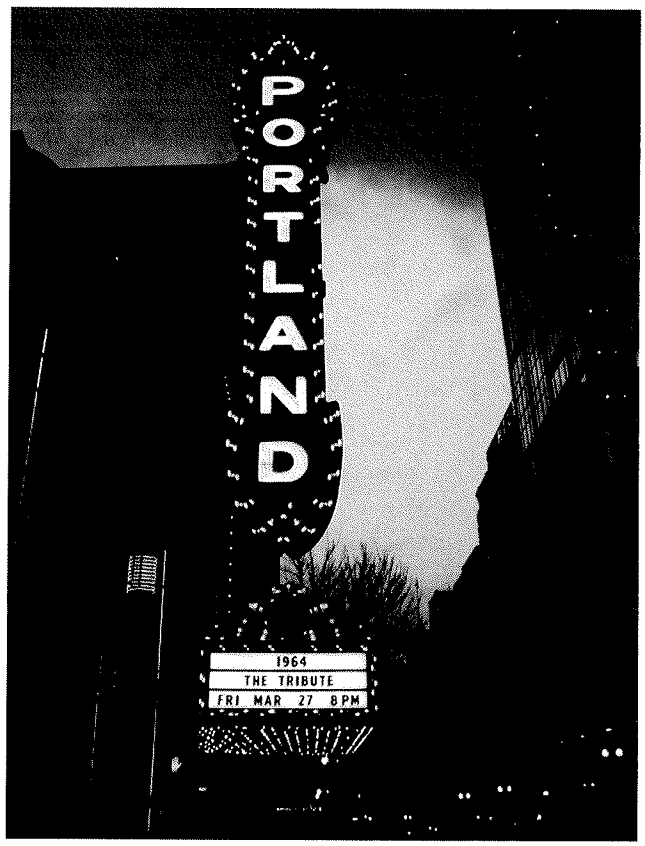
185612

60 Seconds in Support of Community Water Fluoridation

September 6, 2012

Portland City Council

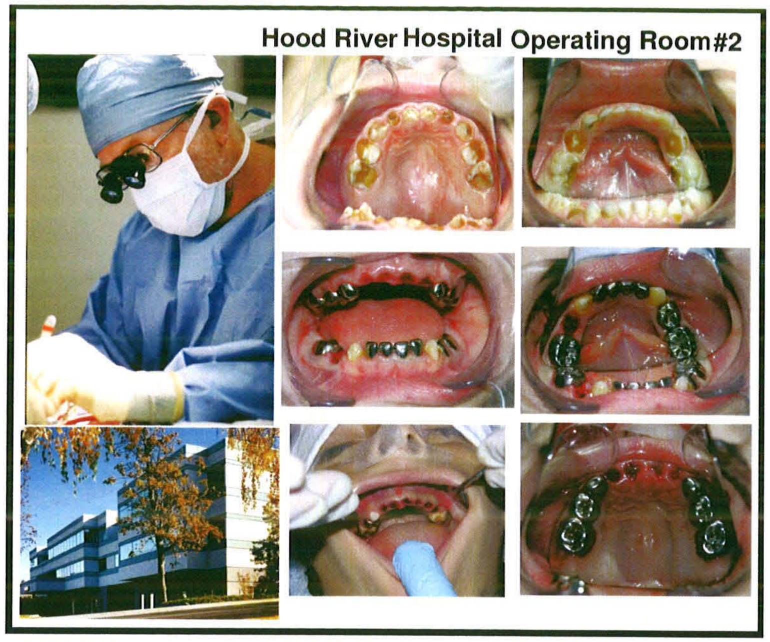


Charles C. Haynie, M.D., FACS
1100 State St.
Hood River, OR 97031
chaynie@gorge.net

