (20,21).

Because many larger cities in the United States began to fluoridate their water supplies within a few years of the publication of early reports of benefits observed in communities that pioneered water fluoridation, by 1955 more than 15 percent of the US population had access to drinking water with optimal or greater concentrations of fluoride (1). By 1965 this percentage had increased to greater than 30 percent and by 1975 to nearly 49 percent (1). Despite persistent opposition by a few vocal opponents and groups, it looked as if the US was well on its way to achieving universal water fluoridation.

Since 1975, however, progress in implementing the procedure has slowed. The most recent estimates indicate that about 144.2 million persons, or nearly 56 percent of the US population, live in communities with sufficient concentrations of fluoride in their drinking water for optimal dental health (1). Nearly all of these communities adjust the natural fluoride of their water to concentrations that range from 0.7 to 1.2 parts per million of fluoride, depending on their mean annual maximum daily temperatures. Because areas exist in the United States without central water supplies, the population with fluoridated water as a percentage of those who live in areas with central water supplies is approximately 62 percent (1).

Well into the 1980s, it still was began to fluoridate its drinking water, a reduction in dental caries in a range of 50 to 65 percent would accrue to future generations compared with the existing status of dental decay. Although there already were indications by that time that the prevalence of dental caries in children was declining throughout the country in fluoridated and nonfluoridated areas (22), review articles of fluoridation and health educational and promotional materials developed by health agencies and professional organizations continued to promise reductions of dental decay that ranged from one-half to two-thirds of their present caries prevalence.

With publication of reports from the NIDR's 1986–87 survey of dental caries prevalence among US schoolchildren, it became apparent that not only had the prevalence of dental caries in permanent teeth declined nationally by about 36 percent in the few years between 1980 and 1987, but that the difference in mean caries scores between children who lived in fluoridated communities and those who lived in nonfluoridated communities was only 18 percent in permanent teeth and 23 percent in primary teeth (23). Could it be possible that community water fluoridation was no longer as effective in preventing dental decay as it once was?

Let me assure you that water fluoridation per se is just as effective as it ever was in being able to prevent dental caries in populations at high risk to dental caries who do not have ready access to other sources of fluoride. Two factors primarily explain the apparent decline in observed benefits from drinking fluoridated water—diffusion effects of fluoridated drinking water, and dilution effects from other sources of fluoride on the measurement of effectiveness of community water fluoridation (19).

Diffusion Effects of Water Fluoridation

The implementation of water fluoridation has been more successful in larger than in smaller communities; approximately 70 percent of all US cities with populations of more than 100,000—including 42 of the 50 largest cities—fluoridate their water (1). Many of these large cities are likely to

many of the processed food products contain varying, functional concentrations of fluoride because they are prepared with fluoridated water. These foods and beverages are consumed not only in the city of manufacture, but provide a windfall by being distributed for sale in areas with fluoride-deficient water supplies. Regular consumption of these products in nonfluoridated areas provides a disseminated or diffusion effect of fluoridated drinking water (19).

The cogency of this phenomenon is validated by a comparison of regional caries scores in fluoridated and unfluoridated areas from the 1986–87 NIDR survey of the dental health status of US schoolchildren (23). In regions of the country in which a relatively low percentage of the population lives in communities with sufficient fluoride in water—e.g., Region VII (Pacific), with 19 percent—the difference in scores between fluoridated areas and nonfluoridated areas is substantial (61%). Children in nonfluoridated communities in those regions are less likely to benefit vicariously from fluoridation by consuming foods or beverages processed in nearby fluoridated communities or by visiting or attending schools or engaging in other activities in such communities. In regions of the United States with a relatively high percentage of the population living in communities with fluoridated drinking water—e.g., Region III (Midwest) with 74 percent—the difference in caries scores between fluoridated and nonfluoridated areas is minimal or nonexistent (6%) (19,23,24).

Other Sources of Fluoride and Their Dilution Effects on Observed Fluoridation Effectiveness

Since water fluoridation first was implemented as a public health caries preventive measure in the United States, the development and use of other fluoride agents have expanded greatly (21,25). Dietary fluoride supplements, with or without vitamins, have been available by prescription for many years as alternative sources of systemic (and topical) fluoride for areas with fluoride-deficient drinking water. Several fluoride solutions, gels, and varnishes have been developed for professional application during dental visits. Other fluoride gels are available by prescription for use at home by persons at high risk to dental caries. Fluoride-containing toothpastes have been marketed in the United States since the 1950s, and now comprise well over 90 percent of total toothpaste sales. Fluoride mouthrinses are used in school-based programs (as are fluoride tablets, where appropriate). Fluoride mouthrinses with dilute concentrations of fluoride are sold over the counter. The use of each of these fluoride delivery systems is supported by a large body of research findings (21,25,26). Evidence indicates that various logical combinations of use of these fluoride agents and methods produce additive benefits in reducing the incidence of caries (27).

Dietary fluoride supplements are designated for use in areas with insufficient concentrations of fluoride in water. The other products and preventive services that incorporate fluoride are intended for use by people in nonfluoridated and fluoridated communities, which has served to provide protection from dental decay throughout the country and diminish the difference in the levels of dental decay between fluoridated and nonfluoridated communities. This phenomenon has been termed a dilution effect on the measurement of effectiveness of community water fluoridation (19). The concomitant dispersion and dilution effects have served to equalize dental caries experience between fluoridated and nonfluoridated communities, especially in regions of the country with high proportions of the population using fluoridated water. As Ripa has pointed out, although communities still may be classified as being optimally fluoridated or fluoride-deficient based on the fluoride concentration of their drinking water, the distinction may be spurious because of the diffusion effects of fluoridated water (19). With respect to dilution effects, Ripa states " ... because fluoride is ubiquitous in food and dental health products, practically no American today is unexposed to fluoride" (19).

Variations in Fluoride Exposure

Not all segments of the US population have benefited uniformly from reduced dental decay (28,29). Inner-city schoolchildren in impoverished neighborhoods, Native American children, and children from migrant families have been observed in surveys to have much higher prevalences of dental decay than the average. Caries remains a public health problem for these groups. In Texas, for example, black and Hispanic children have much more decay than Anglo-American children. Black schoolchildren in South Carolina were shown to have approximately 45 percent more DMFS than white schoolchildren. It is impossible to ascribe with certainty the exact reasons for the disparity, but they may include differences in dietary practices and other behaviors that can affect dental decay. Moreover, many poor children do not have fluoride toothpastes in their homes, do not receive professional preventive services, and are not likely to take dietary fluoride supplements. Many might not have toothbrushes or must share them with other family members.

In contrast, accumulating evidence indicates that some children who live in more comfortable economic circumstances may be receiving too much fluoride during the first six years of life, inasmuch as several reports have indicated increasing prevalences and, to a lesser extent, intensities of dental fluorosis in both fluoridated and unfluoridated communities (30,31). The early epidemiologic studies of the relation between fluoride in water and dental fluorosis showed that about 16 percent of persons born and reared in optimally fluoridated communities would have signs of mild forms of fluorosis (32). The recent increases are not surprising when one considers all the additional sources of fluoride available today that were not available in the 1930s and 1940s, prior to the introduction of water fluoridation. Factors that have been shown to be associated with increased fluorosis today are the early use of fluoride toothpastes (33,34), the use and misuse of dietary fluoride supplements (35,36), and prolonged consumption of infant formula (33,36). These factors principally are responsible for increases in the prevalence of fluorosis. Lewis and Banting (37) recently estimated that more than 60 percent of fluorosis today is caused by sources of fluoride other than in drinking water; they contend that removing fluoride from all water supplies would reduce fluorosis by only 13 percent.

Mechanisms of Action of Fluorides

When community water fluoridation was first implemented and for

many years thereafter, scientists generally believed that the principal, if not the only, mechanism of action of fluoride required the ingestion of the element and its subsequent absorption, circulation through the blood, and incorporation into dental enamel as it was developing (38,39). Teeth regularly exposed to fluoride during their formation were thought to be made harder and more resistant to the acids produced by cariogenic bacteria. This belief led public health officials and researchers to promote water fluoridation as benefiting primarily children, which, in ways, was unfortunate. This perception by the public that fluoridation is "just for kids" undoubtedly has contributed to the failure of persons of all ages, particularly older adults, to support efforts to implement community water fluoridation. The public not only must be educated, but reeducated, about the comprehensive benefits of water fluoridation.

We now know that the continual presence and availability of fluoride ions in and at the enamel surface are instrumental for protection from caries progression and for the repair or remineralization of enamel that has been demineralized by acids produced by cariogenic bacteria (40,41). Various fluoride products, particularly toothpastes, provide frequent sources of fluoride ions for this reparative process. The consumption of fluoridated drinking water not only provides an initial source of topical fluoride during ingestion, but also, again, when fluoride recirculates to the oral cavity via saliva. Salivary fluoride concentrations are functionally sufficient to facilitate remineralization (42). Moreover, fluoride is incorporated into dental plaque and concentrates to provide a reservoir of fluoride ions when needed for remineralization (43).

Future of Water Fluoridation

Although community water fluoridation repeatedly has been shown to be safe and cost effective in preventing dental caries, and has been and continues to be endorsed by leading national scientific and health organizations, predicting its continuing success in the United States and elsewhere is difficult (9). Not only does organized resistance to fluoridation's adoption continue, but economic and political fact is that the public today is inclined to turn down anything that will increase their taxes, regardless of how they might benefit. Although a few of the largest cities in the United States have failed to implement fluoridation, the majority of unfluoridated water systems are located in smaller cities and towns, where per capita costs would be greater to fluoridate (1). Nearly 59,000 water systems exist in the United States, and 73 percent of them serve fewer than 1,000 persons (1). These figures underline the difficulty of ever achieving universal fluoridation in the United States.

One US national health objective for the year 2000 (objective 13.9) is to increase to at least 75 percent the proportion of US residents served by community water systems that provide optimal concentrations of fluoride (29). Twenty states and the District of Columbia already have achieved that objective (1), but fluoridation must be implemented for nearly 30 million persons for the objective to be reached (based on 1993 population estimates).

It would be desirable if health officials could decide on community-based, disease-preventive programs; however, the reality must be faced that the decision to implement community water fluoridation in the United States has become a political issue, with candidates for various offices taking a stand on this health issue or the public voting on whether or not they wish to improve the dental health of their communities. The substitution of federal block grants for categorical grants to states has worked against efforts to fluoridate. Rather than being able to earmark money specifically for community water fluoridation under a categorical grant allocation system, money for fluoridation now must compete with other health issues that usually receive greater priority. And, the block grant pie is ever-shrinking. Today, one might call it a tart.

Other road blocks to future success in implementing community water fluoridation in the United States include the perception by the public and some scientists and government officials that dental caries is no longer a major public health problem, the public's lack of knowledge about the benefits of fluorides and fluoridation, a possible growing concern about increases in the prevalence of dental about environmental pollution (9).

Sales of bottled waters have increased enormously in the United States in recent years for a variety of reasons that include fear of lead contamination and insufficient purification of drinking water. Only a few of these products contain concentrations of fluoride similar to those provided by fluoridated city water (44,45). Many people are installing filtration systems in their homes, some of which inadvertently remove or reduce fluoride in water, particularly those that work by reverse osmosis (46). Acceleration of these trends could partly undermine the benefits currently being provided to fluoridated communities. The issue of proper surveillance or monitoring of fluoridation equipment is a continuing problem; 35 percent of fluoridated water systems that voluntarily report fluoride delivery data to the Centers for Disease Control and Prevention operate at suboptimal levels (less than 0.7 ppm F) (47). The need for education, training, and incentive programs for water plant personnel is obvious.

Those of us here today know what community water fluoridation has accomplished. It has prevented needless infection, pain, suffering, and loss of teeth; improved the quality of life; and saved vast sums of money in treatment costs. By preventing the need for restorations, fluoridation conserves natural tooth structure and avoids the need for a lifetime of ever larger and larger replacement fillings, crowns, and the risks of pulpal complications (48). Worldwide, replacement of existing restorations accounts for more than half and as much as 71 percent of dentists' activities (48). Fluoridation's widespread implementation and the development of its spinoff products, in essence, have changed the smiles of America. Some of us are old enough to recall mouths of many children riddled with unsightly caries in their anterior teeth or with permanent molars with hypertrophic, necrotic pulps that caused great pain. It was not unusual for older adolescents or young adults to receive from their parents complete dentures as high school graduation or wedding presents (49). Our moderator this afternoon has written about the difficulty he has in trying to describe to today's graduate students how devastating dental [illegible]

Grand Rapids' achievement in initiating community water fluoridation 50 years ago and for continuing to serve as a model for other communities and for what public health promotional efforts can accomplish. The development and widespread use of fluoride products around the world are based largely on the striking benefits produced by the consumption of fluoridated drinking water, which means that the whole world owes a debt of gratitude for Grand Rapids' innovative action in 1945. You have reached a significant milestone in the history of public health and preventive dentistry.

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SPECIAL CONTRIBUTIONS

A Half-century of Community Water Fluoridation in the United States: Review and Commentary

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Abstract

The nearly 50-year history of community water fluoridation is reviewed with the major emphasis on the benefits and safety of fluoridation. Other aspects of water fluoridation also described include the apparent reduction in measurable fluoridation benefits because of the abundance of other fluoride sources, the diffusion of fluoridation effects into fluoride-deficient communities, preeruptive and posteruptive effects, technical and cost aspects, sociopolitical and legal issues that affect the successful fluoridation of communities, and alternatives to community water fluoridation. The majority of studies have evaluated the effectiveness of water fluoridation on the permanent teeth of children, while there are fewer studies on deciduous teeth and in adults; the relationship between fluoride ingestion and bone health needs further clarification; the sociopolitical issues of fluoridation need to be better understood.

Key Words: fluoride, fluoridation, caries prevention, coronal caries, review article, root caries, antifluoridationists.

This paper was prepared at the request of the Executive Council and the Oral Health Committee of the American Association of Public Health Dentistry. It is a review of the published scientific literature concerning the benefits and risks of community water fluoridation, as well as other aspects of fluoridation that have been recognized during the nearly 50 years of use of this public health method of caries prevention. This review is meant to be a retrospective of fluoridation's past and to serve as a resource for charting fluoridation's future.

Normally, this type of work is referenced principally with primary sources. However, there have been many excellent reviews of the early and later history of community water fluoridation, and it would be imprudent not to take advantage of them (Table 1). Therefore, while the accompanying reference list demonstrates that primary sources are adequately represented, secondary sources have been cited when appropriate, and readers will need to consult them if they wish to be referred to other primary works. Although this is a review of community water fluoridation in the United States, reports from other countries are also cited.

History of Community Water Fluoridation

The history of community water fluoridation lies within three distinct periods (1). The first (ca. 1901–33) was concerned with the cause of a developmental enamel defect, described in the United States initially by Frederick McKay, and called "Colorado brown stain." This defect was identified as mottled enamel, or, more specifically, chronic endemic enamel fluorosis. The second period (ca. 1933–45), encompassing the classical epidemiologic studies of H. Trendley Dean, focused on the relationships among the naturally occurring fluoride concentration in the drinking water, enamel fluorosis, and dental caries. Later, by balancing the caries-preventive benefit achieved by fluoride and the risk of fluorosis, the limits of optimal fluoridation were set between 0.7 and 1.2 ppm F, based on the average of maximum daily air temperature (2). The third period, designated as the "moment of truth in fluoridation history" by Frank McClure (3), began on January 25, 1945, when Grand Rapids, Michigan, became the first city in the world to adjust its water fluoride concentration to a level expected to promote dental health. Sodium fluoride was added to the water supply of Newburgh, New York, on May 2, 1945, and on June 20, 1945, to the water supply of Brantford, Ontario. Sheboygon, Wisconsin, and Midland, Michigan, were fluoridated in 1946, and in February 1947 Evanston, Illinois, was fluoridated (3). The third period in the history of community water fluoridation continues to this day with nearly 10,000 US communities and numerous foreign countries using adjusted and naturally fluoridated water (4).

Status of Community Water Fluoridation

The 1989 fluoridation census, reported by the Centers for Disease Control, found that 135 million Americans—53.9 percent of the population and 62.1 percent of those on public water supplies—were served by drinking water containing fluoride that was adjusted to optimal

TABLE 1
Principal Secondary Sources Used in the Preparation of this Review

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REVIEW ARTICLE

Kaminsky LS, Mahoney MC, Leach J, Melius J, Miller MJ. Fluoride: benefits and risks of exposure. Crit Rev Oral Biol Med 1990;1:261-81.

levels or that had fluoride already present to a level considered at or above optimal (4). Table 2 presents the 1989 fluoridation figures by geographic area. Region III (Midwest) had the highest proportion of the population with access to fluoridated water and Region VII (Pacific) the lowest. Of the 135 million people whose drinking water is fluoridated, 93 percent have had their water supply adjusted to the recommended fluoride concentration. This figure represents the fluoridation of 9,411 public water systems in 8,081 communities (4). The remaining 7 percent reside in 1,869 communities that are served by 3,463 water systems with natural fluoridation (4). Most of the cities with populations greater than 250,000 have adjusted or naturally optimal fluoride levels (5). Four of the five largest US cities (New York, Chicago, Philadelphia, and Detroit) were fluoridated in the 1950s and 1960s (5). Los Angeles, with a population of 3 million, is the exception (6).

Eight states, the District of Columbia, and the Commonwealth of Puerto Rico have mandated the addition of fluoride to the public water supplies (5,7), although in Puerto Rico there has not been vigorous execution of the mandate. The Minnesota and Illinois legislation has the greatest scope, requiring that all public water supplies be fluoridated. Some of the other states have restrictions in their laws that limit the scope of the mandate. Four states—Georgia, Michigan, Nebraska, and Ohio—allow a community to exempt itself from compliance if it does not wish to institute fluoridation. Two of these states—Michigan and Ohio—placed a time limit, which has already expired, on the period allowed for a referendum on fluoridation. Four states—Michigan, Ohio, Connecticut, and South Dakota—set lower limits on the size of the community that must comply. Table 3 demonstrates the success of water fluoridation in those states where it mandated. All eight rank in the top half of states, based on the percentage of the population with public water supplies who are served by fluoridated water. Moreover, for seven of the eight states the percentage is between 80 and 100 percent, compared with a national average of 62.1 percent (4).

Since community water fluoridation was initiated in 1945, the US population receiving optimal levels of fluoride in their drinking water generally has grown apace with the overall population growth and with the growth of the population on public water systems (Figure 1). Nevertheless, the gap between the total population supplied by public water and the population served by community water fluoridation has not narrowed significantly since 1965 (7). A goal of the US Public Health Service was that by 1990 at least 95 percent of the population on piped water supplies would be serviced with optimally fluoridated water (8). This goal was not realized and the currently revised goal for the year 2000 stated in *Healthy People 2000*, establishes a more modest and realistic target of 75 percent (9).

Of the 52 jurisdictions (50 states, District of Columbia, Puerto Rico) included in the Centers for Disease Control's 1989 fluoridation census, nine of the lowest ranking in terms of the percent of the public water supply population drinking fluoridated water were in the western one third of the country (Washington, Idaho, Wyoming, Montana, Oregon, Arizona, California, Nevada, and Utah). The other lowest ranking states were Kansas, New

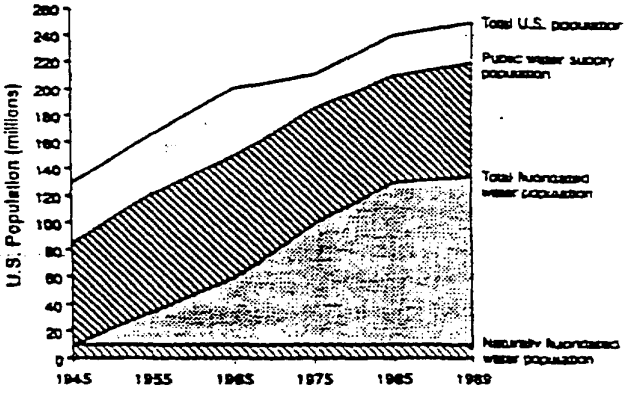
TABLE 2
Extent of Community Water Fluoridation in the United States (1989) (4)

Region	States	Population			% Pop. Receiving Adjusted / Naturally Fluoridated Water	
		Total	Served by Public Water	On Adjusted / Naturally Fluoridated Water	% of Total	% Served by Public Water
I (New England)	ME, VT, NH, MA, CT, RI	13,046,000	11,453,000	7,175,756	61.4	62.7
II (Northeast)	NY, PA, NJ	37,726,000	34,502,000	17,997,284	47.7	52.2
III (Midwest)	MN, WI, MI, IA, MO, IL, IN, OH	54,650,000	44,534,000	40,069,901	73.3	89.9
IV (Southeast)	AR, LA, KY, TN, MS, AL, GA, FL, WV, VA, NC, SC, MD, DE	64,706,000	54,590,000	39,750,863	61.4	72.8
V (Southwest)	CO, AZ, NM, TX	25,392,000	23,658,000	15,403,185	60.6	65.1
VI (Northwest)	NV, UT, ID, MT, WY, ND, SD, NB, KS, OK	13,836,000	11,853,000	5,082,616	36.7	42.8
VII (Pacific)	WA, OR, CA	36,644,000	32,477,000	6,559,949	17.9	20.2
Other	HI, AK, DC, PR	5,534,000	5,370,000	3,589,203	64.8	66.8
United States	—	251,534,000	218,437,000	135,628,757	53.9	62.1

TABLE 3
Status of Water Fluoridation in those States in which it is Mandated (4)

State (Year of Legislation)	% of Pop. Served by Public Water Supply Receiving Adjusted / Naturally Fluoridated Water	Rank (among 50 States)
Illinois (1967)	100.0	1
South Dakota (1969)	98.4	4
Michigan (1968)	90.2	7
Ohio (1969)	89.0	10
Connecticut (1965)	86.6	13
Georgia (1973)	85.7	15
Minnesota (1967)	83.5	17
Nebraska (1973)	71.3	23

FIGURE 1
US Population and Water Fluoridation



Hampshire, New Jersey, and Hawaii (4). If the year 2000 fluoridation goal is to be met, these states should be targeted for a special fluoridation effort.