185612

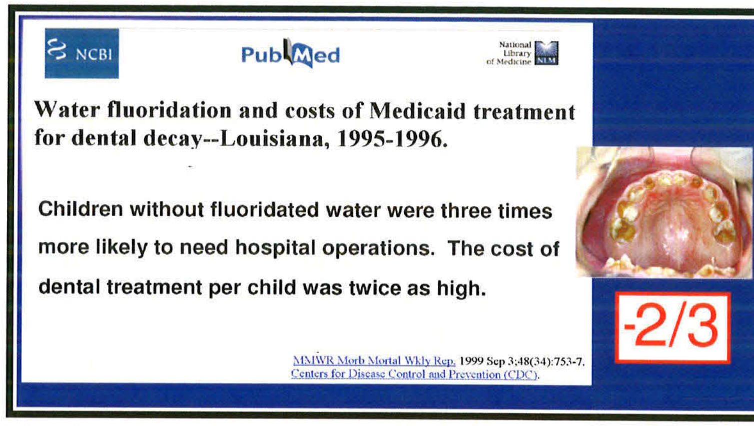
Mr Mayor, Commissioners:

I'm Chuck Haynie, a retired surgeon and ex city council member from Hood River. For years every week in the operating room next to mine I watched 4-7 kids have operations for mouthfuls of cavities. . root canals, stainless steel crowns, extractions.



Fluoridation avoids 2/3rd of these operations.

That huge Louisiana study also showed 50% of the dental bills for Medicaid kids are saved.



We compared The Dalles and Hood River . . their kids are protected even more than in Louisiana

Costing up to 15 grand each this is found money for the Governor's Medicaid plan and will buy more health care for poor kids.

It also benefits middle class adults . senior citizens avoid cavities on exposed roots

We lost our Fluoridation War to baloney . it would ruin the beer and whiskey and cause diseases.

Dentists were picketed with Dr. Death signs.

Following is a list of expert organizations favoring community water fluoridation.

I vote with America's pediatricians and public health scientists.

For the sake of those kids in the operating room, please stay the course.

Endorse Fluoridation

Acad Dentistry InterNatl
Acad General Dentistry
Acad for Sports Dentistry
Alzheimer's Assoc
America's Health Insurance Plans
Am Acad Family Physicians
Am Acad Nurse Practitioners
Am Acad Oral & Maxillofacial Pathology
Am Acad Orthopaedic Surgeons
Am Acad Pediatrics
Am Acad Pediatric Dentistry
Am Acad Periodontology
Am Acad Physician Assistants
Am Assoc for Community Dental Prgms
Am Assoc for Dental Research
Am Assoc for Health Education
Am Assoc for the Advancement Science
Am Assoc Endodontists
Am Assoc Oral & Maxillofacial Surgeons
Am Assoc Orthodontists
Am Assoc Public Health Dentistry
Am Assoc Women Dentists
Am Cancer Society
Am College Dentists
Am College Physicians /
Am Society Internal Medicine
Am College Preventive Medicine
Am College Prosthodontists
Am Council on Science and Health
Am Dental Assistants Assoc
Am Dental Assoc
Am Dental Education Assoc
Am Dental Hygienists' Assoc
Am Dietetic Assoc
Am Federation Labor /
Congress of Industrial Orgs
Am Hospital Assoc
Am Legislative Exchange Council
Am Medical Assoc
Am Nurses Assoc
Am Osteopathic Assoc
Am Pharmacists Assoc
Am Public Health Assoc
Am School Health Assoc
Am Society for Clinical Nutrition
Am Society for Nutritional Sciences
Am Student Dental Assoc
Am Water Works Assoc
Assoc for Academic Health Centers
Assoc Am Medical Colleges
Assoc Clinicians for the Underserved
Assoc Maternal & Child Health Programs
Assoc State & Territorial Dental Directors
Assoc State & Territorial Health Officials
Assoc State & Territorial Public Health
Nutrition Directors
British Fluoridation Society
Canadian Dental Assoc
Canadian Dental Hygienists Assoc
Canadian Medical Assoc
Canadian Nurses Assoc
Canadian Paediatric Society
Canadian Public Health Assoc
Child Welfare League America
Children's Dental Health Project
Chocolate Manufacturers Assoc
Consumer Federation America
Council State & Territorial Epidemiologists
Delta Dental Plans Assoc
FDI World Dental Federation
Federation Am Hospitals
Hispanic Dental Assoc
Indian Dental Assoc (USA.)
Institute of Medicine
Institute for Science in Medicine
InterNatl Assoc for Dental Research
InterNatl Assoc for Orthodontics
InterNatl College Dentists
March Dimes Birth Defects Found
Natl Assoc Community Health Centers
Natl Assoc County & City Health Officials
Natl Assoc Dental Assistants
Natl Assoc Local Boards Health
Natl Assoc Social Workers
Natl Confectioners Assoc
Natl Council Against Health Fraud
Natl Dental Assistants Assoc
Natl Dental Assoc
Natl Dental Hygienists' Assoc
Natl Down Syndrome Congress
Natl Down Syndrome Society
Natl Found Dentistry for the Handicapped
Natl Head Start Assoc
Natl Health Law Program
Natl Healthy Mothers Healthy Babies Coalition
Oral Health America
Robert Wood Johnson Found
Society for Public Health Education
Society Am Indian Dentists
Special Care Dentistry
Acad Dentistry for Persons with Disabilities
Am Assoc Hospital Dentists
Am Society for Geriatric Dentistry
The Children's Health Fund
The Dental Health Found (of California)
US Department Defense
US Department Veterans Affairs
US Public Health Service
Health Resources & Services Administration
Centers for Disease Control & Prevention
Natl Institute Dental & Craniofacial Research
World Federation Orthodontists
World Health Org