Dental Benefits of Community Water Fluoridation

The inverse relationship between higher fluoride concentration of the drinking water and lower levels of dental caries experience, first demonstrated a half-century ago by Dean, continues to be true today. The results of community water fluoridation studies have been summarized in several comprehensive reviews. The reports of the first fluoridation studies conducted in the United States, Canada, the United Kingdom, and New Zealand between 1945 and 1965 were reviewed by McClure in 1970 in his book "Water Fluoridation. The Search and the Victory" (3). In the second edition of "Fluorides in Caries Prevention," published in 1982, Murray and Rugg-Gunn reviewed the literature through 1980 and summarized the results of 95 fluoridation studies conducted in 2 countries (10). Most recently, Newbrun, participating in a University of Michigan Workshop on the cost effectiveness of caries prevention in public health, reviewed the results of water fluoridation studies published between 1979 and 1988 (11).

There have also been several summary reports on water fluoridation, including those by the National

Health and Medical Research Council of Australia (12,13), the New York State Department of Health (14), and the US Department of Health and Human Services (15). Because of the thoroughness of the reviews and summary publications, reevaluation of individual water fluoridation studies would not be productive. The effectiveness of community water fluoridation will be discussed principally using the resources cited above, to which the reader is referred for specifics.

Children. Deciduous Dentition. Both Murray and Rugg-Gunn (10) and Newbrun (11) remarked on the paucity of reports detailing the effects of communal water fluoridation on the deciduous dentition, compared with the many reports on the permanent dentition. Nevertheless, sufficient clinical evidence is available to conclude that there are decided benefits to deciduous teeth from water fluoridation.

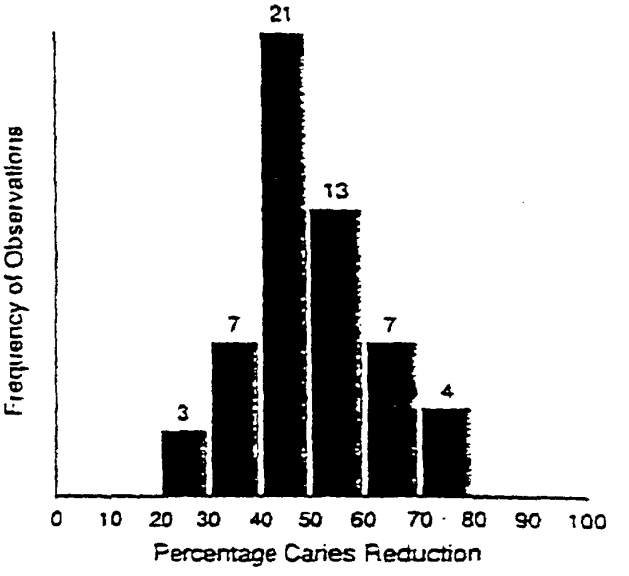
All three initial US fluoridation studies reported advantages to the deciduous teeth from communal water fluoridation. After 10 years (1945–54), the dmft prevalence for Grand Rapids' six-year-olds, the peak caries prevalence age for the deciduous teeth, was reduced by 54 percent compared to the prefluoridation level (3). After 10 years of fluoridation in Newburgh, six- to nine-year-old children had almost six times as many caries-free primary cuspids and molars as children of the same age in fluoride-deficient Kingston (5). During the period from 1946 to 1960, there was a 13.7 percent decrease in the annual caries increment of six-, seven-, and eight-year-old Evanston children's deciduous teeth, compared to a 3.9 percent decrease in the nonfluoridated control city of Oak Park (3).

Murray and Rugg-Gunn plotted the frequency distribution of the percentage of caries reductions for the deciduous teeth from 55 fluoridation studies reported between 1956 and 1979 (10). The modal percentage caries reduction was 40–50 percent (Figure 2).

Newbrun reported only one US study during the period of his review (1979–88) in which the effects of communal water fluoridation on the deciduous teeth were reported (11). Based upon examinations conducted in 1984, there was a 30 percent lower caries prevalence (defs) in three-and-a-half- to five-year-old Ohio Head Start children from fluoridated urban and nonurban sites compared to those from fluoride-deficient sites. Newbrun noted that these children were from low socioeconomic homes and were not representative of all children in this age group. Newbrun also cited data for five-year-olds from NIDR's 1986–87 National Survey of Dental Caries in US Schoolchildren. Five years is the last age when children still have only a deciduous dentition. There was a 39 percent lower caries prevalence (dfs) for five-year-old children with a history of continuous residence in optimally fluoridated communities, compared to those residing in fluoride-deficient communities.

Because of the paucity of information on the effects of

FIGURE 2
Distribution of Percentage Caries Reductions (deft) for Deciduous Teeth from 55 Community Water Fluoridation Studies Reported between 1956–79 (10)*



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communal water fluoridation on the deciduous teeth. US children during the period of his review, Newbrun included eight reports from the United Kingdom, which were published between 1979 and 1988. Caries reductions in the deciduous dentition of 40–60 percent were consistently reported in four- to five-year-old children from fluoridated communities compared with those from fluoride-deficient ones. Most of the UK studies included only children with life-long residence in the communities.

O'Mullane et al. (16) reported the results of an extensive caries survey of children in the Republic of Ireland. Between 1964 and 1972, most of the larger public piped water supplies were fluoridated; by 1986, 65 percent of the population was serviced by fluoridated water. Caries examinations of five-year-old children conducted in 1984 provided information on the deciduous teeth. A comparison was made between children whose home water supply had been fluoridated continuously since birth (and who also may have been exposed to other fluoride sources) and children who had never had any type of fluoride exposure. O'Mullane and coworkers reported the mean dmft score of the children residing in fluoridated communities was 1.8 compared to 3.0 for those residing in fluoride-deficient communities, a difference of 40.0 percent. Fifty-two percent of children from the fluoridated communities had a caries-free deciduous dentition compared to 38 percent of children in the fluoride-deficient communities.

FIGURE 3
Distribution of Percentage Caries Reductions (DMFT) in Permanent Teeth from 73 Community Water Fluoridation Studies Reported between 1956–79 (10)*

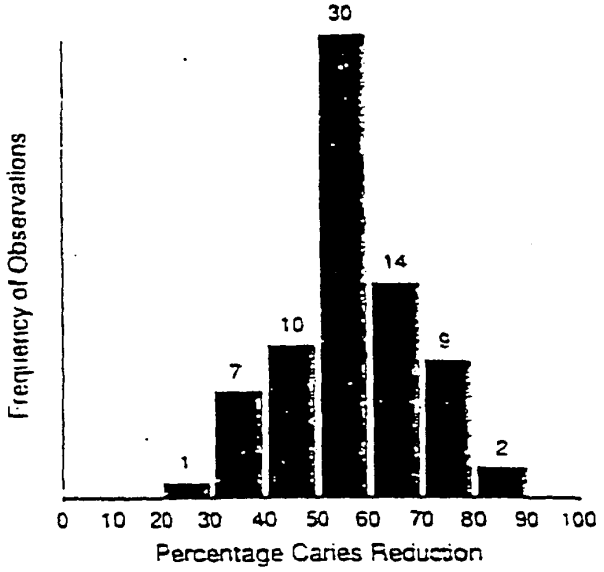

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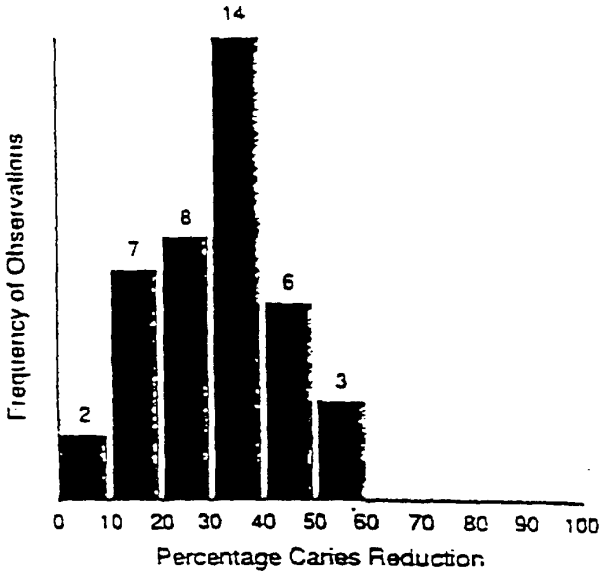
FIGURE 4
Distribution of Percentage Caries Reductions (DMFT or DMFS) in Permanent Teeth from 20 Community Water Fluoridation Studies Reported between 1979–89 (11)



A comparison was also made between the 1984 data and similar data collected in 1961–63, before fluoridation. There was a substantial caries decline in Irish children during the 20 years, with the decline being greatest among the residents of fluoridated communities. The dmft of five-year-olds in 1961–63 was 5.6. In 1984, it was 3.0 for those residing in fluoride-deficient communities (46.4 percent reduction) and 1.8 for those residing in fluoridated communities (67.8 percent reduction). O'Mullane and coworkers attributed the caries decline in fluoride-deficient communities to the widespread use of fluoride dentifrices, which, of course, also contributed to the caries decline in fluoridated communities, and to the diffusion of water fluoridation benefits, caused by such factors as the consumption in fluoride-deficient communities of soft drinks bottled in fluoridated communities.

Permanent Dentition. After 10 years, the results of fluoridation in Grand Rapids, Newburgh, and Evanston demonstrated caries reductions of between 40 to 65 percent in permanent teeth (3). The percentage decline was greatest for proximal surfaces. These highly favorable findings prompted Arnold and coworkers, who were evaluating fluoridation in Grand Rapids, to comment that, with the exception of the decrease in caries in European children caused by World War II sugar restrictions, "no such dramatic and persistent inhibition of caries in large population groups has ever been demonstrated by any other means than fluoridation of a domestic water supply" (3).

Murray and Rugg-Gunn plotted the frequency distribution of the percentage caries reductions in the permanent dentition resulting from water fluoridation (10). Of the 73 studies that they reviewed, published between 1956 and 1979, 46 were from the United States and the other 27 were from 16 other countries. The modal percentage caries reduction was 50–60 percent (Figure 3). Murray and Rugg-Gunn commented that this figure "is in agreement with the oft-quoted statement that 'water fluoridation reduces dental decay by half.'"

Newbrun reviewed the results of 20 reports on the effectiveness of communal water fluoridation in inhibiting dental caries in the permanent dentition (11). The reports, published between 1979–89, were based on studies conducted in the United States, Britain, Canada, Ireland, and New Zealand. When the results of these reports were averaged, a mean caries reduction of 30.4 percent was obtained. When the results of fluoridation studies in the US and in other countries were each averaged separately, the mean caries inhibitions were 26.5 percent for the US and 36.1 percent for the other countries. Figure presents a frequency distribution of the percentage caries reductions from the reports in Newbrun's review. For these reports published between 1979 and 1989, the modal percentage caries reduction was 30–40 percent compared to the 50–60 percent found earlier by Murray and Rugg-Gunn (Figure 3).

Newbrun (11) and others (15,17,18) have comments on the narrowing of the relative caries difference between children living in fluoridated and those living in fluoride

TABLE 4
Coronal and Root Caries Prevalence in Adults Based on Fluoride Concentration of Water Supply (11)

Reference	Water Fluoride Concentration (ppm)	Age (Mean or Range)	# of Subjects	DMFT DFS*	% Diff.
Coronal caries†					
Russel and Elvove (1951)	0.1	20–44	155	17.2	56
	2.5	20–44	385	7.5	
Ekiund et al. (1987)	0.7	40.1	502	10.9	20
	3.5	39.8	164	8.7	
Hunt et al. (1989)	<0.5	74.1	174	15.6	21
	0.7–1.0	75.2	101	12.4	
Stamm et al. (1990)	0.2	43.0	465	15.1	28
	1.6	40.2	502	10.9	
Root caries†					
Brusman (1986)	<0.3	>60	162‡	11.9§	35
	1.0–1.2	>60	103	7.7	
Burt et al. (1986)	0.7	39.8	164	0.69	88
	3.5	43.2	151	0.08	
Hunt et al. (1989)	<0.5	74.1	174	2.3	17
	0.7–1.0	75.2	101	1.9	
Stamm et al. (1990)	0.2	43.0	465	3.0	17
	1.6	40.2	502	2.5	

*DMFT for coronal caries, DFS for root caries.
†These articles are cited by Newbrun (11) and do not necessarily appear in the references for the current article.
‡The only study listed in which some subjects did not have a continuous residence history.
§Lower 6 anterior teeth.

deficient communities. The reasons for this reduction in the measurable benefits of water fluoridation are discussed in the section of this review that addresses the issues of the dilution and diffusion of fluoridation benefits.

Adults. Adults also benefit from water fluoridation. Earlier studies on the effects of fluoridation on dental caries in adults have been reviewed extensively by Murray and Rugg-Gunn (10). Newbrun's review has brought the topic up to date (11). Newbrun stressed that in studies of adults, the comparison was often between those living in fluoride deficient or optimally fluoridated communities and those living in *above*-optimally fluoridated communities. More studies are needed on the caries levels of adults in which the conventional comparison is made between residents of optimally fluoridated communities and residents of communities that are fluoride deficient.

Table 4 presents the results of reports from Canada and the United States comparing the prevalence of coronal or root caries in adults living in communities with different water fluoride concentrations. The coronal and root caries prevalence rates of adults residing in the communities with the higher water fluoride concentrations were consistently lower than the rates for adults living in communities with lower levels of fluoride in their water.

In a recently completed study of approximately 600 adults 20 to 34 years old, the investigators found a 25.1 percent lower mean coronal caries score (DFS) in subjects who resided in optimally or naturally fluoridated communities compared to subjects who had no exposure to fluoridated water (19). Pre- and posteruptive fluoride exposure patterns relative to caries activity were also assessed, but the sample size of the preeruptive exposure group was too small for meaningful comparison.

Dilution and Diffusion of Fluoridation Benefits

As cited above, comparisons of the caries prevalence rates between optimally fluoridated and fluoride-deficient communities conducted during the last decade show less of a difference than comparisons reported before 1980. The decrease in the magnitude of the difference in caries prevalence between these two types of communities probably is not the result of an abatement of the ability of water fluoridation to inhibit caries. Rather, it appears to be the result of what may be called "dilution" and "diffusion" effects.

Dilution is the apparent reduction in measurable water fluoridation benefits resulting from the ubiquitous availability of fluoride from other sources. Beginning in the 1950s, each succeeding decade has seen the introduction of new fluoride products, including professionally applied topical agents, fluoride toothpastes, dietary fluo-

ride supplements, fluoride mouthrinses, and self-applied fluoride gels. This abundance of readily available fluoride has contributed to a lowering of the "background" caries levels, both in fluoridated and fluoride-deficient communities, from which the effectiveness of communal water fluoridation is measured (20,21). Kaminsky and coworkers listed 14 studies in fluoride-deficient communities in the US and elsewhere, which collectively covered about 30 years from the 1950s to the 1980s, in which the prevalence of dental caries had declined 17 to 60 percent (14). Undoubtedly, these declines resulted partly from the availability and use of both professional and consumer fluoride products.

Diffusion is the extension of the benefits of community water fluoridation to residents of fluoride-deficient communities. Diffusion can result from the consumption of commercial beverages and foods that were processed in optimally fluoridated communities and transported to fluoride-deficient ones (22). It can also occur when children or adults who live in fluoride-deficient communities travel to optimally fluoridated communities where they attend child care centers, school, or work. (Presumably, reverse diffusion can also occur when beverages bottled in fluoride-deficient communities are consumed in fluoridated communities, or when children or adults who reside in optimally fluoridated communities routinely travel to school or work in a community that is fluoride deficient. Reverse diffusion would have the same leveling effect when caries rates in the two types of communities are compared, although in this situation, fluoride benefits are being denied rather than extended).

Brunelle and Carlos analyzed the data from the second NIDR national survey of caries in US schoolchildren, completed in 1987, in order to determine the effect of exposure to community water fluoridation (18). They reported an 18 percent difference in caries prevalence between schoolchildren who were life-long residents of optimally fluoridated and those who were residents of fluoride-deficient communities. However, to control for the dilution effects of other sources of fluoride, they excluded from their analysis those children with histories of exposure to dietary fluoride supplements or topical fluorides received in dental offices or school programs. After eliminating these children, the difference in caries prevalence was 25 percent.

The effects of diffusion on the benefits of water fluoridation can be deduced by comparing the caries prevalence of schoolchildren in optimally fluoridated and those in fluoride-deficient communities according to the seven US geographical regions. Table 5 ranks the US geographical regions according to the percentage of the population served by communal water fluoridation (18). Comparing mean DMFS scores of children who are life-long residents of optimally fluoridated communities and those without communal water fluoride exposure, the magnitude of the percentage difference is lowest in the region (Region III, Midwest) with the greatest percentage of the population having community water fluoridation. In fact, in Region III, there is actually less caries in the children with no residence history of communal water fluoridation. Brunelle and Carlos (18) suggest that the negative percentage difference in DMFS scores for Region III may be due to sampling limitations. Because so much of this region is fluoridated, the number of children who never had contact with fluoridated water was small.

Conversely, the percentage difference between mean DMFS scores is greatest in the region (Region VII, Pacific) with the lowest percentage of its population on communal water fluoridation. The difference of 60.6 percent in Region VII is consistent with the reports of the magnitude of the caries inhibition from water fluoridation in the 1950s prior to the introduction of other fluoride interventions. The regions that are intermediate in their extent of fluoridation have differences in caries scores between

TABLE 5

Comparison of the Caries Prevalence of US Schoolchildren with or without Residence Histories of Fluoridated Water Exposure, Relative to the Geographic Region in which They Live (18)

Region	% of Pop. Receiving Adjusted/Naturally Fluoridated Water (1988)*		DMFS—Residence History of Water Fluoridation		Difference in Mean DMFS Scores		
			Lifelong	None	%	Rank	
III (Midwest)	72.2	(greatest)	2.86	2.69	-5.6	1	(lowest)
I (New England)	66.2	↑	3.11	3.45	9.8	3	↓
IV (Southeast)	57.5		2.75	3.60	23.6	6	
V (Southwest)	57.4		2.49	2.71	8.1	2	
II (Northeast)	48.1		3.08	3.42	9.9	4	
VI (Northwest)	35.9		2.36	3.07	23.1	5	
VII (Pacific)	17.8	(lowest)	1.42	3.61	60.6	7	(greatest)
	53.2		2.79	3.39	17.7		

*1988 figures, rather than 1989 figures (Table 2), are used here, since they more closely conform to the date of the caries examinations.

residents of fluoridated and fluoride-deficient communities that also are intermediate, although irregular. While the limitations in attempting to correlate the water fluoridation status of a region with the caries status of individuals within the region must be recognized, the comparisons in Table 5, nevertheless, suggest that the extent of water fluoridation in a region determines the magnitude of the diffusion effect and its influence on the relative difference in caries prevalence between optimally fluoridated and fluoride-deficient communities.

Failure to consider fluoride residence history, inaccurate reporting of residence histories, and intermittent compliance with exact standards of water fluoride concentration in fluoridated communities also can lead to improper assumptions concerning the true value of water fluoridation, generally underestimating its benefits (18,23,24). Brunelle and Carlos found that of the approximately 36,000 subjects participating in the NIDR national caries survey for whom residence histories were available, 23 percent had life-long exposure to fluoridated water, 23 percent had never lived in a fluoridated community, and 54 percent had lived in both fluoridated and fluoride-deficient communities (18). Thus, more than five of every 10 US schoolchildren have intermittently consumed fluoridated water because of residence changes. Burt et al. (25) and Clovis et al. (26) have shown that for American and Canadian children, respectively, a limited residence exposure to fluoridated water will impart dental benefits. A highly mobile American society, compared to a relatively stable society when water fluoridation was introduced in the 1940s, also serves to blur the distinction between populations that have or have not been exposed to water fluoridation.

It is evident that a variety of factors—principal among them being the dilution effects of other sources of fluoride, the diffusion of the benefits of water fluoridation beyond the geographic limits of the community being served, and the mobility of contemporary US society—have confounded the traditional distinction between communities that are fluoridated and communities that are fluoride deficient. It is no exaggeration to say that, for all practical purposes, the phrase "not exposed to fluoridated water" now is a misnomer in the United States and, possibly, in other developed countries that employ fluoridation widely.

Effect on Dental Benefits of Discontinuing Water Fluoridation

Several studies have evaluated the effect of discontinuing water fluoridation. Two of the earliest studies were in Galesburg, Illinois, and Antigo, Wisconsin (27,28). Galesburg's water, which contained a natural fluoride concentration of 2.0 ppm, was replaced by fluoride-deficient water (<0.1 ppm F) in 1959. Within two years there was a 10 percent decrease in the number of caries-free 14-year-olds and their DMFT scores increased from 2.02 to 2.79 (27). In Antigo, fluoridation of the water supply was discontinued in 1960 after 11 years. Six years later the DMFT scores of second, fourth, and sixth grade children had risen by 70, 41, and 48 percent, respectively (28). The water fluoride concentrations were also reduced to suboptimal levels in Austin, Minnesota, in 1956 (29) and Wick, Scotland, in 1979 (30). In both communities the caries prevalence of the children increased. In the more recent episode in Wick, defluoridation in 1979 resulted in a downward adjustment of the water fluoride concentration from 1.0 ppm to the natural level of 0.02 ppm. Five- and six-year-old children received clinical and radiographic caries examinations in 1979, after life-long exposure to optimally fluoridated water, and similar aged children received caries examinations in 1984, after life-long exposure to fluoride-deficient water. The dmft index rose from 3.14 in 1979 to 4.30 in 1984, a difference of 27.0 percent, and the dmfs index went from 8.42 to 13.93, a difference of 39.6 percent.

In Karl-Marx-Stadt (now Chemnitz), Germany, technical problems reduced the adjusted fluoride concentration from 1.0 ppm to a low of 0.2 ppm (31). From 1959 to 1970 the water fluoride concentration had been maintained at a constant 1.0±0.1 ppm. There was an interruption in water fluoridation from 1970 to 1971 that lasted 1.5 years, followed for the next five years by suboptimal levels of water fluoridation until, in 1977, the optimal fluoride level was restored. During this 18-year period all schoolchildren in Karl-Marx-Stadt received regular visual-tactile caries examinations from the same dental examiner. For 5- to 15-year-old children, dmft and DMFT scores showed a reduction during the original period of optimal fluoridation, increased during the period when the water fluoride concentration fell, and then were reduced again when fluoridation was fully restored.

A recent study that determined the effect of defluoridation was conducted in Stranraer, Scotland, which was fluoridated in 1970 and then defluoridated in 1983 because of a judgment by the Scottish court (32-34). The consequences of defluoridation in Stranraer, as well as those described for Wick, are of particular interest since they happened during the overall secular caries decline occurring throughout the United Kingdom, which has been attributed largely to the use of fluoridated toothpastes.

In 1980, after 10 years of fluoridation, the DMFT of 10-year-olds was 1.66, compared with 3.35 for 10-year-olds in Annan, a comparable fluoride-deficient community. This was a difference of 50.4 percent. After defluoridation, the mean DMFT of Stranraer 10-year-olds increased, despite the secular decline that continued in Annan. In 1986, three years after defluoridation, the DMFT of 10-year-olds in Stranraer was 39 percent lower than in the same aged children in Annan. By 1988, the mean DMFT of Stranraer 10-year-olds was 2.28 compared with 2.56 in Annan, a difference of only 11 percent

(34). At the same time, dental treatment needs and costs rose in Stranraer. Between 1980–86, the costs associated with restorative care had risen by a dramatic 115 percent, compared to a 9 percent rise in Arnan.

Salivary fluoride levels are low in individuals who reside in communities where the water fluoride concentration is low (35-38). When the fluoride concentration in drinking water is reduced to suboptimal levels, the concentration of fluoride in dental plaque can decrease to almost nonmeasurable levels (39). Inasmuch as the permanent teeth of the 10-year-old Stranraer children who were examined in 1988 were largely formed during the period of optimal fluoridation, the decreased caries protection might be attributed to the lack of posteruptive fluoride contact that, presumably, reduced salivary and plaque fluoride concentrations (40).

In its review of the benefits and risks of communal water fluoridation, the Ad Hoc Subcommittee on Fluoride of the US Public Health Service proposed that one criterion for conferring effectiveness of an agent is the disappearance of effects when the agent is removed (15). The report cites the studies described above in which increases in caries scores are associated with discontinuation of communal water fluoridation as additional evidence of a causal relationship between optimal concentrations of fluoride in drinking water and caries resistance.

Mechanism of Action of Fluoride in Drinking Water

The mechanisms by which fluoride provides caries resistance have been reviewed by Newbrun (41), Murray and Rugg-Gunn (42), and Mellberg and Ripa (43). The latter state that fluoride mechanisms can be grouped into five categories: increased enamel resistance to acid demineralization, increased rate of posteruptive maturation, remineralization of incipient lesions, interference with microorganisms, and improved tooth morphology. Furthermore, it is customary to classify fluoride therapy and mechanisms under two broad categories: systemic and topical. Systemic methods are those in which fluoride is ingested and the unerupted teeth are the targets of fluoride activity. Topical fluorides are not meant to be ingested and act posteruptively on the teeth. [redacted] water, provides [redacted] contact to erupted teeth as it passes through the oral cavity and systemic contact to unerupted teeth after it is absorbed and circulated. Despite nearly 50 years of fluoride use, the relative importance of these two modes of contact in the prevention of dental caries and, by implication, the mechanisms involved are still uncertain."

When water fluoridation began, most scientists believed that the anticaries activity of fluoride was principally a result of its incorporation into the apatite crystals of developing enamel, thus increasing the stability and reducing the solubility of the apatite structure. However, the correlation between enamel fluoride concentration and caries experience was inconsistent (21,43). Perhaps this equivocal finding should have been expected, considering that the effects of some preeruptive mechanisms of fluoride, such as improved crystallinity (42,43) and octacalcium phosphate conversion (44), cannot be measured by an enamel biopsy. Since a conclusive relationship between fluoride levels in sound enamel and caries protection could not be established, the emphasis in research about fluoride mechanisms shifted from the creation of high levels of fluoride in sound enamel (systemic effect) to the presence of low concentrations of fluoride in the intraoral environment (topical effect) and to the role of fluoride in remineralization (45,46). In 1991, the Ad Hoc Subcommittee on Fluoride stated, "The theory of preeruptive fluoride incorporation as the sole or principal mechanism of caries prevention has been largely discounted" (15). Data from both early and recent clinical studies of water fluoridation and other systemic fluoride methods support the view of *both* a preeruptive and a posteruptive influence on caries (21).

Preeruptive Effects. The Grand Rapids, Newburgh, and Evanston water fluoridation studies all demonstrated greater percentage reductions in the younger age groups of children, who had the greatest amount of preeruptive fluoride contact (3). Of more recent vintage, Driscoll et al. reported greater caries protection to teeth that were unerupted at the start of a fluoride supplement program compared to teeth already in the mouth (47). In that study children received 1 or 2 mg F/day as tablets for six school years. The control group was given placebo tablets. Four years after discontinuing the study the mean DMFS increments for early erupting teeth in children using 1 mg F/day and 2 mg F/day were 15.0 percent and 23.3 percent less than in the control children, respectively. For late erupting teeth the mean DMFS increments were 38.6 percent and 33.6 percent less. However, Thylstrup believes that the most critical period for caries protection from fluoride is when the teeth are emerging into the oral cavity (48), and Driscoll and coworkers' findings could reflect the effect of topical fluoride contact at the time of tooth emergence. Burt and coworkers' findings are less subject to antithetical interpretations (25). These investigators compared the DMFS increments of children, initially six and seven years old, who lived in a fluoride-deficient community (0.2 ppm F), but who had resided in fluoridated communities prior to the eruption of their permanent teeth with children of similar age who were life-long residents of the fluoride-deficient community. The native residents had a three-year DMFS increment of 2.35 compared with 1.72 for the fluoride-exposed group, a difference of 26.8 percent. Burt and coworkers concluded: "Despite evidence that the benefits of limited ingestion of fluoridated water are topical in nature, the fact that many of the affected teeth in this study were unerupted at the time of the fluoride exposure means that preeruptive benefits cannot be ruled out."

Posteruptive Effects. In addition to indicating a preeruptive effect, findings from the original US fluoridation studies also demonstrated posteruptive benefits (21). In his review of these studies, McClure stated, "The evidence strongly suggested that there were beneficial effects on teeth which were formed or erupted prior to the initiation of water fluoridation" (3). Beltran and Burt (21) cite recent studies from Britain (49) and Denmark (37,50) that provide additional evidence of posteruptive benefits from systemic fluoride. In the British study, the four-year mean caries increment of children who were 12 years old when fluoridation (1.0 ppm F) began was compared with that of a control group residing in a fluoride-deficient community (<0.1 ppm F) (49). Children were transported to a central facility so that the examinations were conducted without the examiner knowing to which group the children belonged. The four-year mean DMFS increments of the fluoride and control groups were 6.73 and 9.19, respectively, representing a difference of 27 percent. Since all or most of the permanent teeth had erupted prior to the initiation of fluoridation, the difference was attributed to "substantial topical effects on teeth already erupted at the start of fluoridation."

Other, less direct, arguments may be considered to support the claim of posteruptive benefits from water fluoridation. For instance, it is known that when contact ceases, caries protection diminishes (see section "Effect on Dental Benefits of Discontinuing Water Fluoridation"). It may be inferred, therefore, that the continued caries protection in fluoridated areas into adulthood is the result of repeated topical contacts.

Beltran and Burt (21) proposed that if the major effect of fluoride is a posteruptive one, then caries experience in communities with long-standing comprehensive topical fluoride programs should approach that of communities where the drinking water is fluoridated. However, they admitted that the clinical results they presented lacked consistency and failed to resolve the issue. Ripa (51) reviewed the results of three US fluoride mouthrinse programs that used historical controls to assess the effectiveness of this topical intervention (52-54). In all three studies, the results showed that when the children began rinsing as kindergartners, there was a caries reduction of approximately 50 percent, which is similar to that reported in water fluoridation studies. Ripa believed that since the children were five to six years old when they entered the mouthrinse programs, the fluoride solution contacted most of the permanent teeth as they emerged into the mouth and this was a major factor determining the caries reductions achieved. This interpretation agrees with Thylstrup's contention that the most important time for fluoride to contact the teeth is when they are erupting into the mouth (48).

Pre- vs Posteruptive Effects. Groeneveld et al. analyzed the results of caries examinations between 1953 and 1971 in the Tiel (1.0 ppm F)–Culemborg (0.1 ppm F), Netherlands, water fluoridation study (55). Children were followed longitudinally and examined every two years from seven to 18 years of age, until water fluoridation ended. Those living in fluoridated Tiel received fluoride continuously from birth. The analysis is too complex to describe here, but their conclusions concerning the relative benefits of pre- and posteruptive fluoride contact are summarized:

(1) The initiation of enamel lesions is hardly affected by water fluoridation. However, lesion progression is slowed by posteruptive fluoride contact.

(2) For 15-year-olds exposed to water fluoridation since birth, the DMFS reduction was half due to the preeruptive effect and half to the posteruptive effect.

(3) The best protection is achieved if fluoridation is available from birth, but 85 percent of the maximum protection will occur if fluoride consumption starts between ages three and four.

(4) About two-thirds of the caries protection imparted to pits and fissures from water fluoridation comes from preeruptive contact. For smooth surfaces, the effect of preeruptive contact accounts for 25 to 50 percent of the caries protection. Groeneveld et al.'s analysis needs verification by others (55). Nevertheless, it indicates that the cariostatic activity of water fluoridation includes both systemic and topical mechanisms.

Safety of Communal Water Fluoridation

Fluoride metabolism studies have consistently established that the principal fate of ingested fluoride is either urinary excretion or retention by the skeleton and teeth. Because of the affinity of the fluoride ion for calcified tissue and its concentration in the kidneys, the safety of fluoride in relation to the skeleton, the teeth, and renal function specifically will be discussed. Because of the importance of the relationship between cancer mortality and fluoridation, this will be an additional safety topic. For a discussion of fluoride safety concerning other issues, such as the effects on other organs and tissues, hypersensitivity and allergy, reproductive toxicity and birth defects, readers are referred elsewhere (12,14,15,56). Several reviews of fluoride safety over the last decade constitute the principal source material for this section (12,14,15,56). Additional primary sources are cited where appropriate.

Skeletal Fluorosis and Osteosclerosis. Endemic skeletal fluorosis is confined largely to tropical climates with very high levels of at least 10 ppm fluoride in the water (12). Skeletal fluorosis also has been observed in workers exposed to high levels of fluoride in industry, such as aluminum production. Skeletal fluorosis has several stages and is usually characterized by generalized bone pain, stiffness and pain of the joints, and arthritic symptoms. Radiographic findings have shown osteosclerosis of the pelvis and vertebral column (12,14,15).

There have been five reported cases of crippling skel-

etal fluorosis in the United States. These individuals were exposed to natural levels of fluoride in the drinking water ranging from 3.9–8.0 ppm, and, in the two cases with an established history, the daily water consumption was excessively high (15). Radiographically detectable osteosclerosis has been reported in other individuals exposed to 4.0–8.0 ppm F, but there were no clinical symptoms of skeletal fluorosis (14). Skeletal fluorosis has not been reported in the US at water fluoride concentrations below 3.9 ppm, nor is skeletal fluorosis a public health problem in the US (15).

Bone Fracture and Osteoporosis. Sodium fluoride is used sometimes in the United States and other countries to treat osteoporosis. The minimum daily dose is about 40 mg NaF, and although the US Food and Drug Administration has never approved NaF treatment for osteoporosis, it is approved in other countries. People on the regimen have displayed an increase in the density of the vertebrae (trabecular bone) by as much as 35 percent over four years. Some studies have shown that there is a simultaneous decrease in cortical bone, such as the shaft of the radius, causing concern that the observed increase in bone density may be at the expense of other portions of the skeleton losing calcium.

The incidence of vertebral fracture is the most important outcome in osteoporosis treatment using fluoride (15). While studies have consistently shown that a daily NaF regimen will increase vertebral bone mass, the findings on reduced vertebral fracture are mixed, with two well-controlled recent studies failing to show a reduction in bone fracture rates (57,58). In 1989, an FDA Advisory Committee concluded that NaF has not been shown to be effective in reducing the incidence of vertebral fractures resulting from osteoporosis (15).

Because of the effect of fluoride in increasing trabecular bone mass and apparently reducing cortical bone mass, interest also has focused on the relationship between the concentration of fluoride in water supplies and both the prevalence of osteoporosis and the prevalence of fractures, especially the hip. Simonen and Laitinen compared the incidence of femoral-neck fracture over a decade in two Finnish towns, one with an adjusted water fluoride concentration of 1.0 ppm and the other with 0.0 to 0.1 ppm F (59). They found that the risk of fracture in both men and women was significantly higher in the fluoride-deficient community. A study in North Dakota reported that residents, especially women, exposed to water containing about 4.0 ppm F had less osteoporosis and vertebral collapse than a comparable group in a low-fluoride area (60).

Three studies have failed to find a relationship between water fluoride levels and hip and long bone fracture (61-63), whereas other studies have found a relationship (64,65). Cooper et al. evaluated hospital discharge records for 1978–82 in 39 counties in England and Wales (63). Approximately 20,000 men and women above aged 45 years were admitted with hip fractures (fracture of the proximal femur). The water fluoride concentrations in the counties under study ranged from almost none (0.005 ppm) to approximately 1.0 ppm. No significant correlation was found between water fluoride concentration and the prevalence of hip fracture. In the United States, Jacobsen et al. analyzed nationwide hospital discharge records from the Health Care Financing Administration and the Department of Veterans Affairs of white women aged 65 years and older for the period 1984–87 (64). They found a distinct north to south pattern for hip fracture, with the lower rates in the North and the higher rates in the South. Although they stated that no presently recognized factor or factors adequately explained the geographic variation, they nevertheless found an increased prevalence of hip fracture associated with the availability of fluoridated water. The report of Jacobsen et al. caused Cooper and Jacobsen to reevaluate the data from the UK. In a letter to the editor of the *Journal of the American Medical Association*, they said that after weighting their data for each county by the size of the population aged 45 and older, they found a positive correlation between water fluoride levels and the prevalence of hip fractures, i.e., the higher the fluoride level, the greater was the risk of hip fracture (66). In a prospective five-year study of women in three Iowa communities conducted between 1985–84 and 1988–89, Sowers et al. also reported an association between water fluoride concentration and bone fractures (65). They reported a twofold increased risk of fracture of the wrist, spine, and hip in 55- to 80-year-old women in the higher fluoride community (4.0 ppm) compared with the control community (1.0 ppm).

Phipps and Burt reported no difference in cortical bone mass when the density of the distal radius was measured in post-menopausal women who were life-long resident of communities with either 3.5–4.2 ppm F or 0.7 ppm F in the water (67). However, they concluded that one predictor of cortical bone mass was fluoride exposure, with the higher fluoride level associated with lower bone mass. Considering the conflicting reports, it must be concluded that the question concerning the role of water fluoride exposure in both osteoporosis and bone fracture is unresolved (15).

Renal Effects. The kidneys are potential targets of acute and chronic fluoride toxicity because they remove fluoride from the blood, and the kidney cells that concentrate urine are exposed to high fluoride concentrations. The National Kidney Foundation has attested that water fluoridation does not harm the kidneys (56). Despite the importance of the kidneys as waystations for the disposal of fluoride from the body, there is no evidence that the incidence of mortality from any renal disorder is increased by water containing 1.0 ppm F(12). Furthermore, in several epidemiologic studies, long-term consumption of water containing fluoride as high as 8.0 ppm was found not to be associated with the induction or exac-

bation of kidney dysfunction (14,15). While higher fluoride concentrations are definitely found in calcium oxalate kidney stones from residents of fluoridated compared with kidney stones from residents of fluoride-deficient communities, the effect of fluoride on stone formation is poorly understood. At least one group of investigators believes that there might be a dose-dependent fluoride inhibition of kidney stone formation. Increasing fluoride concentration, for instance from 0 to 10 ppm, inhibits the growth of calcium oxalate crystals (68). However, concentrations as high as 10 ppm are not relevant to controlled water fluoridation.

Studies have shown that persons with renal insufficiency have decreased fluoride clearance and will have elevated plasma levels of fluoride compared with unaffected individuals (14). For these people, the need is recognized to use water for hemodialysis that has a low fluoride concentration, as well as a low concentration of other ions. Recently, Bello and Gitelman showed that hemodialysis patients who received dialysis fluids from a fluoridated tap-water source purified by reverse osmosis had a higher plasma fluoride level than those who used a commercially prepared peritoneal dialysis fluid (69). They attributed this difference to the fact that although reverse osmosis systems remove most of the fluoride from water, this process cannot produce dialysis fluid from a fluoridated water source that is as low as the fluoride concentration in a commercial preparation. They speculated that since municipal water fluoridation and the reliance on reverse osmosis systems for water purification are both commonplace, many hemodialysis patients are being overexposed to fluoride, which may accumulate in their skeleton. In general, patients with impaired kidney function have an increased risk of skeletal fluorosis and in young children whose teeth are forming there is a risk of dental fluorosis. Cases of both, usually associated with high fluid intake, have been reported (14).