185612

Mr Mayor, Commissioners:

I'm Chuck Haynie, a retired surgeon and ex city council member from Hood River.

In the OR next to mine weekly 4-7 kids had operations for cavities. . root canals, stainless steel crowns,

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Fluoridation avoids 2/3rd of these operations. and saves half of Medicaid dental bills.

***

Comparing The Dalles and Hood River we found their kids protected even more than in the Louisiana study.

At up to 15 grand each this is found money for the Governor's Medicaid plan to buy poor kids more health care.

It also benefits middle class adults . senior citizens avoid cavities on exposed roots

We lost Hood River's fluoridation war. Baloney won . it would have ruined the beer and causes diseases. Dentists were picketed with Dr. Death signs.

***

A list of expert organizations favoring.

I vote with America's pediatricians and public health scientists.

For the sake of those kids, please stay the course.

Testimony, Thursday, Sept. 6, 2012 – Laurie Johnson, MA, RDH

My name is Laurie Johnson. I am testifying as a Portland resident and a member of the Oregon Dental Hygienists' Association, not as an employee of the Oregon Health Authority.

I had been a clinical dental hygienist for about 20 years when I started volunteering on the Medical Teams dental vans in 1993. After about 2 years on the vans providing anesthetic so dentists could extract teeth, I realized that something had to be done about prevention or we would never get on top of the dental crisis here in Oregon. I went back to school and eventually went to work for the Oregon Health Authority and have, for the past five years, coordinated their two school-based oral health programs – the School Fluoride Program and the School Dental Sealant Program.

We see lots of devastating decay in these kids. This past May, for example, I was in an elementary school, doing screenings of the 1st and 2nd graders. I saw one cute little 6 year old girl who had 8 baby teeth that were decayed almost down to the gumline. I triaged her as a "4" – "Serious dental problems; Please see your dentist immediately." A little later that day, her twin sister came in. Her twin sister had evidently seen the dentist because all of her baby teeth had been extracted – no spacers were present. She was 6 years old. Now, her first, four permanent molars will come in sometime during the next year, so she will have something to chew with, but then she will have to wait until 2017 for the rest of her back teeth. And this was preventable.

We currently put only 5% of our healthcare dollars into prevention. The goal of the new healthcare model is to make sure that we provide proven preventive measures to keep people from needing emergency care. Research shows conclusively that Community Water Fluoridation works, is safe, and benefits people throughout the lifespan. We need to implement it as soon as possible.

185612

Greetings Mayor Sam, Members of the City Council, Fellow Portlanders,

I am Richard Garfinkle, DDS, MSD; a practicing Orthodontist for 39 years in SW Portland's Hillsdale Town Center. That's a Main Street Plug.

In 1966 I married a Portlander, and thus began two love affairs.

At that time I was a sophomore dental student at UCSF School of Dentistry. I graduated with honors in 1969, a 2nd generation dentist in my family.

In 1970 I began practicing general dentistry in Portland.

What became immediately apparent to me and amazed me as a young restorative dentist is that with a large degree of accuracy I could tell if a person grew up in the Portland Metro Area compared with the San Francisco Bay Area just by looking at their teeth! The difference in the number of decayed, missing and filled teeth still amazes me 40 years later.
And the only reason? Fluoridated Water!

As stated, CDC

~~I believe it was Dr. C Edward Coop, while Surgeon General of the United States, that~~ ranked the Fluoridation of Public Water Supplies as one of the 10 most significant public health advances of the 20th century! We are in the 21st Century now and we need to get caught up.

Water fluoridation is good public health policy.

It's also is good common sense.

It Saves Dollars! It Saves Emergency Room visits, it Saves Teeth.

And it probably Saves Lives.

If you wonder about the impact of water fluoridation on you personally, take a hand mirror like this one when you get home or at your next visit to your dentist and if your water was NOT fluoridated when you were a kid you have 33% more cavities than you would have had if you lived next door to me growing up!

In my ongoing 40+ year career in Dentistry my mission has always been to help people be more healthy. I'm asking for your help with that mission. It takes the whole village to raise a child and I have 3 young grandchildren who will hopefully soon be drinking fluoridated water from their tap.

I would like to take this time to thank those of you who are supporting this good, sound public policy and not hiding behind the political expediency that has governed this discussion for so long on so many occasions here in Portland and in Salem in the past.

Respectfully submitted,
Richard L. Garfinkle

richard@garfinkleortho.com

Good Afternoon, my name is Dr. Weston Heringer, Jr. and I am a retired Pediatric Dentist.

For 27 years I practiced in Salem with a part time practice in Lincoln City. Over the years, moving between my two practices, I observed that children of the same socio-economic background had way more decay in Lincoln City than Salem. The only difference between citizens of these two cities? Salem has Fluoride in their water and Lincoln City does not.

From 2008-2010 I was the Dentist on the Dental Foundation of Oregon's mobile clinic the "Tooth Taxi". We travelled the state providing care for school aged children all over Oregon, including Portland. I have also done 19 overseas Dental Civic Action trips to Mexico, Cambodia, Honduras, and Romania. Within 2 miles of this building I can find rampant tooth decay as severe as anywhere I have traveled, in Oregon or the world.

The children most impacted by rampant tooth decay come from low income families. Families that are worried about paying the bills and where their next meal is coming from struggle with taking Fluoride vitamins or supplements. Community water fluoridation is the best way to get fluoride to these children.

Dental health is intimately linked to overall health. Poor dental health not only contributes to heart disease and diabetes later in life, it also effects children's ability to grow, to be healthy, and to do well in school. Children experiencing dental pain from tooth decay are more likely to be distracted in and unable to focus in school or even on their homework. In fact, Dental decay is the leading cause of absenteeism.

There is no reason to accept dental decay. Prevention, (through dental education, regular dental exams and fluoride) is the most cost-effective way to end the pain, suffering, and cost associated with oral health problems and water fluoridation is the cornerstone of community oral health programs.

Thank You.

185612

Draft 9/6/12

Sally Jo Little RDH, MS

Water Fluoridation Testimony:

Mayor, Commissioners,

My name is Sally Jo Little. I am a dental hygienist with a Master's in Public Health. I worked for Kaiser Permanente Center for Health Research for 17 years. I co-authored a study that is frequently misrepresented by opponents to fluoridation. It compared dental treatment costs in fluoridated and nonfluoridated areas in the Portland metropolitan, Marion county and Clark county areas.

We studied people who had dental insurance and access to dental care, and found that most age groups in fluoridated sites had fewer restorations and thus lower dental costs. Elders appeared to have the greatest difference in need for dental treatment – older people living in fluoridated areas needed fewer services, and had lower costs than older people living in non-fluoridated areas.

Some anti-fluoridation activists have twisted this paper in an attempt to discredit water fluoridation's impact in reducing tooth decay and saving money. This is simply misapplication of data and reasoning taken out of the context.