Hyperfluoridation of a water supply can occur due to "overfeeds" involving equipment malfunction (70,71) or to "accidents" in which equipment is not directly involved (72). There has been one report of a hyperfluoridation accident in a municipal water supply. In that instance, fluoride was accidentally added to the water supply of Annapolis, Maryland, at a level of over 30 ppm for several days (72). As a result, a resident undergoing kidney dialysis with softened tap water instead of purified water died and seven other dialysis patients became extremely ill. These individuals were in end-stage renal disease and were not receiving the recommended dialysis procedure. No untoward effects were documented in the population at large.

Cancer Mortality. After the introduction of communal water fluoridation, five reports appeared in the 1950s that evaluated general mortality rates in US communities with different concentrations of water-borne fluoride (15). No relationship between fluoride concentration and cancer was detected. Two studies from the UK, which appeared in the early 1970s, also reported no significant association between cancer rates and water fluoridation (15).

In a series of publications and public announcements beginning in 1975, Yiamouyiannis and Burk claimed that their analysis of cancer mortality statistics showed that fluoridation significantly increased the risk of cancer and that 10 US cities that had instituted controlled fluoridation programs had a rapid increase in cancer mortality rates compared with 10 nonfluoridated US cities over the same time period. The methodology of Yiamouyiannis and Burk was criticized, mainly for failure to adjust for confounding variables such as age and sex differences that affect cancer rates. The National Cancer Institute and others who reanalyzed the same cancer mortality data, using different methods, failed to find significant increases in cancer deaths in the cities with fluoridated water. The consensus of the scientific community is that the studies of Yiamouyiannis and Burk do not support the conclusion that fluoridation causes cancer (15).

Additional epidemiologic studies that investigated a possible link between water fluoridation and cancer morbidity and mortality have been conducted in several countries including the United States (75-77), the United Kingdom (78-81), Canada (82,83), and Australia (84). In all, over 50 epidemiologic studies have evaluated the possibility of an association between cancer mortality or morbidity and water fluoridation. The overall conclusion from these studies is that there is no credible evidence that water fluoridation increases the risk of cancer. Several independent commissions have reviewed the scientific literature on a cancer–fluoridation link and all came to a similar conclusion (85-87). The report of one of these commissions, reads, in part (85):

> We have found nothing in any of the major classes of epidemiological evidence which could lead us to conclude that either fluoride naturally in water, or fluoride added to water supplies, is capable of inducing cancer, or of increasing the mortality from cancer. This statement applies both to cancer as a whole, and to cancer at a large number of specific sites. In this we concur with the great majority of scientific investigators and commentators in this field. The only contrary conclusions are in our view attributable to errors in data, errors in analytical technique, and errors in scientific logic.

The issue of cancer and water fluoridation resurfaced in late 1989 with the premature release of data from a study of chronic toxicity and carcinogenicity of NaF in laboratory animals, conducted by the National Toxicology Program (NTP) of the National Institute of Environmental Health Sciences. In the NTP study, fluoride, as NaF, was administered to male and female rats and mice

TABLE 6
Doses and Number of Animals in the NTP Study of the Toxicity and Carcinogenicity of Sodium Fluoride (15)

Dose (ppm)		Daily Dose of NaF in mg/kg/Body Weight		# of Animals			
				Rats		Mice	
NaF	F	Rats	Mice	Male	Female	Male	Female
0	0	0.0	0.0	80	80	80	80
25	11	1.3	2.4–2.8	50	50	50	50
100	45	5.2	9.6–11.2	50	50	50	50
175	79	8.6–9.5	16.7–18.8	80	80	80	80

TABLE 7
Fluoride Concentrations in Bone Ash and Incidence of Osteosarcomas in the NTP Study of the Toxicity and Carcinogenicity of Sodium Fluoride (15)

Dose (ppm)		F Concentration in Bone Ash in μg F/mg Ash		Incidence of Osteosarcomas			
				Rats		Mice	
NaF	F	Rats	Mice	Male	Female	Male	Female
0	0	0.45–0.50	0.72–0.92	0	0	0	0
25	11	0.98–1.35	1.52–1.61	0	0	0	0
100	45	3.65–3.73	3.55–4.37	1	0	0	0
175	79	5.26–5.55	5.69–6.24	4*	0	0	0

*Includes one extraskeletal osteosarcoma.

in concentrations of 0, 11, 45, and 79 ppm (Table 6). Osteosarcomas were found in one high-dose (45 ppm F) and four highest dose (79 ppm F) male rats (Table 7). In the latter group, one of the osteosarcomas was extraskeletal—that is, it did not originate in bone. There were no osteosarcomas in the female rats or in the mice of either sex. Oral squamous cell neoplasms also were diagnosed in the dosed and control rats, but the incidence rates between dosed and control animals were not statistically significantly different (15).

The results of the NTP study were reviewed in April 1990 by the NTP Peer Review Panel. The panel concluded that, under the conditions of the two-year study, there was "equivocal" evidence of carcinogenic activity of NaF in male rats, based upon the small number of osteosarcomas in dosed animals. "Equivocal" is a classification for uncertain findings demonstrated by studies that are interpreted as showing a marginal increase of neoplasms that may be chemically related. The panel also concluded that there was no evidence of carcinogenic activity from NaF in the female rats or in the male or female mice.

The doses of fluoride in the NTP study were extremely high when contrasted to optimally adjusted or above-optimal naturally occurring levels of fluoride in US drinking water. In the two-year NTP study, the fluoride concentration in the bones of the dosed animals increased by a factor of approximately 2 to 10 (Table 7). Both rats and mice had dose-related fluorosis of the teeth and female rats had osteosclerosis of the long bones.

In a separate carcinogenicity study, commissioned by the Procter & Gamble Company and conducted from 1981 to 1983, rats and mice received daily doses of 0, 1, 4, 10, and 25 mg NaF/kg body weight. Two osteosarcomas were identified in low-dose (4 mg NaF) female rats that died before the end of the study; one fibroblastic sarcoma, possibly with osteoid formation, was found in a mid-dose (10 mg NaF) male rat; and one osteosarcoma was found in a high-dose (25 mg NaF) male rat. Benign osteomas increased in high-dosed male and female mice (15). The Carcinogenicity Assessment Committee, Center for Drug Evaluation and Research, of the US Food and Drug Administration observed that, under the conditions of the study, malignant tumors were not related to fluoride ingestion in rats or mice, but that a significant increase in the incidence of benign osteomas was observed in high-dose mice.

The Ad Hoc Subcommittee on Fluoride of the US Public Health Service characterized the combined results of these two animal studies as follows (15):

> When the NTP and the Procter & Gamble studies are combined, there is a total of eight individual sex/species

groups examined. Seven of these groups showed no significant evidence of malignant tumor formation. One of these groups, male rats from the NTP study, showed "equivocal" evidence of carcinogenicity, which is defined by NTP as a marginal increase in neoplasms — i.e., osteosarcomas — that may be chemically related. Taken together, the two animal studies available at this time fail to establish an association between fluoride and cancer.

In view of the NTP findings, the National Cancer Institute in 1990 conducted a study of cancer incidence in fluoridated and fluoride-deficient US communities (see Ref. 15 for a full description). Cancer incidence rates between 1973 and 1987 were evaluated in whites in Iowa and the Seattle metropolitan area. A county was considered exposed to fluoride if the proportion of the population served by fluoridated water increased from less than 10 percent to greater than 60 percent within a three-year period. Control counties had less than 10 percent of the population served by adjusted or naturally fluoridated water through 1987. Expected numbers of cancer cases were derived from the rates in nonexposed counties and the measure of risk was the ratio of observed to expected cases. For none of the cancers surveyed, including osteosarcoma, could a consistent link between cancer incidence and water fluoridation be established (15).

In a separate case control study involving 22 matched pair cases of osteosarcoma and controls from Iowa and Nebraska, McGuire et al. did not find the development of osteosarcoma to be associated with fluoridated water exposure (88). Although the investigators emphasized that the sample size of their study was small, they detected a negative relationship between fluoridation and osteosarcoma, suggesting that water fluoridation at recommended levels might have a protective, or antimutagenic, effect. The investigators indicated that they are currently investigating this hypothesis in a larger, nationwide study.

Dental Fluorosis. Dental fluorosis is a developmental defect of enamel that occurs when an excessive amount of fluoride is ingested during the period of enamel formation. The severity of the defect depends upon the amount of fluoride ingested, the duration of exposure, and the age(s) when exposure occurs. In humans, the defect consists of subsurface hypomineralization—that is, an increase in the porosity of subsurface enamel (89). The structural arrangement of the enamel crystals appears normal, but the width of the intercrystalline spaces is increased. Clinically, the enamel appears opaque or matte white, in contrast to the glossy translucence of normal enamel. In animals exposed to very high doses of fluoride, hypoplastic enamel lesions, seen clinically as surface malformations or pitting, can also occur (90). In humans, the pitting present in severe cases of dental fluorosis is the result of posteruptive breakdown of porous surface enamel (89,91-94). However, Richards believes that, with extremely high doses of fluoride during enamel development, preeruptive pitting might also occur (90). Posteruptive staining of the white areas also occurs in severely affected enamel (94).

TABLE 8
Dean's Dental Fluorosis Classification (5,95)

Classification	Dental Fluorosis Score	Description of Enamel
Normal	0	Smooth, glossy, pale creamy-white translucent surface
Questionable	0.5	A few white flecks or white spots
Very mild	1	Small opaque, paper-white areas covering <25% of tooth surface
Mild	2	White opaque areas covering <50% of tooth surface
Moderate	3	All tooth surfaces affected; brown stain; marked wear on biting surfaces
Severe	4	All tooth surfaces affected; brown stain; discrete or confluent pitting

Historically, the term "mottled enamel" has been used as a designation for enamel fluorosis. Its use is unfortunate, since "mottled" means colored spots or blotches, and it inaccurately indicates that all affected teeth have unesthetic blemishes. Actually, the degree of fluorosis runs a continuum from barely noticeable white striations that may affect a small portion of the enamel to confluent pitting and unesthetic dark brown or black staining that affects almost the entire enamel surface (95). Early researchers who examined children exhibiting the milder forms of fluorosis felt that the teeth were cosmetically more attractive than teeth that developed in areas with fluoride-deficient water. In fact, in 1970, McClure commented, "there is a consensus that an optimum quantity of fluoride may actually enhance the appearance of the teeth" (3). Because "mottled enamel" inaccurately describes the less severe forms of the condition and gives the erroneous impression that all affected teeth are cosmetically compromised, its use should be discontinued in favor of dental fluorosis or enamel fluorosis.

Dean developed a dental fluorosis classification that categorized the condition according to its severity (Table 8) (96,97). With Dean's method, an individual fluorosis score or a community fluorosis index (CFI) could be obtained. The fluorosis classification of an individ was based on the two most affected teeth. If the two teeth were not equally affected, the classification was determined by the lesser involved tooth. The CFI was calculated from the mean of the individual scores within a

TABLE 9
Public Health Significance of Community Fluorosis Index, According to Dean (95)

Community Fluorosis Index Range	Public Health Significance
0.0–0.4	Negative
0.4–0.6	Borderline
0.6–1.0	Slight
1.0–2.0	Medium
2.0–3.0	Marked
3.0–4.0	Very marked

$$F_d = \frac{\Sigma(\text{frequency} \times \text{individual fluorosis score})}{\text{number of individuals}}$$

When the CFI reached 0.6, Dean believed it warranted consideration as a public health concern (Table 9).

Since Dean's classification system was published, other fluorosis indices have been developed, including ones by Moller (3,98), Thylstrup and Fejerskov (93), and the NIDR (tooth surface index of fluorosis) (TSIF) (99). These have been reviewed by Horowitz (95), who, along with others (100–102), has emphasized the problem of distinguishing dental fluorosis from nonfluoride enamel defects. Enamel opacities can be classified into three categories: fluoride-induced opacities, i.e., dental fluorosis; nonfluoride-induced opacities of known etiology; and idiopathic opacities (101). Some believe that the clinical appearance and the distribution of the enamel defects can enable experienced examiners to correctly identify dental fluorosis from other conditions (15,95,102). However, others believe that a positive clinical diagnosis can be supported only by an adequate history of exposure to fluoride. Cuttress and Suckling, who developed a flowchart for the differential diagnosis of dental fluorosis, indicated that only when the condition is encountered in an endemic fluorosis area where above-optimal water fluoride conditions prevail, can a diagnosis of dental fluorosis be made confidently, without recourse to an individual's medical/dental history or laboratory analysis of enamel, hair, nails, or urine (101). Confidence in the diagnosis of fluorosis increases as the prevalence and severity of the defects increase. Diagnostic uncertainty increases with lower prevalence and severity, which is generally the situation in the United States (101).

Assessment of whether the prevalence or severity of enamel fluorosis in the United States has changed over time is based on three types of time-related comparisons: (1) a comparison of different cities with similar fluoride concentrations using the same fluorosis index but different examiners, (2) a comparison of the same cities using the same fluorosis index but different examiners, (3) a comparison of the same cities using the same fluorosis index and the same examiners. Studies concerned with these three types of assessments have been reviewed by the Ad Hoc Subcommittee on Fluoride of the US Public Health Service and the conclusions of the subcommittee will be presented here (15). In addition, Brunelle has reported the only national US survey of dental fluorosis, which was conducted in 1986–87 on schoolchildren (103).

TABLE 10
Percent Prevalence of Dental Fluorosis in 1939–40 and in 1976–82 Using Dean's Index (15)

Water Fluoride Concentration	Total # of Cities		% Fluorosis Prevalence (Mean)	
(ppm F)	1939–40	1976–82	1939–40	1976–82
<0.4	10	5	0.9	6.4
0.4–0.6	3	1	5.6	2.4
0.7–1.2	4	4	13.6	22.2
1.3–1.7	1	3	30.2	25.7
1.8–2.2	2	1	44.0	53.2
2.3–2.7	1	5	73.8	78.5
2.8–3.2	0	3	—	74.0
3.3–3.7	0	0	—	—
>3.7	0	2	—	83.4

Different Cities/Same Fluorosis Index/Different Examiners Comparisons. Comparisons were made between the prevalence and severity of fluorosis in 1939–40 in 21 US cities and the prevalence and severity in 1976–82 in 24 different cities (Table 10). Dean's index was used as the measure of fluorosis.

In cities with less than 0.4 ppm F, the mean prevalence of fluorosis increased from less than 1 percent to approximately 6 percent. Nearly all of the increase occurred in the very mild and mild categories. In cities with optimal water fluoridation (0.7–1.2 ppm F), the mean dental fluorosis prevalence increased from 14 to 22 percent, and the increase was limited almost entirely to the milder forms. Except for the 1.3–1.7 ppm F category, cities with above-optimal fluoride concentrations showed a slight increase in fluorosis prevalence, from 44 to 53 percent where the water fluoride concentration was 1.8–2.2 ppm, and from 74 to 79 percent in cities with 2.3–2.7 ppm F. If moderate dental fluorosis has increased since the 1940s, the increase most likely has occurred in communities with fluoride concentrations of 1.8–2.2 ppm F (15).

Same Cities/Same Fluorosis Index/Different Examiners Comparisons. During the 1980s, Driscoll et al. (104) surveyed children for fluorosis in Kewanee, IL (1.06 ppm F), and Kumar et al. (105) conducted a similar survey in Newburgh (1.0 ppm F) and Kingston, NY (0.3 ppm F). Both groups compared their results to historical data from the same communities, reported in 1942 and 1955, respectively (106,107). Dean's CFI was used as the index.

In 1980 Driscoll and coworkers found the CFI of Kewanee was 0.39 compared to 0.31 reported in 1942

(104). Approximately 85 percent of children were diagnosed as normal (no or questionable fluorosis) in 1942 and 1980. The investigators found eight out of 336 children (2.4%) with moderate or severe fluorosis compared with none with those classifications in the earlier survey; however, they could not ascertain the cause. Comparing Dean's findings of nearly half a century earlier to their own, Driscoll et al. concluded, "No important changes in the prevalence and severity of fluorosis had taken place between the two periods."

Kumar and coworkers reported that for seven- to 12-year-olds in optimally fluoridated Newburgh, the CFI scores were 0.14–0.21 in 1986, compared to 0.11–0.18 in 1955 (105). For fluoride-deficient Kingston, the CFI was 0.00 in 1955 and 0.13–0.23 in 1986. The investigators concluded that for the fluoridated community, over the three-decade span, "the differences over time were negligible" and "no change of consequence" had occurred. There was an increase in the prevalence of fluorosis in fluoride-deficient Kingston, principally in the very mild and mild categories, to approximately the same level as fluoridated Newburgh. While the CFI was well below 0.6, the level Dean felt might prompt public health concern, the findings indicated "the availability of fluorides in nonfluoridated areas."

Same Cities/Same Fluorosis Index/Same Examiners Comparisons. Heifetz and coworkers examined eight- to 10-year-old and 13- to 15-year-old children in four Illinois communities with optimal and two, three, or four times the optimal levels of fluoride (108). The examinations were conducted in 1980 and repeated in 1985. The TSIF index was used. The study was cross-sectional, except for the eight- to 10-year-olds in 1980 who were available as 13- to 15-year-olds for the second examination.

There was little difference in the distribution of TSIF scores between 1980 and 1985 for all tooth surfaces of eight- to 10-year-olds, at all fluoride levels. In contrast, in 1985, there was a greater prevalence and severity of fluorosis for the 13- to 15-year-olds, at every fluoride level, compared with 1980. However, the most severe categories of fluorosis were not detected at either survey, and the fluorosis that occurred at the optimum fluoride level was characterized as "only whitish discolorations" (108).

From their data, Heifetz et al. hypothesized about the changes in fluoride ingestion that may have occurred during the lifespan of the children in their study (108). A similar analysis was conducted by the Ad Hoc Subcommittee on Fluoride (15). The following represents the combined conclusions from these independent analyses:

(1) Fluoride ingestion was lowest from 1965–70.

(2) Fluoride ingestion began to increase in the early 1970s.

(3) There was little or no additional change in fluoride intake between 1970–77.

(4) Fluoride ingestion continued to remain about constant through 1982.

TABLE 11
Comparison by Geographic Region of Percentage of Population Receiving Fluoridated Water with Mean DMFS Scores of Schoolchildren and Mean CFI Scores (18,103)

Region	% of Pop. Receiving Adjusted or Naturally Fluoridated Water (1988)	Mean DMFS Schoolchildren (1986–87)	Mean CFI (1986–87)
III (Midwest)	72.2 (1) [1]	2.91 (3) [1]	0.53 (2) [1]
I (N. England)	66.2 (2) [2]	3.60 (7) [5]	0.38 (5) [3]
IV (Southeast)	57.5 (3) [3]	3.08 (4) [2]	0.44 (3) [2]
V (Southwest)	57.4 (4)	2.39 (1)	0.72 (1)
II (Northeast)	48.1 (5) [4]	3.43 (6) [4]	0.36 (6) [4]
VI (N.west)	35.9 (6)	2.75 (2)	0.40 (4)
VII (Pacific)	17.8 (7) [5]	3.37 (5) [3]	0.27 (7) [5]

( )=rank: the left and right columns are ranked from greatest to least in keeping with the positive relationship expected between the status of community fluoridation and the community fluorosis index. The middle column is ranked from least to greatest in keeping with the negative relationship expected between the status of community fluoridation and caries prevalence.
[ ]=same, but omitting Regions V and VI.

The last conclusion, however, is surprising, since the late 1970s saw a reduction in the American Academy of Pediatric's supplemental fluoride schedule for children to age two, as well as a voluntary reduction in the fluoride content of baby formulas and foods to approximately 0.1 ppm F. Perhaps the consequences of these changes will become more apparent with time.

National Fluorosis Survey. In the first national survey of dental fluorosis among US schoolchildren, conducted in 1986–87, 78 percent were found to be normal (no or questionable fluorosis), 21 percent had very mild or mild fluorosis, 1 percent had moderate fluorosis, and 0.3 percent had severe fluorosis (103). (Refer to Table 8 for a description of Dean's fluorosis categories.) The highest prevalence of fluorosis, as well as the highest percentage of children with moderate or severe fluorosis, was found in Region V (Southwest), where natural fluoride concentrations are known to be above optimum in many communities.