If we had accounted for total fluoride intake or living consistently long-term in a fluoridated or nonfluoridated water community, I expect the outcome would have shown an even stronger correlation between fluoridation and lower need for dental treatment.

In a non-insured population with limited access to dental care, water fluoridation is even more important.

I've treated patients as a volunteer. I've seen the worst dental disease in people who cannot afford dental care and have not had protection of optimally fluoridated water. These children and adults could have avoided much of the suffering and pain of tooth decay if they lived in a city with fluoridated water.

Please feel free to contact me should you have questions re this study. Thank you

Cell 503 734-8456

[signature]

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A Comparison of Dental Treatment Utilization and Costs by HMO Members Living in Fluoridated and Nonfluoridated Areas

185612

Gerardo Maupomé, BDS, MSc, PhD; Christina M. Gullion, PhD; Dawn Peters, PhD; Sally Jo Little, RDH, MS

Abstract

Objectives: *To compare dental treatment experiences and costs in members of a health maintenance organization (HMO) in areas with and without community water fluoridation.* ***Methods:*** *HMO members with continuous dental eligibility (January 1, 1990 to December 31, 1995) who resided in Oregon and Washington were identified using administrative databases. Fluoridation status was determined by geocoding subscriber address. Measures were utilization of dental procedures, fluoride dispensings, and associated costs. Costs were based on nonmember fees, adjusted to 1995 dollar values. Data were analyzed using analysis of covariance, controlling for age and interactions.* ***Results:*** *About 85 percent of eligible members (n = 51,683) were classified as residing either in a fluoridated (n = 12,194) or non-fluoridated (n = 39,489) area. Mean age was 40.0 years; 52.3 percent were women. More than 92 percent of members had one or more dental visits. Community water fluoridation was associated with reduced total and restorative costs among members with one or more visits, but the magnitude and direction of the effect varied with locale and age and the effects were generally small. In two locales, the cost of restorations was higher in nonfluoridated areas in young people (<age 18) and older adults (>age 58). In younger adults, the opposite effect was observed. The impact of fluoridation may be attenuated by higher use of preventive procedures, in particular supplemental fluorides, in the nonfluoridated areas.* ***Conclusions:*** *These results are particularly relevant to insured populations with established access to dental care. Differences in treatment costs (savings) associated with water fluoridation should be estimated and included in future cost-effectiveness analyses of community water fluoridation.*

Key Words: fluoridation, cost, dental care utilization, dental restorations, health maintenance organizations

Introduction

Dental caries remains a prevalent disease. Nearly 80 percent of adolescents have had one or more carious lesions (1), and 93.8 percent of adults have evidence of treated or untreated caries (2). While optimal water fluoridation has long been known to reduce caries experience (3-6), by 1992 only 62 percent of the US community water systems were fluoridated, short of the relevant goal of at least 75 percent in *Healthy People 2000* (7) and *Healthy People 2010* (8). With the proliferation of fluoride technologies applied to individual patients, smaller differences exist in caries experience between community water fluoridated (CWF) and nonfluoridated (NF) areas (9). Given the changing epidemiological profile of caries, however, data are needed on the cost-effectiveness and health consequences of CWF and other fluoride technologies.

Cost-effectiveness analysis – assessment of the comparative impacts of expenditures on different health interventions (10) – can inform resource allocation decisions to improve health. One major evaluation aspect of any preventive program is to estimate the net cost or savings realized through preventing disease and reducing the need for treatment. Net dental treatment costs associated with prevention of caries should be included in the economic analysis of CWF programs. Estimates of net treatment costs should include the initial restoration, replacement costs, cast restorations, endodontic therapy, extractions, bridges, and so on (11).

CWF cost-effectiveness analyses have not typically included reduced caries treatment costs, thereby overestimating the marginal change in health care costs attributable to CWF (12). Cost-effectiveness guidelines are based on the appraisal of the performance of preventive programs (13,14), but no consensus has been reached on whether to include treatment savings or not (11), and very few estimates have been done of the potential cost savings associated with CWF.