Table 11 presents figures by geographic region for the percentage of the population with adjusted or naturally fluoridated water, the mean DMFS of schoolchildren in 1986–87, and the mean CFI from the same survey. Conventional wisdom dictates that there should be a direct positive relationship between the percentage of the regional populations receiving fluoridated water and the CFIs of the regions and a *negative* relationship between the percentage of the regional populations receiving flu-

oridated water and the mean caries prevalences of the regions. Notice that there is not an exact rank-order relationship between the percentage of the population consuming fluoridated water and either the mean caries scores or the mean CFI scores. One probable reason for the lack of a straightforward relationship is the consumption of water containing above-optimal natural concentrations of fluoride that tends to lower caries prevalence and to raise the CFI. Large percentages of the populations in Regions V and VI reside in communities with above-optimal fluoride levels. When Regions V and VI are omitted from consideration, thus reducing the confounding variable of naturally occurring high fluoride levels, the rank-order of the columns falls into closer agreement.

The analysis presented in Table 11 is only observational, and it is subject to the same limitations already discussed for Table 5, namely that regional fluoridation data are being linked with caries and fluorosis observations of individuals. Nevertheless, considering the ambient fluoride in the environment, the relationships presented in Table 11 are surprisingly strong. This suggests that, despite the many other sources of fluoride available, community water fluoridation still exerts a major influence on both caries and fluorosis and it is probably not surprising that, concomitantly, there has been a decrease in the prevalence of the former and an increase in the prevalence of the latter. Any explanation of these phenomena in the US must include the complex role of water-borne fluoride.

Nonwater sources of fluoride that can increase fluorosis risk include dietary fluoride supplements, the ingestion of fluoride toothpaste by preschool children, and the inadvertent ingestion of other topical fluorides. Fluoride dentifrices are the most ubiquitous of the topical fluoride methods and their use has been closely examined as a possible contributing factor to the fluorosis increase. Generally, preschool children will swallow some dentifrice when brushing(109), and although children's ages when dentifrice use began (110) and the amount of dentifrice used (111) have been identified as fluorosis risk factors, clinical studies so far have failed to confirm dentifrice ingestion as a primary cause for the increased prevalence of fluorosis (51). Conversely, the improper prescription and use of fluoride supplements has been identified as a major risk factor, indicating the need for close scrutiny of the prescriptive practices of physicians and dentists. Even proper fluoride supplement use may constitute a fluorosis risk factor in some children when other uncontrolled sources of ingested fluoride are considered (109,112,113). Further discussion of the relationship between dental fluorosis and these other fluoride modalities falls outside the scope of a review on water fluoridation and readers are referred elsewhere (15,51,114,115).

TABLE 12
Recommended Optimal Fluoride Levels According to Air Temperatures (4)

Annual Average of Max. Daily Air Temps. (°F)	Recommended Fluoride Concentration (ppm)	Recommended Control Range (ppm)
40.0–53.7	1.2	1.1–1.7
53.8–58.3	1.1	1.0–1.6
58.4–63.8	1.0	0.9–1.5
63.9–70.6	0.9	0.8–1.4
70.7–79.2	0.8	0.7–1.3
79.3–90.5	0.7	0.6–1.2

Technical and Cost Aspects

Liquid consumption is affected by the local ambient temperature and, therefore, the amount of fluoride ingested daily from fluids is influenced by climate (116,117). In 1962, the US Public Health Service established limits for optimal levels of fluoride in drinking water for the North American climate zones (3). The concentration standards, which were revised in 1982, range from 0.7 to 1.2 ppm F and are presented in Table 12 (4).

Three factors complicate the relationship between an assumed presence of a specific concentration of fluoride in the drinking water and caries protection: namely, variation in the municipal water fluoride concentration (118), the consumption of beverages or of water other than from the municipal water supply (118), and variable compliance with the accepted water fluoridation standards (119).

The use of home water purification systems, either reverse osmosis or distillation types, can reduce the concentration of fluoride in piped water sources to below optimal levels. Bottled water also has become a popular substitute for tap water. The amount of fluoride in bottled water varies and may result in individuals consuming too little or too much fluoride for their climate zone. Flaitz and coworkers reviewed the health histories of 1,126 children in a private pediatric dentistry practice in order to determine the prevalence of bottled water usage as a primary source of drinking water (118). The investigators asked the brands of bottled water used and determined the amount of fluoride they contained at that time. Of the 1,126 children, 1,070 (95%) lived in homes served by municipal water sources; the other 5 percent used well water. One hundred twenty-four children (11.0%) did not use their available drinking water source. Of these, 105 used bottled water and the other 19 had home water purification systems. Depending on the brand, the bottled water contained from 0.04 to 1.4 ppm F. The investigators concluded that of the 105 children using bottled

water as their primary water source, 17 percent were receiving less than the recommended daily amount of fluoride, 72 percent were receiving more and 11 percent were receiving the correct amount. In this study, the bottled water came from nine different bottled water companies, six of which were located in Colorado. However, in another study of the fluoride content of 24 brands of bottled water from the US and abroad, 18 (75.0%) had fluoride concentrations of 0.34 ppm or less, two (8.3%) had a fluoride concentration of 0.55 ppm, and four (16.6%) had fluoride concentrations from 0.70 to 1.25 ppm (112).

Several studies have reported discrepancies between the intended and actual concentrations of fluoride in fluoridated water supplies (24,120-125). The state of Illinois enacted mandatory fluoridation legislation in 1967. Kuthy and coworkers reviewed monthly laboratory slips from 249 fluoridated public water systems in Illinois for a five-year period from 1977–81 (24). Compliance was not consistent. Municipalities with large populations and water plants with low chief operator turnover more consistently maintained the recommended fluoride level. Other characteristics that influenced compliance rates were the source of the water supply and the classification of the water plant operators. Thus, even though a community practices water fluoridation, the addition of optimal amounts of fluoride cannot be assumed.

The Centers for Disease Control reported that in 1988 there were nearly 9,000 municipal water systems with the fluoride concentration adjusted to an optimal amount (4), serving approximately 123,900,000 Americans. The three principal types of fluoridation distribution systems used in the US are the saturator, the dry-feeder, and the acid-feeder systems. The Indian Health Service uses another type, the Venturi fluoridator system, in some small rural communities. Descriptions of these systems have been published (126).

The three principal compounds used for fluoridation in the US are hydrofluosilicic acid, sodium silicofluoride, and sodium fluoride (4). The fluoride compound used as the fluoride source and the distribution system must be compatible. A saturator system is used with granular sodium fluoride, a dry-feeder system with sodium silicofluoride or sodium fluoride, and a solution-feeder with hydrofluosilicic acid (126).

Sodium fluoride was the first compound used in controlled fluoridation programs. Because of its low cost, sodium silicofluoride replaced sodium fluoride as the most frequently used compound for fluoridation. Within the last 20 years, hydrofluosilicic acid has become the preferred compound in the US. In 1975, hydrofluosilicic acid was used by 37.4 percent of the fluoridating municipalities (5). In 1989, it accounted for 57.3 percent (Table 13) (4). Several factors are responsible for the increased preference for hydrofluosilicic acid, including its low cost and relative ease in handling (5).

TABLE 13
Major Compounds Used for Community Water Fluoridation (1989) (4)

	Pop. Served		Systems	
Compound	#	%	#	%
Hydrofluorosilicic acid	75,295,924	62	5,187	57
Sodium silicofluoride	35,050,494	29	1,432	16
Sodium fluoride	11,474,400	9	2,431	27
Total	122,526,226	100	9,050	99

The chemical used was not indicated for all systems reporting, so data are incomplete.

Recent publications have addressed the economics of communal water fluoridation. Murray estimated the annual cost per person of fluoridation in 1981 for Hong Kong, Watford, England, and a series of US cities (126). He believed that assessments of fluoridation costs made by the US Public Health Service were inflated because of failure to amortize the costs of fluoridation equipment over a 10–15-year period. The costs of caries-preventive programs, including water fluoridation, were discussed at symposia held at the University of Michigan in 1978 and 1989 (127,128). Also in 1989, White and coworkers addressed issues associated with cost–benefit and cost-effectiveness analyses of communal water fluoridation (129).

The cost of communal water fluoridation is usually expressed as the annual cost per capita of the total population being served. Costs include amortization of initial capital expenditures and the annual operating costs for supplies, maintenance, and salaries. Costs vary according to a plant's capacity, the type of installation and fluoride compound, the number of injection points, and the existing natural fluoride concentration. Internationally, costs obviously will vary depending on the nature of the local economy in which fluoridation is introduced. However, a universal economic tenet for water fluoridation is that cost varies inversely with the size of the population being served.

In 1978, Newbrun estimated that the approximate annual cost of water fluoridation programs was $0.20 per capita in the US (127). He estimated that, after fluoridation had been operating for 12 years, a maximum annual savings in dental treatment expenditure would be $10.00 per capita, so that the approximate cost–benefit ratio for water fluoridation would be 1:50.

In 1989, Garcia reported that direct annual costs c fluoridation in the US ranged from $0.12–$1.31 per person with a mean of $0.54 (128). She presented costs based upon capitalization of existing equipment and on equipment replacement costs. Based upon the capital cost of

existing equipment, she reported that the annual cost per person to fluoridate communities with populations of 2,000 or less was $0.77–$1.16; for communities between 2,800–20,000 it was $0.21–$0.95; and for communities with populations over 100,000 the cost was $0.12–$0.21.

The cost data on fluoridation collected by Garcia were reanalyzed separately by each of the five work groups at the Michigan Workshop (130). The results of the reanalysis are collectively summarized as follows:

Community Size	Range of Costs (per person/yr)
>200,000	$0.12–0.21
10,000–200,000	$0.18–0.75
<10,000	$0.60–5.41

The costs are in 1988 dollars using a 4 percent discount rate, and the range considers high and low estimates of assumptions on labor, capital, number of injection points, fluoride compound, and use of weighted and unweighted averages. The greatest variability was shown in the smallest cities because of their sensitivity to changes in the variables that comprise the analysis.

White et al. reviewed eight published reports that compared the cost of fluoridation with its benefit or effectiveness (129). The cost–benefit analyses all used treatment savings, expressed in dollars, as the measure of fluoridation success. The cost-effectiveness analyses used caries prevented or surfaces saved as the measure of effectiveness. In these studies, which were published between 1973 and 1987, the cost–benefit ratio varied from 1:2.5 to 1:11.5, and the cost was given as between $0.20–$1.22 per surface saved. They stated that the effectiveness of water fluoridation is influenced by at least three variables: (1) the baseline caries rate and change in disease pattern over time, (2) the mobility of the population of the community, and (3) the number of people at risk for caries. White et al. believed that, of the three, the most important is the disease fluctuation over time, which was not duly considered in other published analyses. They concluded that "water fluoridation is one of the most cost-effective preventive dental programs and, indeed, may be one of the most cost-effective preventive programs in health care."

Alternatives to Community Water Fluoridation

The principal requirement for communal water fluoridation is a centralized piped water system (126). As of 1988, 12.2 percent of the US population, approximately 30 million people, used private wells or other sources, rather than a municipal water supply (4). For these individuals, alternative sources of fluoride are recommended.

In the US, in lieu of communal water fluoridation, other community-based methods of supplying systemic fluoride to children are the fluoridation of an individual school's water supply and the establishment of a school-based fluoride supplement program. Also used in the US, as well as other countries, are school-based fluoride mouthrinsing programs that provide topical fluoride contact to the teeth.

Fluoridated salt has been sold in Switzerland since 1955 (131) and recently has been introduced into other countries, including France, Mexico, Jamaica, Colombia, and Costa Rica (17). This method is believed to be as effective as communal water fluoridation, provided the daily intake of fluoride, measured by urinary excretion levels, is similar (131). Fluoridated salt is useful in countries with a lack of centralized water supplies that make water fluoridation technically difficult and expensive. The addition of fluoride to salt is not indicated in the US because of its well-developed network of municipal water systems and because of the presence of naturally occurring optimal or higher levels of fluoride in many communities. Other considerations are the propriety of promoting salt ingestion with its known link to hypertension and the substantial variation in the ingestion of fluoride from salt.

Milk has also been used as a vehicle for fluoride and been proposed for use by children in areas where the water supply is fluoride deficient. However, studies of this particular method are limited (132,133).

School Water Fluoridation. School water fluoridation is well suited for rural areas where the schools are supplied by their own wells and especially where children in many grade levels from kindergarten through 12th grade may attend class in the same or adjacent buildings. Considering that the age group served may range from approximately five to 18 years, the teeth could receive both systemic and topical fluoride exposure.

In 1954 the first evaluation of school water fluoridation began in St. Thomas, US Virgin Islands (134). Since children have a limited exposure to their school's water, it was fluoridated at 2.3 ppm, slightly over three times the optimum indicated for the community. Other studies followed in Kentucky, Pennsylvania, and North Carolina (135–138). In Seagrove, NC, after 12 years of school water fluoridation adjusted to seven times the optimum for that locale (6.3 ppm F), students had 48 percent fewer DMF surfaces compared with children examined before the fluoridation program began (139). In 1976, after eight years of school water fluoridation at 6.3 ppm F, continuous participants in the seventh and eighth grades in Seagrove were examined for dental fluorosis of the canines, premolars, and second molars (138). These teeth were mineralizing at the time of the children's entrance into the program. Of 134 examined children, 11 had "questionable" fluorosis and the rest were classified as normal. Because the caries inhibition from adjusting to seven times the optimal fluoride level was only slightly greater than the caries inhibition from adjusting to 4.5 times optimal (137), the current recommendation is that the lower level, i.e., an adjustment to 4.5 times the optimal

fluoride concentration for the area, be used for school water fluoridation programs (140).

Despite the documented effectiveness of this method, it has not been widely implemented. At its height, only 500 schools with slightly more than 200,000 schoolchildren participated (17). As of 1989, the Centers for Disease Control reported that 122,458 schoolchildren in 351 schools were involved in school water fluoridation programs, predominantly in Kentucky, North Carolina, and Indiana (4). Consolidation of school districts and extension of municipal water supplies may have contributed largely to the reduction in the number of programs.

Fluoride Supplement Programs. When it is not feasible to adjust water fluoride concentrations to optimal levels in a community or to initiate school water fluoridation, the use of dietary fluoride supplements in schools has been considered. School-based fluoride supplement programs use daily a 2.2 mg NaF tablet, which provides 1.0 mg F. This dosage for school-aged children is based on current American Dental Association and American Academy of Pediatrics recommendations where the water is fluoride deficient (0.3 ppm F or less) (141).

As with school water fluoridation programs, children may have their first contact with school-based fluoride supplement programs in kindergarten. However, supplement programs can begin earlier at age three or four in Head Start or at birth in individual home programs. The younger the children are when introduced to fluoride supplements, the greater will be the systemic contact to the teeth. Nevertheless, home-based programs are notorious for their lack of long-term compliance, which is a marked disadvantage to this caries-preventive approach.

Results of clinical trials of fluoride supplements have been reviewed by Driscoll (142) and Mellberg and Ripa (143). An average DMFS reduction of approximately 32 percent can be expected. Because the tablets are chewed, swished, and swallowed, both systemic and topical benefits accrue to the teeth when the children enter the program at age five or six. In school-based fluoride tablet studies, teeth that erupted during the study (144) or late-erupting teeth (145) received the most benefit. For instance, DePaola and Lax reported that use of acidulated NaF tablets for two school years produced an overall caries reduction of 23 percent (144). However, the caries reduction for teeth that erupted during the study was 53 percent. Fluoride tablets were part of a comprehensive fluoride regimen provided to schoolchildren in Nelson County, Virginia (146). In addition to the dietary fluoride supplement, the children were provided with a fluoride dentifrice for home use and rinsed once a week in school with a 0.2 percent NaF rinse (900 ppm F). Utilizing a historical control, the investigators reported a 65 percent lower DMFS prevalence in six- to 17-year-olds who, depending upon their school grade, had participated continuously in the program from one to 11 years. Since the Nelson County study relied upon a historical control, the results also reflect the general decline in caries that has occurred in US schoolchildren. This circumstance, coupled with the multiple fluoride regimen that was used, makes it impossible to separate the effects specifically attributable to the fluoride tablets. On the other hand, trials of fluoride tablets in the US that used concurrent placebo controls were all conducted more than a decade ago, before the major decline in caries prevalence had been documented. Presumably, studies conducted today would produce a lower absolute difference in teeth or surfaces saved as a result of the fluoride tablet intervention.

Garcia has reviewed the costs of school-based fluoride supplement programs in terms of 1988 dollars. She reported a mean cost of $2.53 per child with a range of $0.85–$5.40 (128). Differences in cost result principally from whether the personnel involved with the program are salaried or volunteers.

Fluoride Mouthrinse Programs. Fluoride mouthrinsing is a widely used public health method. In the US, it is second only to communal water fluoridation. The exact number of American children participating in school-based fluoride mouthrinsing is not clear, and the figure has been reported as low as 2–4 million (147) and as high as 12 million (148). School programs in the United States usually use a 0.2 percent NaF solution (900 ppm F). Children most often rinse once a week under supervisi with 10 ml of solution for one minute. If kindergarten children participate, they rinse with 5 ml.

The results of fluoride mouthrinsing studies have been reviewed recently by Leverett (149) and Ripa (51). Both agree that studies of fluoride mouthrinsing have given consistently positive results, with few reporting caries inhibitions of less than 20 percent. Ripa found that for North American studies in which a mouthrinse concentration of 900–1,000 ppm F was used, DMFS reductions of 16 to 44 percent, with an average of 31 percent, were obtained in fluoride-deficient communities (51). Four studies have been conducted in fluoridated communities, of which three were positive (51). However, since the disease levels in fluoridated communities are usually lower than in fluoride-deficient ones, the number of surfaces saved per year from fluoride rinsing is less (150). Leverett discussed that while most fluoride mouthrinse studies yielded statistically significant caries inhibitions, those using a historical control design could be challenged because of the background decline in caries prevalence that was also occurring (149). He observed that even the more recent trials using appropriate control groups were reporting smaller differences in the caries incidence between the experimental and control groups. Leverett concluded that future fluoride mouthrinse p grams were unlikely to result in annual savings in DM increment greater than 0.4 surfaces, thus reducing th clinical importance of the result.

Ripa and coworkers found that participation in a

school-based fluoride mouthrinsing program produced a greater percentage caries reduction in smooth proximal surfaces than in either occlusal or buccolingual surfaces (151). After seven years of rinsing, DF proximal surfaces accounted for 5.8 percent of the total caries prevalence, compared with 10.1 percent in children examined before the program began. Although this result was based upon a historical comparison, it is consistent with the known action of fluoride in smooth tooth surface caries.

The cost of supplies to conduct a fluoride mouthrinsing program have been estimated to range from $0.69 to $1.22/child/year (in 1988 dollars) (128). The material costs vary depending upon how the rinse is dispensed. The least costly method uses pump bottles to dispense the appropriate volume of solution; the most expensive uses premixed individual packets. If volunteers supervise the program, its cost tends to be low. Paid personnel will obviously increase the total cost. In an evaluation of 11 different school-based fluoride mouthrinse programs, Garcia calculated the average cost to be $1.30/child/year (128).

In a recent prospective study, kindergarten and first grade students in Springfield, OH, were assigned to one of three groups: one group rinsed once a week in school with a 0.2 percent NaF solution, the second group chewed and swallowed daily in school a 2.2 mg NaF tablet (1.0 mg F), and the third group did both procedures (152). For ethical reasons, there was no placebo control group. Eight-year DMFS increments were 3.6, 2.8, and 2.4 for the rinse, tablet, and combined programs, respectively. Even though the combined regimen showed increased caries protection compared with the mouthrinse, the investigators felt that "the additional cost, time, and effort required to carry out the procedure would appear to outweigh the small savings in DMF surfaces." Therefore, they recommended that ongoing fluoride mouthrinse programs should not be replaced with programs employing both procedures.

Sociopolitical and Legal Issues

McClure subtitled his 1970 book on water fluoridation "The Search and the Victory" (3). Yet, in 1985, an article appeared in a prestigious nondental journal entitled, "America's Longest War: The Fight over Fluoridation, 1950–" (153). This article described the militant resistance to fluoridation that began in 1949–50 in Stevens Point, Wisconsin, and that continues to this day. In a survey of state dental directors conducted in 1984, the American Dental Association found that, during the five years prior to the survey, there had been 255 challenges to dental programs (154). Of these, 82 percent concerned fluoridation and 13 percent involved school fluoride mouthrinse programs. As a result of the challenges, 14 percent of the programs were delayed or curtailed and 36 percent were terminated. McClure's claim of victory was premature.

The expansion of fluoridation in the United States has slowed (7). Issued in 1980, one of the US Public Health Service's objectives was that within 10 years, at least 95 percent of the US population with community water systems should be serviced with optimally fluoridated water (8). That objective was not met. According to the Centers for Disease Control, by December 31, 1989, only 62.1 percent of Americans living in areas with public water systems were drinking fluoridated water (4). Part of the lack of success was a result of a change in how federal funds were allocated to the states. Allocation changed from categorical grants, under which money could be designated specifically for fluoridation, to block grants, under which fluoridation competes with other uses for the money (7). The year 2000 oral health objectives propose a 75 percent target that is less than the 95 percent originally proposed (9). Considering the higher level, Easley stated, "Without a major increase in emphasis among national, state, and local health policy makers, it is questionable whether the proposed year 2000 fluoridation objectives ... will be able to be met" (155). That admonition also applies to the current level.

It would be ideal if health issues were decided by health experts. For water fluoridation, this is rarely the case, as the issue has found its way into the political arena (17). Authorization to fluoridate a public water supply can be made by administrative decision, such as by city or county executives or councils, public utility boards, or public health boards; by a voter initiative; or by legislative action. State legislation providing for water fluoridation is of two types. It may be mandatory, in which communities of a certain size are required to fluoridate their public water supplies, or it may be permissive, or enabling, in which a local authority is empowered to institute fluoridation (126,156). Eight states, the District of Columbia, and Puerto Rico have mandatory laws requiring the fluoridation of public water supplies. Unsuccessful attempts for mandatory fluoridation legislation were made within the last decade by Hawaii and Pennsylvania (155). States with enabling fluoridation legislation include Alaska, Nevada, and Massachusetts (126). Massachusetts' statute empowers the State Commissioner of Public Health to recommend fluoride adjustment of the public water supply of any city, town, or district. The commissioner is required to notify the local boards of health, and the boards may, if they consider doing so in the best interest of the residents under their jurisdiction, order fluoridation of the public water supply (126).

With either a mandatory or enabling statute, the legislation may also allow or require that a vote or referendum be taken on the issue (126). Nevada, for instance, requires that any proposal for fluoridation must be submitted to the voters within the affected community. Unfortunately, referenda have proved to be the nemesis of fluoridation. Easley found that between 1980–89, 63 percent of 163 community fluoridation referenda failed to pass. Con-

versely, of 281 fluoridation initiatives in which only a governing body was involved, 78 percent were successful (155). Easley concluded that, in the absence of a state mandate, the most effective means to implement community water fluoridation is to "pursue promotion with the local legislative body and hope that a referendum does not ensue" (155).

The reasons for the public's rejection of a proven health benefit have presented a quandary for dentistry since the issue first emerged in Wisconsin (157-159). To explain this phenomenon, a World Health Organization publication lists three factors (126): *First*, ignorance and confusion on the part of the public about the dental health benefits of fluoridation. In the late 1960s it was believed that during a fluoridation campaign, people were confused by exposure to conflicting arguments. However, in a 1977 national survey conducted by the Gallup Organization, 49 percent of adults correctly answered that the purpose of fluoridation was to reduce tooth decay, and in a 1980 Massachusetts survey, 76 percent of respondents correctly believed that the purpose of fluoridation was to improve dental health (160). In Massachusetts this knowledgeable public opinion did not translate into voter acceptance, since, of 14 referenda held between 1980 and 1983, local Massachusetts voters rejected fluoridation in 11 of them, and the pooled results showed that only 39 percent of those voting favored fluoridation (160). While these findings do not refute the contention that people may be confused during a fluoridation campaign, they indicate that simply understanding the benefits of water fluoridation may not be sufficient to make people favor it.

Second, ambivalence of the public toward science with greater reservations about scientific findings that concern the human body. Yet, in a 1980 survey conducted in three California communities that had or were scheduled for fluoridation referenda, the majority of respondents did not hold opinions against drinking fluoridated water (161). Moreover, in a survey of mothers of preschool children from low socioeconomic areas of Scotland, the mothers held more positive attitudes toward vaccinations against caries than toward water fluoridation (162), which seemed to indicate that ambivalence toward science was not a major concern.

Third, misunderstanding of the scientific and technical information involved, enabling the opposition to distort the issues and frighten the public. Sapolsky (163) proposed what Hastreiter later termed the "confusion hypothesis" (164). During a fluoridation campaign, voters are exposed to conflicting arguments by individuals who claim to be experts, and the voters have difficulty identifying correct information, misinformation, or disinformation. As catalogued by Horowitz, not only do antifluoridationists assert that fluoridation is not effective against caries, but they also allege that fluoride promotes cancer, sickle cell anemia, kidney and heart diseases, birth defects, Alzheimer's Disease, and Acquir Immune Deficiency Syndrome (AIDS) (17). They al have portrayed fluoridation as a communist plot, a conspiracy of the sugar and aluminum industries, and an invasion of freedom of choice since it forces medication on people who may not want it (17). Armed with these many accusations, the antifluoridationists can easily generate a modicum of doubt in voters' minds, which often is sufficient to sway them against fluoridation. Conversely, fluoridation's supporters need to try to prove, without any question of a doubt, that fluoride is safe and effective in order to gain the vote. Simply put, raising doubt is easier than suppressing it.

A fourth factor, not listed by the World Health Organization, but which may assume importance, is the issue of controlling one's destiny. It is of interest that in the Scottish study cited above, Kay and Blinkhorn found that the mothers whom they interviewed preferred methods of preventing disease that were dictated by their desire to retain some control of the situation (162). This sentiment echoes the statement of the leader of a successful 1983 campaign to defluoridate Levittown, NY, who explained that a strong element of the antifluoridationists' argument was that, "We're skeptical of government—we want control over what our children consume" (153).

The antifluoridationists have also taken their bat against community water fluoridation to local, state, a federal courts. Litigation against fluoridation began ir the early 1950s in Northhampton, MA, and San Diego, CA. In both cases, the legality of fluoridation was upheld (165). Generally, the opponents of fluoridation contend that fluoride is biologically harmful and water fluoridation is an unreasonable exercise of police power, that fluoridation is a violation of religious freedom, that fluoridation violates constitutional guarantees of personal liberties and protection from harm to the public, and that fluoridation is a form of class legislation (see review by Block (165)). However, [illegible] legal challenge to fluoridation has been successful, no court of last resort has ever ruled against it (155). Block lists 13 fluoridation cases that reached the US Supreme Court between 1954 and 1984 (165). None was actually heard by the court. Either the case was dismissed for lack of a substantial federal question, or the court denied the *writ of certiorari* for which no reason need be given. Essentially, fluoridation has been upheld as a legitimate exercise of governmental authority.

The continued constitutional legitimacy of fluoridation upheld by US courts bodes favorably for the future of water fluoridation. There are other favorable signs, as well. Although the absolute number of fluoridation initiatives decreased during the 1980s, Easley's statist show a higher percentage of favorable outcomes during the second half of the decade (155). For the first half, 2 percent of fluoridation referenda were favorable compared with 52 percent in the second half; likewise, favor-

able outcomes for fluoridation initiatives instituted by legislative action increased from 74 percent in the first half of the decade to 86 percent in the second half.

A successful outcome for a fluoridation initiative requires careful planning (166,167). The success of a La-Crosse, WI, fluoridation referendum in 1988 was attributed to a well-conceived plan that included broad-based community support led by citizens for a better health committee; consultation and support from concerned professional organizations; knowledgeable scientific reporting by the press; the timing of the ballot to coincide with the Wisconsin presidential primary election in order to ensure a large voter turnout; and the support of some local chiropractors, who, as a group, traditionally have been fluoridation opponents (166). Even the 1985 vote against fluoridation in San Antonio cannot be considered a complete failure. The organization and planning of the fluoridation advocates were excellent and fluoridation was narrowly defeated by a margin of 42,323 to 39,050, compared with a 2 to 1 margin when San Antonians were offered the same choice 19 years earlier (168).

Recently, Martin has analyzed the fluoridation debate at a social, rather than a dental scientific level (169). He emphasizes that his analysis is not concerned with the scientific merits of fluoridation, but rather with the elements that have contributed to making fluoridation an issue of unresolved public debate. He considers the public argument on fluoridation an "exercise of power" involving proponents and opponents, organized dentistry, individual researchers and the research establishment, and certain elements of industry including the aluminum and fertilizer industries, the sugar-food industry, and over-the-counter dental products manufacturers. Martin's book is unique, since it attempts to avoid the "rightness" or "wrongness" issue in favor of how scientific knowledge is used and shaped in the course of what he calls a bitter public debate.

Conclusions

Community water fluoridation is one of the most successful public health disease prevention programs ever initiated. It has the potential to benefit all age groups and all socioeconomic strata, including the lowest, which has the highest caries prevalence and is least able to afford preventive and restorative services. Community water fluoridation is also the most cost-effective of all community-based caries preventive methods (128).

Early water fluoridation studies produced caries reductions of approximately 40 to 60 percent for the permanent dentition, and slightly lower reductions for deciduous teeth (10). Recent studies have found a smaller difference in the caries prevalence between optimally fluoridated and fluoride-deficient communities (11). This change is believed to be due to the availability, beginning in the early 1950s, of a variety of fluoride products, including professionally applied gels and solutions, dentifrices, mouthrinses, and systemic supplements. Use of these products reduces the caries prevalence in both optimally fluoridated and fluoride-deficient communities and, therefore, decreases the magnitude of the caries difference between the two. The presence of fluoride in beverages and foods that are processed in fluoridated communities but transported to, and consumed in, fluoride-deficient ones further acts to blur the distinction in caries activity between fluoridated and fluoride-deficient communities.

Corbin has written that it is "virtually impossible to find 'nonfluoride' communities due to the many opportunities for alternative exposures to fluoride" (170). Communities in the United States still may be classified as being optimally fluoridated or fluoride-deficient based upon the concentration of fluoride in the drinking water. However, because fluoride is ubiquitous in food and dental health products, practically no American today is unexposed to fluoride. Therefore, to designate a US community as strictly fluoridated or fluoride-deficient may now be a spurious distinction and, in the future, should no longer be emphasized. Rather, the emphasis should be directed to the geographic and socioeconomic differences in caries prevalence in the United States. While it is desirable that initiatives continue to increase the number of Americans drinking optimally fluoridated water, the underlying goal should be to attain a *uniformly low* caries level for all geographic regions of the country and for all socioeconomic strata.

Along with analyses of the benefits of any health procedure should be studies of coincident risks that might be reasonable to expect. Because fluoride is primarily deposited in the bones and teeth or excreted in the urine, the effects on the body's hard tissues and kidneys have been especially well studied. In addition, fluoride risk assessment has also considered the relationship between fluoride in the drinking water and cancer.

At the time optimal fluoridation was introduced, it was known to result in about 10 percent of the population developing very mild fluorosis (5). In the 1940s and 1950s, this risk was considered acceptable, considering the substantial caries preventive benefits both in absolute and percentage terms. However, reports published in the 1980s found an increase in the prevalence of fluorosis in fluoride-deficient communities and, to a lesser extent, in fluoridated ones. This increase is principally in the milder forms of fluorosis, which was considered by some early investigators to enhance the appearance of the teeth rather than to be cosmetically detracting. Nevertheless, the increase in the prevalence of fluorosis is *prima facie* evidence that increased fluoride ingestion has occurred among young children. It has not been determined whether the observed increase in fluorosis is a necessary tradeoff for the reductions in caries prevalence that have been achieved or whether the same reductions could have occurred without the increase in fluorosis.

Leverett presented a graph comparing recent caries and fluorosis levels with water fluoride concentrations (171). When similar comparisons were first done some 40 to 50 years ago, using the data available then, the caries and fluorosis curves intersected at a water fluoride concentration of 1.2 ppm. The curves prepared by Leverett intersected at 0.8 ppm, a difference of 33 percent. Leverett attributed this difference to the increased ingestion of fluoride that has occurred as a result of fluoride becoming more ubiquitous in the environment than it was a half century ago. Prudence dictates that inadvertent and unnecessary fluoride ingestion should be avoided. This requires that dentists be aware of the indications and proper techniques for professional topical fluoride treatments; that consumer products, such as fluoride dentifrices and mouthrinses, be labeled regarding their proper use, especially for preschool-aged children; and that physicians, dentists, and pharmacists know when dietary fluoride supplements are indicated and what the recommended dosage is. In addition, further research is indicated to understand better the complexities of fluoride ingestion from multiple sources, especially from water and other beverages, dietary supplements and dentifrices, and their roles in fluorosis etiology and risk.

~~The effects of fluoride on bone need further clarification from epidemiologic and other studies.~~ The problem is twofold. First, ~~fluoride may behave differently in different types of bone.~~ It appears to ~~increase the density of~~ trabecular bone, ~~such as the vertebrae~~, and decrease ~~the density of cortical bone,~~ such ~~as the hip and long bones~~. Second, it should be determined if the overall effects on the bones provide a health benefit or pose a health threat. Although fluoride may increase the bone mass of the vertebrae, there is not strong evidence of a concomitant reduction in the incidence of vertebral fracture or an alleviation of the clinical symptoms of osteoporosis. Likewise, the evidence of a relationship between drinking fluoridated water and the incidence of bone fracture is not clear, with different studies reporting more, less, or the same incidence of bone fractures in communities with naturally high, or adjusted, levels of fluoride in the drinking water compared with fluoride-deficient communities (15,61-67).

No untoward effects on the kidneys result from drinking water containing optimal levels of fluoride. Even when high concentrations of fluoride, as much as 30 ppm, were inadvertently added to the drinking water, healthy individuals did not suffer harmful kidney effects (72). Medically compromised patients undergoing hemodialysis require the use of water with a low concentration of fluoride as well as a low concentration of other ions.

The relationship between water fluoridation and cancer is especially important because of people's fear of cancer and because antifluoridationists' tactics capitalize on that fear in an effort to defeat fluoridation. The cancer/fluoride issue was exacerbated in 1989–90 by the release of the results of the National Toxicology Program's study of sodium fluoride in laboratory animals. An independent peer review panel concluded that there was "equivocal" evidence of carcinogenicity from sodium fluoride in male rats, based upon the findings of a small number of osteosarcomas in the NTP study. The panel found no evidence of carcinogenicity in female rats or in male or female mice (15). Another study, commissioned by the Procter & Gamble Company, failed to find an association between malignant tumors and sodium fluoride ingestion by mice and rats of either sex (15). The Ad Hoc Subcommittee on Fluoride of the US Public Health Service concluded that when the results of these two animal studies were considered together, they failed to establish an association between fluoride and cancer (15). Properly conducted epidemiologic studies also have failed to find a correlation between fluoride in the water supply and cancer. Every review of this evidence by expert committees has found naturally or adjusted levels of fluoride in drinking water not to be associated with cancer in humans.

Because water fluoridation provides proven dental benefits with minimal risks, the frequent success of antifluoridationists in preventing fluoridation or removing it from communities in which it had been established is perplexing. Reasons that have been proposed to explain the antifluoridationists' success were listed in the section "Sociopolitical and Legal Issues." The arguments of the antifluoridationists, which are designed to create doubts, are easier to advance than ones that must instill confidence in fluoridation. Nevertheless, the antifluoridationists' campaigns are usually well organized and often enlist the support of community leaders, politicians, and the media, and they have been successful in creating an aura of controversy where no scientific controversy exists.

The dental public health community's success rate in accomplishing the fluoridation of municipal water supplies must increase. Well-planned profluoridation campaigns have been successful (166,167), and the elements of these campaigns should be studied carefully. Considering the graying of the American population, the benefits of fluoridation for adults must be more fully documented and publicized. More research on the effects of fluoridation on bone is needed and, if the findings are positive, will support claims of general health benefits in addition to dental benefits. Finally, it must be made clear that water fluoridation is a near-ideal public health measure whose benefits can transcend all racial, ethnic, socioeconomic, and regional differences.

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The Fluoridation War: a Scientific Dispute or a Religious Argument?

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Abstract

Communal water fluoridation is not considered controversial by the vast majority of the scientific community; however, politically it has persisted as an issue that many legislators and community leaders have avoided because of an aura of dispute. it has been a battleground for vigorous opposition by a very small but outspoken minority who have fought it with the dedication of religious zealots. This paper reviews the nature of the opposition, who they are, the broad thrust of their arguments, some of the specific issues they have raised, and their techniques. [J Public Health Dent 1996;56(5):246-52]

Key Words: AIDS, antifluoridationists, cancer, courts, dental caries, effectiveness, community water fluoridation, safety.

When I was invited to participate in this symposium celebrating the 50th anniversary of controlled communal water fluoridation at Grand Rapids, Michigan, I was asked to discuss the opposition to this measure. Fortunately, I was given carte blanche on how to address this topic and I confess the title is of my own choosing. Professor Donald McNeil has referred to "the fight for fluoridation" and described it as "America's longest war" (1). He went on to state that "a few things remain constant in America—death, taxes, baseball, and since 1950, widespread, often successful efforts by a passionate minority to keep fluoride out of public drinking water" (1).

Health professionals and biomedical researchers see water fluoridation as a scientific issue, and almost all agree that questions about its efficacy and safety were more than adequately settled long ago. Opponents, however, object to fluoridation on philosophical principles concerning the rights of individuals to freedom of choice on health matters. With the exception of some Christian Scientists, few oppose it on strictly religious grounds, but many of those opposed to fluoridation are willing to fight with the dedication of religious zealots—hence the title of my lecture. In this review I will examine the nature of the opposition, who they are, the broad thrust of their arguments, some of the specific issues they have raised, and their techniques.

The Antifluoridationists

When Trendley Dean, Philip Jay, and John Knutson met with the mayor of Grand Rapids 50 years ago to gain his approval for a water fluoridation experiment, no opposition existed to becloud the issue (2). However, complaints of ill effects due to water fluoridation were reported shortly after January 1, 1945, the official starting date. These complaints included: "Since they've been adding fluoride in our drinking water I have been gaining weight rapidly," and "Bathing in fluoridated water is causing a rash all over my body." Owing to delays in delivery of the equipment, fluoridation did not actually start in Grand Rapids until January 25, yet the complaints preceded the implementation of water fluoridation! Initially the complaints came from isolated individuals, but eventually there grew to be an organized network of hard-core opposition to this public health measure, not only at a local level, but at national and international levels. This opposition is not altogether surprising from a historical perspective, as there was opposition in the 1920s to pasteurization of milk and immunization of children against diphtheria and smallpox. Similarly, at the turn of the last century there existed fierce opposition to chlorination of the drinking water. More recently, gene splicing and organ transplantation have encountered some hostility. In all of these cases, the opposition perceives these procedures not as advances in public health and preventive medicine, but rather as "tampering with nature" and as forced medication.

At a national level, the antifluoridationists include the National Health Federation, the Center for Health Action, Citizens for Health, and the Safe Water Association. Their activities are detailed elsewhere (3,4). The *National Fluoridation News* was published quarterly "in the interest of all organizations and individuals concerned with keeping our drinking water free of chemicals not needed for purification" and was illustrated with clever cartoons ridiculing academia, the health establishment, government, and industry for their endorsement of fluoridation. In addition, local "pure water" associations have been organized to prevent fluoridation, their name itself being something of a misnomer as there are over 40 different chemicals, apart from fluoride, that are commonly used in water treatment plants to make water potable (5).

It is important to distinguish people who have voted against this measure in referenda but have not been active opponents from those in the much smaller but extremely vociferous group who are the real "antifluoridationists." According to most opinion surveys conducted between 1952 and 1977, the antifluoridationists constituted about 10 to 20 percent of the US population (6). In a more recent survey of parents' attitude toward fluoridated

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drinking water, 10 percent disapproved, 78 percent approved and 12 percent did not know or refused to answer (7) (Figure 1). Disapproval ranged from 4 percent in communities that were already fluoridated to 16 percent in communities that were not.

The opponents of fluoridation are a heterogeneous lot and cannot be described easily. They come in many guises, including some, but certainly not all, of the following: right-wing extremists, misguided environmentalists ("Greens"), chiropractors, elderly persons concerned about the costs of fluoridation, food faddists, and anti-science "naturalists." Other species have emerged, including the self-proclaimed "neutral" who tries to portray an image of dispassionate open-mindedness, but clearly has accepted the opposition's arguments irrespective of whether they have been adequately tested and answered (8-10). Another is the "born-again antifluoridationist" who previously accepted the mainstream belief in the benefits of fluoridation, but has experienced an epiphany so that the scales have fallen from his eyes and he has seen the light (11-13).

FIGURE 1
Attitude Toward Fluoridation of Drinking Water
[Survey of 1,200 parents by Gallup Organization, December 1991 (7)]

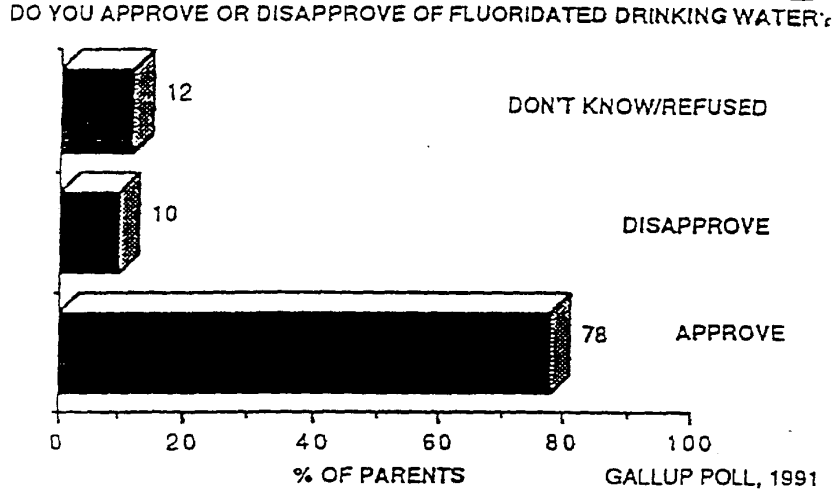

TABLE 1
Chronology of Antifluoridation Propaganda

Period	Antifluoridation Propaganda
1950s	Communist plot
1960s	Environmental concerns, use of buzzwords: toxic waste, pollutant, poison
1970s	Anti-military-industrial complex mood; conspiracy of US government, health establishment, and industry; human cancer
1980s	Aging, Alzheimer's disease, AIDS
1990s	Bone fracture, decreased birth rate, human cancer

Chronology of Opposition Arguments

As would be expected, the nature of the opposition has undergone some changes over the past 50 years (Table 1). In the 1950s, in the heyday of the McCarthy era when Nixon had succeeded in winning elections by Red-baiting his opponents and the Rosenbergs had been convicted of espionage, fluoridation was portrayed as a "Red conspiracy" that would produce "moronic, atheistic slaves" who would end up praying to the communists. Groups such as the John Birch Society and the Ku Klux Klan rallied to oppose fluoridation. In the film "Dr. Strangelove," who can forget Sterling Hayden's hilariously paranoid portrayal of Col. Jack D. Ripper, the demented commander of Burpelson Air Force Base? He was obsessed with "purity and essence of our natural body fluids" and therefore only drank bourbon with distilled water because he did not want his "bodily fluids" violated by fluoridated water, a Communist plot. He was convinced that fluoridated water caused postcoital exhaustion and would have none of it.

In the 1960s Rachel Carson, in her book "The Silent Spring," expressed her concerns about the effects of insecticides on wildlife and the foods we eat. Americans became more aware of the problems of unbridled industrial pollution and abuse of insecticides. Accordingly, antifluoridation propaganda switched to environmental concerns, using buzzwords like toxic waste, pollutant, and poison in reference to fluoride.

In the 1970s, in the aftermath of the Vietnam War, the antifluoridationists cashed in on the anti-establishment and anti-military-industrial complex mood of the country. Fluoridation was portrayed as a conspiracy among the US government (Public Health Service), the medical-dental establishment, and industry. The year 1975 was also the time when John Yiamouyiannis, during the Los Angeles referendum, attempted to link water fluoridation with the risk of human cancer (14-16).

By the 1980s, when Americans became more health conscious and were exercising in large numbers, antifluoridationists claimed fluoride caused aging, Alzheimer's disease, and AIDS (17,18). Now, in the 1990s, fluoride is charged with being the cause of bone fracture in postmenopausal women and is blamed for the declining birth rate, as well as again being accused of causing cancer. Although I have given some chronological order to the antifluoridation propaganda, clearly some of these tactics have been recycled periodically and some have never gone away. For example, as recently as 1992 an opponent referred to water fluoridation as socialistic mass medication, repeating the term "socialized" in reference to water or medicine five times in the same article (19). Who said McCarthyism is dead?

Arguments of the Opponents

California, a state that ranks near the bottom (48th) in the nation with respect to percent of the population (18%) enjoying the benefits of water fluoridation, I have been called upon to participate as a scientific expert on fluoridation in several city council or water authority hearings in Los Angeles, Marin County, and the East Bay Municipal Water District, as well as to testify to the California legislature. In addition, I have testified to a committee of the US Congress, in the Queen's Court in Canada, and the Ministry of Health in Chile, and I have submitted written testimony to a Royal Commission in Victoria, Australia. I have debated antifluoridationists on television and radio and appeared on call-in radio programs to answer questions about fluoridation. I have heard or read most of the arguments that the opponents have presented, although I confess I have never heard them specifically claim that fluoridation causes nymphomania and satyriasis, as others have reported (2). I feel I have been in the trenches in this fluoridation war for most of my professional life. Although the specific arguments of the antifluoridationists may change with the *Zeitgeist*, the basic tenets have changed very little over the years. They are as follows: fluoride is a poison and causes deleterious health effects, fluoride is ineffective in preventing decay, fluoridation is costly, and fluoridation interferes with freedom of choice and infringes on individual rights (Table 2).

TABLE 2
Principal Antifluoridation Arguments and Profluoridation Answers

Antifluoridation Arguments	Profluoridation Answers
Poison	Safe at 0.7–1.2 ppm
Ineffective	15–40% less caries
Delays caries	Less caries at all ages
Costly	Cheap 25¢ (median/person/year) 50¢ (mean/person/year)
Freedom of choice Individual rights	Individual restraints in the interest of community public health

TABLE 3
Expert Reports on the Safety, Risks, and Benefits of Water Fluoridation

Year	Organization	Ref
1957	Commission of Inquiry, New Zealand	25
1968	Royal Commission of Tasmania, Australia	26
1970	World Health Organization, Geneva, Switzerland	27
1976	Royal College of Physicians, London, UK	28
1977	National Academy of Sciences, Washington, DC	29
1977	Commission of Inquiry, Victoria, Australia	30
1982	International Agency for Research on Cancer, Geneva, Switzerland	31
1985	Department of Health, San Francisco, California	32
1985	Working Party (Knox), London, UK	33
1990	State Department of Health, New York	34
1991	National Health and Medical Research Council, Canberra, Australia	35
1991	US Public Health Service (Young), Washington, DC	36

Claims that Fluoride is Harmful. Opponents identify fluoride as a poison both specifically as being toxic and generally as being responsible for a wide spectrum of common ills including allergy, birth defects, cancer, and heart disease, as well as rarer conditions such as crib death, immune deficiency, and Gilbert's syndrome (20). Antifluoridation propaganda frequently shows fluoride with a skull and crossbones, labeled poison, ignoring the matter of dosage. When antifluoridationists speak about fluoride, they compare it with lead and arsenic (17,21), rather than with essential elements such as iodine, zinc, or iron, or with Vitamins A and D, which are also toxic in excess. Waldbott, one of the earlier physicians to oppose fluoridation, listed the illnesses attributable to "artificial" fluoridation as: stomach and intestinal, stomatitis, polydipsia, joint pains, migraine-like headaches, visual disturbances, tinnitus, and mental depression (22). Regrettably, all too often these illnesses are reported as anecdotal cases that are not based on randomized clinical trials. Such uncontrolled or poorly controlled observations can be dismissed.

It is beyond the scope of this review to respond to all the health-related claims of antifluoridationists; these have been amply detailed elsewhere (23,24). Reports of independent experts in relevant fields of medicine and epidemiology, as well as scientists and water engineers, have been unanimous that the benefits of water fluoridation far outweigh any potential risks. Data concerning the safety of water fluoridation have been reviewed repeatedly by international, national, state, and local authorities (25-36). Scientists have recently reviewed the results of more than 50 epidemiologic studies on the relationship between fluoride concentrations in the drinking water and the risk of human cancer, as well as animal toxicity data (37). The conclusion of all of these reports has been uniform: there are no significant health risks associated with water fluoridation at an optimal level (Table 3). At optimal fluoride concentration the growth, health, and development of children is normal. Claims of carcinogenicity, teratogenicity, genotoxicity, and the like have not been substantiated under rigorous scientific examination. Mortality rates and other health statistics (other than dental caries) in fluoridated and nonfluoridated communities are similar. No injury from optimally fluoridated water has been proven to date. Dental fluorosis, mostly of the very mild to mild degree, may occur in some of the population, but this is primarily a cosmetic issue and not an adverse health effect.

Claims that Fluoridation is Ineffec-

tive in Caries Reduction. Several opponents have criticized the design, analysis, or conclusions of the studies on communal water fluoridation, implying that water fluoridation is ineffective in caries reduction (13,38,39). Sutton's (39) claim of examiner bias and the need for blind studies has been amply answered by the consistent finding of lower caries prevalence in comparisons of fluoridated with nonfluoridated communities, when examinations of patients or of radiographs were conducted under blind conditions (40-44). Diesendorf (38) considers that the temporal reductions in tooth decay observed in nonfluoridated communities as well as in fluoridated communities cannot be attributed to fluoride, implying that changes in dietary patterns, especially sugar consumption, are responsible.

Unquestionably, decay rates have fallen in nonfluoridated communities, but not to the same extent as in fluoridated ones (45,46). This temporal decrease in caries rates in nonfluoridated communities is primarily due to the widespread use of fluoridated dentifrices, particularly since the 1970s. A recent review of the efficacy of water fluoridation based on surveys conducted in the decade of 1979 to 1989 in Australia, Britain, Canada, Ireland, New Zealand, and the United States concluded that the current data show a consistently and substantially lower caries prevalence in fluoridated communities (47). The effectiveness of water fluoridation has decreased as the benefits of other forms of fluoride have spread to communities lacking optimal water fluoridation; still, even a 20 percent additional reduction of decay due to water fluoridation is substantial.

Economics of Fluoridation. Opponents have argued that since only a very small fraction (less than 0.1%) of public water supplies is actually drunk, most being used for other purposes such as washing, watering gardens, and flushing toilets, water fluoridation is inherently wasteful. Of course, the same logic also would stop water chlorination as wasteful. The initial outlay for equipment costs of large cities may be quite considerable; however, this is amortized over 20 to 25 years and the cost of an extra building facility, if any, is amortized over 50 years. Operating costs for supplies and water engineers are quite small when calculated on a per capita basis. In the United States the annual cost of community water fluoridation averages 50¢ per person (25¢ per person median), depending mostly on the size of the community, labor costs, and types of chemicals and equipment utilized. Accordingly, lifetime costs of fluoridation are about $38, which is less than the $42 cost of an average two-surface amalgam restoration. Fluoridation remains the most cost-effective caries preventive measure wherever there is an established municipal water system.

Freedom of Choice and Infringement of Individual Rights. To opponents of fluoridation, the issue of freedom of choice and individual rights is sacred and probably the most important single issue on which they all agree. In 1971 an opinion survey on the attitudes of opponents to fluoridation was carried out by the *National Fluoridation News*, which has a circulation of 10,000 (48). Although only 570 responses were received, 97 percent of those responding considered fluoridation "unconstitutional." Objections based upon "philosophical, ethical, or moral beliefs" ranked first in validity and priority and second in importance out of 10 categories. In contrast, "health hazards" ranked eighth in validity and fifth in importance and priority (Table 4). In other words, opponents do not really believe all their own propaganda about the dangers of fluoridation; they use the health risk argument for political purposes to scare the public.

What really turns on the opponents, motivates them to donate mor tc their organizations, to particip. in massive letter-writing and facsimil- sending campaigns, and to persona lobby legislators is their opposition to government involvement in health care—what they refer to as "mass medication" or government bureaucrats "trampling on your health freedoms." The legal validity of fluoridation has been thoroughly tested in the United States over the past decades and invariably confirmed. The courts have agreed that while the Constitution guarantees the right to protect one's own health, this right is subject to regulation by police power in the interest of the public's health (4). No appellate court in the United States has ruled against fluoridation. In the Netherlands and Scotland, fluoridation has been overturned on legal grounds. It is worth noting that in Scotland Lord Jauncey, the judge, while sustaining the petitioner's plea that fluoridation for the purposes of reducing caries was *ultra vires* the Strathclyde Regional Council, vindicated the safety and effectivene f water fluoridation (49).

Techniques Used by Opponents

The methods used by the opponents in attempting to block fluoridation have been detailed elsewhere (50,51) and will only be summarized here (Table 5). Let me offer examples of neutralizing politicians, of the big lie, and of reasons for not debating with opponents of fluoridation.

The US Postal Service was urged to issue a postage stamp in 1995 to com-

TABLE 4
Relative Rankings of Grounds for Objections to Fluoridation by Opponents Responding to Survey*

Validity	Importance	Priority
1. Philosophical	1. Ecological	1. Philosophical
2. Ecological	2. Philosophical	2. Ecological
3. Other	3. Common sense	3. Common sense
4. Common sense	4. Lack of benefits	4. Lack of benefits
5. Economic	5. Health hazard	5. Health hazard
6. Lack of benefits	6. Other	6. Other
7. Other damage	7. Economic	7. Political
8. Health hazard	8. Political	8. Economic
9. Religious	9. Other damage	9. Other damage
10. Other	10. Religious	10. Religious

National Fluoridation News (48).

memorate the 50th anniversary of water fluoridation—hardly a controversial issue considering that the postal service has issued commemorative stamps for Elvis Presley and Marilyn Monroe, both of whom died of a drug overdose. Other countries have issued postage stamps recognizing water fluoridation. Apparently the members of the US Postal Commission were "neutralized" and have as yet refused to issue a fluoridation commemorative stamp.

In September 1984, Wendy Nelder, a member and at that time president of the San Francisco Board of Supervisors, requested an investigation into fluoridation as a cause of increased risk of AIDS, cancer, and other diseases (18). In a debate on the "Today" television show, she stated that the death rate in fluoridated communities was 300 percent higher than in nonfluoridated ones and subsequently claimed an "overwhelming increase of the death rate from heart disease in fluoridated areas" (52). In a few minutes she was able to present much misinformation that would require a much longer time to refute. Nelder was referring to the Bartlett (8 ppm F)–Cameron (0.4 ppm F) study in Texas of residents who had lifelong exposure to natural fluoride (53). In the ten-year period from 1943 to 1953, 14 persons died in Bartlett whereas only 4 persons died in Cameron, hence the "300 percent" increase (Table 6). What she failed to inform the viewers was that in Bartlett, 15 percent of the population in 1943 and 12 percent of the population in 1953 were older than 70 years of age, while in Cameron during the same time span only 4 percent were older than 70 years of age (Figure 2). No wonder there was a higher death rate in the fluoridated community! Such tricks of lying with statistics are not new (54); nevertheless, the use of uncorrected data, particularly in relation to cancer deaths, is typical of the opposition, and was used most effectively in the Los Angeles referendum in 1975 (55).

Another convincing example of why not to debate with opponents of fluoridation comes from San Antonio, where in October 1985, on the eve of a referendum, proponents and opponents of fluoridation participated in a televised debate. The station manager required that all debaters be San Antonio residents, which disqualified Dr. C. Everett Koop, the prestigious Surgeon General who supported fluoridation. However, John Yiamouyannis, who lives in Ohio, showed up at the station with a San Antonio voter registration card and was allowed to debate. The antifluoridationists took the night with a barrage of assertions phrased in scare rhetoric that were difficult to refute in 30 seconds or less and

TABLE 5
Techniques Used by Opponents to Prevent Fluoridation

- Neutralizing politicians: creating the semblance of "controversy" by using massive letter-writing campaigns, telephone calls, and even threats
- The big lie: alleging serious health hazards, including many different diseases attributed to fluoridation
- Half-truths: fluoride is a poison and causes dental fluorosis
- Innuendo: urging fluoridation be delayed until all doubts are resolved
- Statement out of context: citing only a portion of a study and misrepresenting the conclusions
- "Experts" quoted: all doctors are considered equal by viewers of TV or newspaper readers; some dentist, physician, or scientist can always be found who will oppose fluoridation
- Conspiracy gambit: health establishment, government, and industry are in cahoots
- Scare words: pollutant, toxic waste, cancer, artificial, chemical
- Debating the issue: debates give the illusion of scientific controversy, even though the vast majority of health professionals and scientists support fluoridation

FIGURE 2
Comparison of Age Distribution of Population 70 Years and Older in Bartlett (7.6–8.2 ppm F) and Cameron (0.4–0.5 ppm F) [Data from Leone et al. (53)]

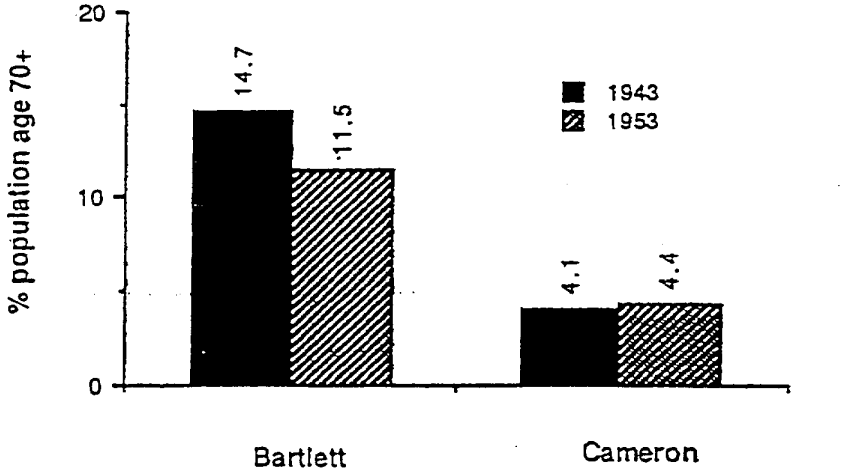

TABLE 6
Number of Participants in 10-year Medical/Dental Study of Residents in Bartlett and Cameron, Texas, with High and Low Levels of Natural Fluoride*

	Bartlett (8 ppm F)	Cameron (0.4 ppm F)
1943	116	121
1953	96	113
Deceased	14	4

*Data from Leone et al. (53).

went on to win the referendum (56).

What Motivates the Opponents?

As the opposition is a heterogeneous group of individuals, no single motivating factor accounts for their prodigious hours of work and untiring efforts. A few might be true "fluorophobics" who believe their health is threatened. Some believe that caries can be prevented by good diet and that those who eat sweets and drink sugary beverages deserve what they get. But most oppose fluoridation on philosophical grounds because they perceive it as government intervention in personal health. Of course, most public health measures do affect individuals, as well as entire communities.

Why has fluoridation been singled out as the target for such long-lasting and firm opposition? The ardor of the opponents borders on crusading, similar to that engendered by the opponents of abortion and gun control. Some opponents are probably paranoid and truly believe that a cabal of government, health professionals, and industry is involved in promoting fluoridation. The fact that the aluminum and phosphate fertilizer industries have not provided financial support for fluoridation referenda seems to have escaped their attention. Yet in the American political system there are numerous examples of companies supporting what they perceive to be in their industry's interests (e.g., beer and soft drink manufacturers donating vast sums of money to campaigns against laws that require bottle deposits, or tobacco companies supporting opposition to anti-smoking ordinances). The leading opponents of fluoridation, for the most part, have no record of scientific productivity or research creativity (at least not in peer-reviewed journals), nor have they played a leadership role in their professions. However, their vocal opposition gives them an instant platform—invitations to speak all over the United States, Canada, and elsewhere, and to testify at government hearings and in court cases. In other words, they achieve a recognition and an illusion of power that they would not otherwise enjoy.

Let me conclude by quoting from Nobel Laureate Professor Sir Peter Medawar, who, when he was director of the National Institute for Medical Research in London, was asked his opinion about fluoridation of the water by the mayor of a large American city (57):

> I accordingly put before him the epidemiological evidence, and to help him appreciate the direction in which the evidence tended, I told him that every time an American municipality determined against fluoridation there was a little clamor of rejoicing in the corner of Mount Olympus presided over by Gaptooth, the God of Dental Decay. Of course, the more difficult part of the fluoridation enterprise is not scientific in nature—I mean that of convincing disaffected minorities that the purpose of the proposal is not to poison the populace in the interests of a foreign power or to promote the interests of a local chemical manufacturing company, a big employer of labor.

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Why Fluoridate?

ALL-INCLUSIVE

INEXPENSIVE

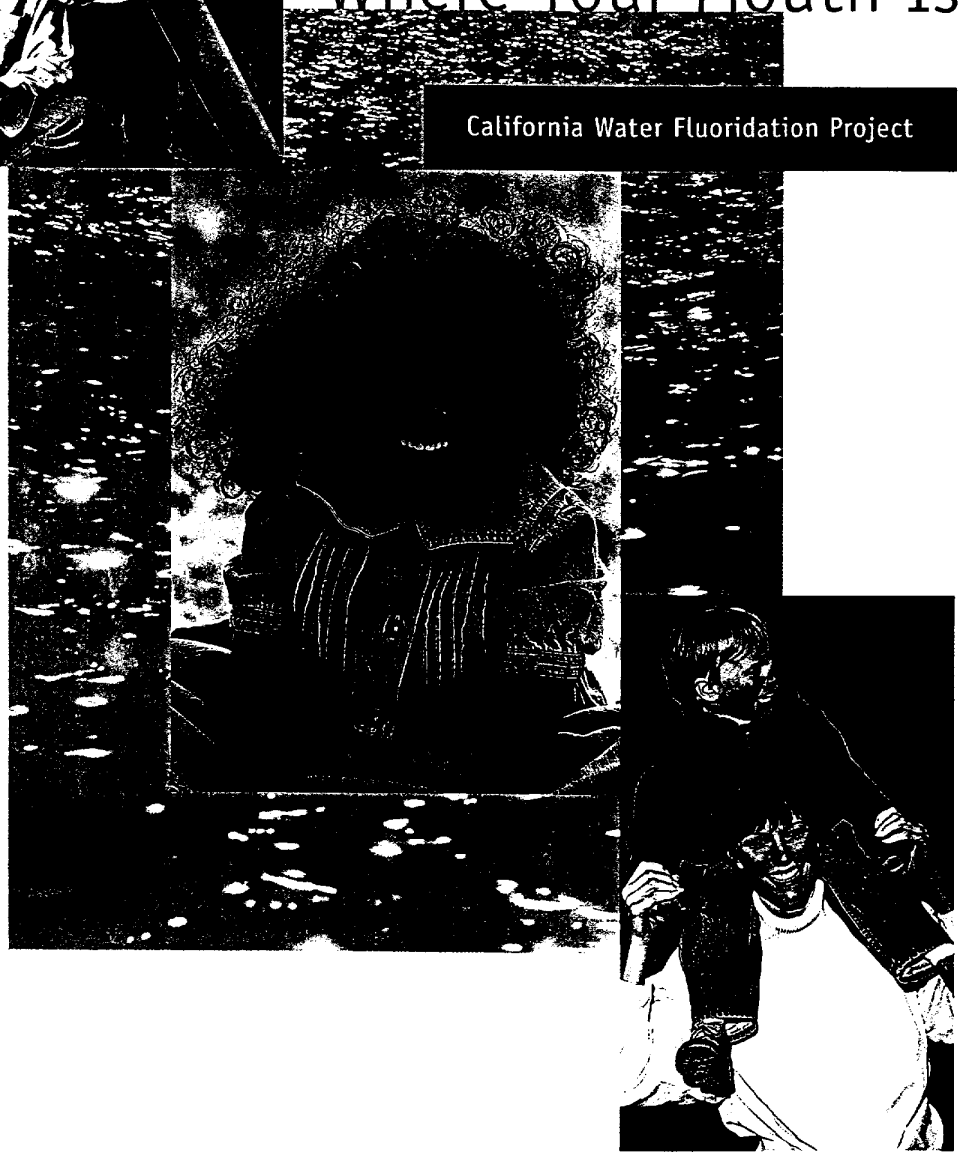
LESS ABSENTEEISM

EDUCED COST TO TAXPAYERS

WIDELY ENDORSED

Put Your Money Where Your Mouth Is

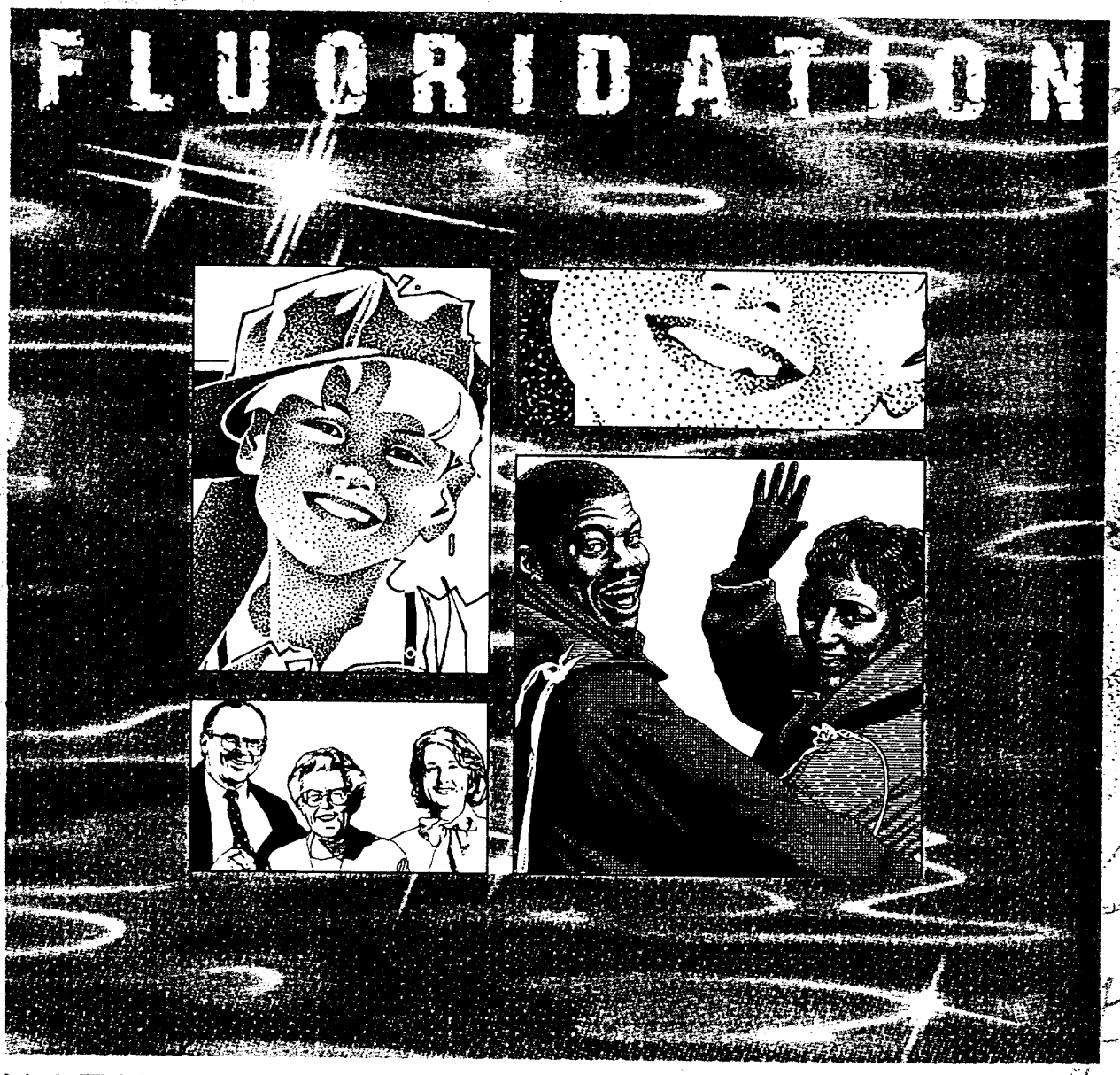
California Water Fluoridation Project



COMMUNITY WATER FLUORIDATION FACT SHEET

- Fluoridation is a community health measure that benefits people of all ages.
- Fluoridation is safe.
- Fluoridation saves money.
- Fluoridation *protects over 300 million people in more than 40 countries worldwide,* with *over 10,000 communities and 145 million people in the United States alone.*
- Fluoride exists naturally in rocks, soil, fresh water and ocean water; and is essential for protection of teeth from dental decay.
- If a community's water supply is fluoride-deficient (less than 0.7 parts per million), fluoridation simply adjusts the fluoride's natural level, bringing it to the level recommended for decay prevention (0.7 - 1.2 parts per million).
- Studies show that water fluoridation results in *up to 60% less decay in baby teeth, and up to 35% less decay in adult teeth.*
- Over 50 years of research and practical experience have demonstrated that there are *no harmful effects as a result of fluoridation.*
- Leading scientists and health professionals, numerous professional organizations, and governments around the world endorse community water fluoridation. The United States Public Health Service recommends community water fluoridation to prevent dental decay.
- Numerous city councils and health boards decide to initiate fluoridation each year. Enlightened community leaders have come to realize that fluoridation is in the *best interest of their entire community - adults and children - even senior citizens.*
- Once water fluoridation begins in a community, it should not be discontinued. *If fluoridation stops, tooth decay rates will rise once again.*
- Depending on the size of the community, its labor costs and the kind of equipment that is used, *water fluoridation costs about 20-50 cents per person per year.*
- Information regarding costs associated with community water fluoridation equipment and supplies, or the existing level of fluoride in your community's water, can be obtained by calling your local or state health department, local water supplier, or the Oral Health Program at the Centers for Disease Control and Prevention.

WATER FLUORIDATION



NATURE'S WAY TO A HEALTHY SMILE

WHAT IS WATER FLUORIDATION?

To fluoridate water means to raise the natural level of fluoride in the drinking water of a community for dental health. Fluoride is a substance found in all water. Fluoride protects people of all ages against tooth decay. It makes teeth stronger and harder, so that they last longer.

Water fluoridation is an inexpensive and safe practice. Many communities have been adding fluoride to their water for over 50 years!

WHY IS DENTAL HEALTH IMPORTANT?

The health of your teeth affects the health of your whole body. Here are some of the benefits of healthy teeth:

- You will be able to eat better.
- You can speak clearly.
- You will have fewer toothaches.
- You will have a pleasant smile.

WHAT ARE OTHER WAYS TO IMPROVE YOUR DENTAL HEALTH?

Fluoride is very important for dental health. Here are some other things you and your children can do to take care of your teeth.

- **Eat well.** Milk and other calcium-rich foods make teeth stronger. It is also important not to eat too much sugar (sweets and desserts).
- **Brush your teeth every day using a fluoride toothpaste and use dental floss.**
- **See a dentist twice a year to get your teeth cleaned and checked.**
- **Ask your dentist about dental sealants.**

Water fluoridation • better dental health

UCSF

School of Dentistry
Department of Dental Public Health & Hygiene

dhf

The Dental Health Foundation

dhs

The California Department of Health Services

MCHB

Maternal and Child Health Bureau

California Wellness Foundation

For additional copies, contact:
The Dental Health Foundation
510/663-3727 or DHS at 916/323-0852

The Dental Health Foundation
520 Third Street, Suite 205
Oakland, CA 94607

Water Fluoridation

CALIFORNIA WATER FLUORIDATION PROJECT

Providing the health benefits of fluoridated water to all Californians

FOR MORE INFORMATION, PLEASE CALL

CALIFORNIA DEPARTMENT OF HEALTH SERVICES: 916.327.8903

Special thanks to the University of California-San Francisco, Department of Dental Public Health and Hygiene, for funding this brochure.

Your Support Helps California Fulfill The Bill

Authored by State Assemblywoman Jackie Speier and passed by the California Legislature, AB 733 authorizes fluoridated drinking water in public water systems with more than 10,000 service connections. Speier, like many Californians, assumed every water system was fluoridated until her children started accompanying her to Sacramento, a nonfluoridated community.

You can help California fulfill the bill by contributing to the estimated $200 million needed to build the fluoridation systems. Your all-important support will benefit the health of all Californians, in addition to saving state taxpayers millions of dollars each year.

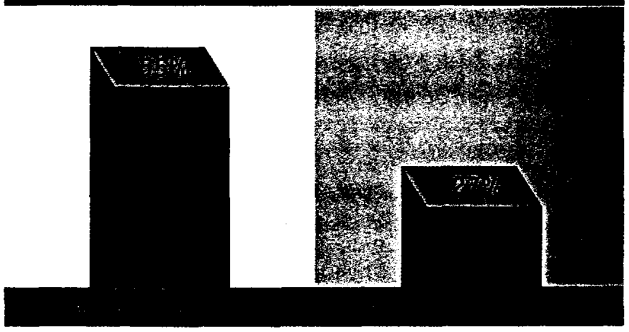
That's a significant amount of money when you consider Denti-Cal, California's dental welfare program, costs taxpayers more than $700 million each year. By comparison, water fluoridation costs about 54 cents per person annually—about $70 in one's lifetime. That's less than the price of a single dental filling.

Fact is, water fluoridation is the most economical and effective way to prevent tooth decay, particularly among children. Projections indicate that tooth decay for children will decrease as much as 30 percent within five years of water fluoridation. Preventing just one cavity in each school-aged child in California will save taxpayers an estimated $385 million over that same five-year period.

A NEEDED PUBLIC HEALTH MEASURE

The 1993-1994 *California Oral Health Needs Assessment of Children* revealed that children in California have much higher rates of oral disease than their counterparts in national studies conducted 10 years earlier. In fact, untreated tooth decay for six-to-eight year olds in California was more than twice as high as the U.S. average for this age group.

UNTREATED TOOTH DECAY IN CHILDREN AGES 6 - 8



SOURCE: CALIFORNIA ORAL HEALTH NEEDS ASSESSMENT OF CHILDREN, 1993-1994

Children who experience dental problems early in childhood are likely to experience recurring tooth decay as adults. Fortunately, water fluoridation results in up to 60 percent less decay in baby teeth. Adults benefit, too, with up to 40 percent less decay. That's very reassuring to the elderly who are susceptible to root surface decay, in addition to families with limited income and other Californians who do not receive routine, preventive dental care.

ALL-NATURAL WITH NO HARMFUL EFFECTS

Fluoride exists naturally in rocks, soil, fresh water and ocean water. Like zinc, iron and other minerals, fluoride is classified by the National Research Council as an important trace element in human nutrition.

The first U.S. city to fluoridate was Grand Rapids, Michigan in 1945. After 11 years of study, scientists reported that the cavity rate among schoolchildren in Grand Rapids had dropped 60 percent. Since then, more than 3,700 independent, peer-reviewed studies have documented

WATER FLUORIDATION IS CONSIDERED ONE OF FOUR PILLARS OF PUBLIC HEALTH ALONG WITH PASTEURIZATION OF MILK, IMMUNIZATION/VACCINATION OF CHILDREN AND WATER PURIFICATION.

the health benefits of fluoridated water. Millions of people have consumed water containing natural or adjusted fluoride at 0.7–1.2 parts per million with no adverse effects.

ENDORSED STATEWIDE AND NATIONWIDE

In 1952, San Francisco became the first major city in California to fluoridate. Soon after, communities such as Berkeley, Palo Alto, Long Beach and Beverly Hills followed suit. Today, more than 100 state, national and international health and civic organizations endorse water fluoridation. This includes the U.S. Public Health Service, the World Health Organization, the Centers for Disease Control and Prevention, in addition to every U.S. Surgeon General in the last 50 years.

OF THE 150 LARGEST U.S. CITIES THAT DO NOT FLUORIDATE WATER, 87 ARE IN CALIFORNIA, INCLUDING LOS ANGELES, SAN DIEGO, SAN JOSE, SACRAMENTO, SANTA ANA, ANAHEIM AND STOCKTON.

HOW FLUORIDATED WATER SYSTEMS WORK

Naturally occurring fluoride is already present in most drinking water across the U.S. in variable levels. The two most common fluoridation treatment systems use sodium fluoride and hydrofluosilicic acid. These chemicals are compatible with other chemicals now used in water treatment and do not cause any additional operating problems with existing plant processes.

Fluoridating community water systems is an easily implemented procedure. The treatment systems take up minimal space and, in many situations, can be installed in existing structures at water wells and treatment plants. Basic fluoridation systems include a storage tank for the chemicals, a metering pump to inject the fluoride chemical solution into the water supply, plus associated piping.

Actual fluoridation only involves a minimal adjustment of water to reach an optimum level: one part fluoride treatment per million gallons of water. Once implemented, fluoridation levels are monitored and calibrated on a weekly basis and reported to the state as part of ongoing compliance evaluations by the California Department of Health Services' Office of Drinking Water.

HOW FLUORIDATION FUNDING IS SPENT

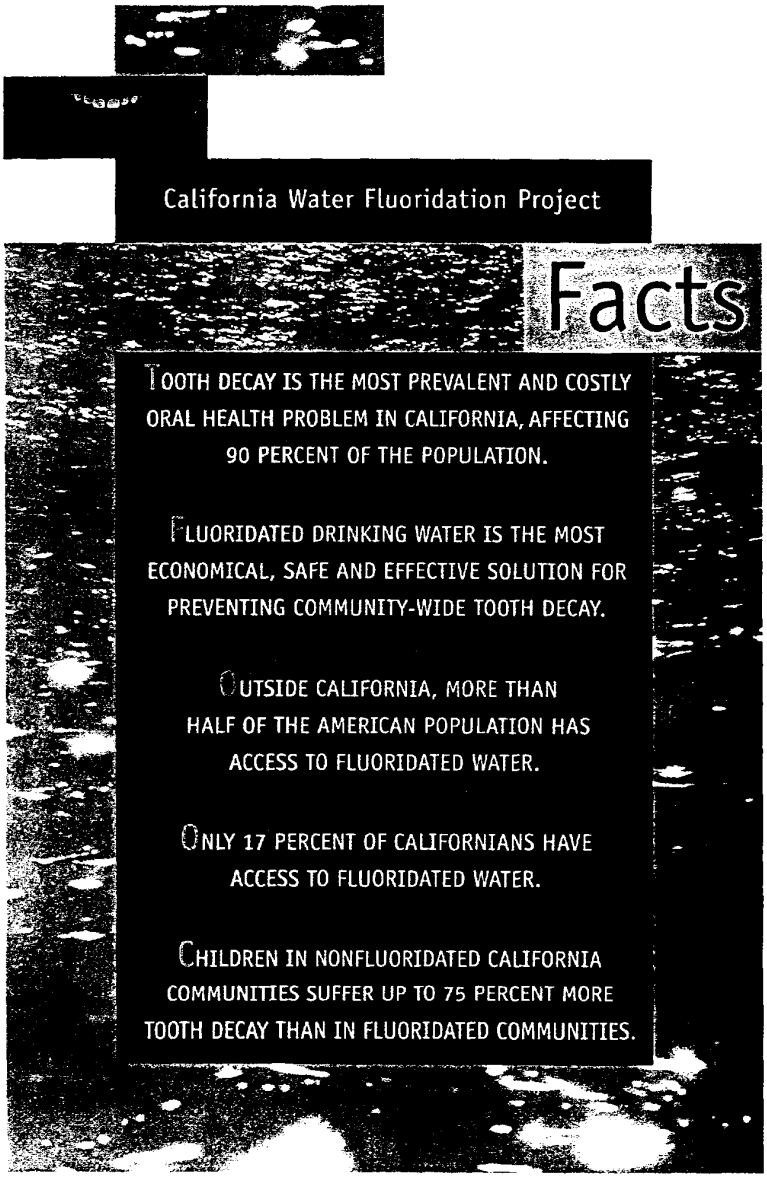
Every dollar of the $200 million required to fluoridate California's public water systems goes toward capital costs. This covers acquisition of land, provision of equipment, site visits, permits and construction inspection. In addition, the funds raised will provide up to two years of operations and maintenance cost for each new system.

If you wish, you can direct your donation to a specific water system. Otherwise, the money will be placed in a trust. The Fluoridation 2000 Workgroup will allocate those funds to water systems based on the Office of Drinking Water's priority list of cities, with the highest priority given to systems with the lowest cost-per-service connections.

IF NOT YOU, THEN WHO?

Imagine the good your generous contribution can do to improve the dental health of all Californians while saving millions in taxpayer dollars. It's a grin-grin for everyone. Now and in the future.

For more information on the California Water Fluoridation Project, please call 916.327.8903.


California Water Fluoridation Project
Facts
TOOTH DECAY IS THE MOST PREVALENT AND COSTLY ORAL HEALTH PROBLEM IN CALIFORNIA, AFFECTING 90 PERCENT OF THE POPULATION.
FLUORIDATED DRINKING WATER IS THE MOST ECONOMICAL, SAFE AND EFFECTIVE SOLUTION FOR PREVENTING COMMUNITY-WIDE TOOTH DECAY.
OUTSIDE CALIFORNIA, MORE THAN HALF OF THE AMERICAN POPULATION HAS ACCESS TO FLUORIDATED WATER.
ONLY 17 PERCENT OF CALIFORNIANS HAVE ACCESS TO FLUORIDATED WATER.
CHILDREN IN NONFLUORIDATED CALIFORNIA COMMUNITIES SUFFER UP TO 75 PERCENT MORE TOOTH DECAY THAN IN FLUORIDATED COMMUNITIES.