Send correspondence and reprint requests to Dr. Gerardo Maupomé, Oral Health Research Institute, Indiana University School of Dentistry, 415 Lansing Street, Indianapolis, IN 46202-2876. Tel.: 317-274-5529; Fax: 317-274-5425; e-mail: gmaupome@iupui.edu. Gerardo Maupomé is with the Oral Health Research Institute, Indiana University School of Dentistry, and The Regenstrief Institute, Inc. Christina M. Gullion is with the Center for Health Research, Kaiser Permanente Northwest. Dawn Peters is with the Oregon Health and Science University. Sally Jo Little is with the Center for Health Research, Kaiser Permanente Northwest and Pacific University, School of Dental Health Science. **Source of support:** Support provided by a contract with the Centers for Disease Control and Prevention through a contract with The HMO Group (Alliance for Community Health Plans), New Brunswick, NJ. Contract Number 200-95-0953; Task Order Number 0953-005. Support for Dr. Peters through NIDCR K25 DE14093. **Previously presented:** White BA, Little SJ, and Martin JA. Fluoridation and its impact on the use and cost of dental care. *Journal of Public Health Dentistry* 1998;58(2):181. Manuscript received: 3/6/06; accepted for publication: 5/13/07.

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One study found that in adults aged 20-34 years with private dental insurance, CWF reduced disease but may or may not have reduced the use of restorative services (12). The researchers speculated that in CWF regions with a large number of dentists, less disease and more dentist competition might have resulted in supplier-induced restorative demand. Another study used epidemiological data from national surveys to model the reduction in dental treatment and associated costs. It found that the reduction in restorative care costs as a result of averted disease attributed to CWF exceeded the cost of water fluoridation in communities of any size (15). A third study found differences ascribable to caries prevalence and community size (16). A recent study estimated costs (and savings) associated with CWF in permanent teeth, including patients' time spent while obtaining care and the cost of CWF (17). While the results were robust under a variety of assumptions, these reports did not use actual treatment experience or longitudinal restorative cost data to estimate costs and/or savings.

The objective of this study was to identify the dental treatment experiences of persons living in CWF and NF areas and to evaluate differences in dental treatment costs using a 1990-95 dataset from a dental health maintenance organization (HMO). While the data collection was contemporary, data analyses and publication were unfortunately delayed for years.

Materials and Methods

Institutional review board approval was obtained for this data-only study.

Study Population and Its Environment. Kaiser Permanente Northwest region (KPNW) is a not-for-profit, federally qualified HMO that served about 162,800 dental plan members in 1990 in Northwest Oregon and Southwest Washington. The KPNW Dental Care Program (KPDCP) offers comprehensive preventive and restorative services. Dentists, who are not employees of KPDCP, contract their salaried services exclusively to KPDCP as a self-governing, independent professional group; they use their professional judgment in deciding what care to provide, within the guidelines set by the group.

Administrative data from dental HMO subscribers and their dependents (collectively, members) were included in the study if members: a) were continuously eligible for dental services from January 1, 1990 through December 31, 1995; and b) had the then-current subscriber residence address in the Portland, OR, metropolitan area (Clackamas, Multnomah, and Washington counties), Marion County, OR (primarily Salem), or Clark County, WA (primarily Vancouver), that could be classified as having a fluoridated or NF water supply (HMO administrative data sets provide only current address, precluding ascertainment of historical changes).

Fluoridated and NF Regions. Each of the three geographic locales contained both CWF and NF water districts, and we observed three levels of fluoridation compliance across the three locales. This variation was an important factor in designing the analyses, which evaluated the contribution of locale as well as fluoridation status to costs and number of procedures.

In Clark County, water districts with CWF (primarily Vancouver) consistently had fluoride levels within the optimum range of 0.8 to 1.3 parts per million (ppm).

In contrast, in Marion County water districts (primarily Salem), CWF optimum criteria for fluoridation were only intermittently met. For 3 of the 6 years of the study period, the percentage of days each year that the fluoride level in the water supply was equal to or greater than 0.5 ppm was less than 25 percent. In only 2 of the 6 years did this percentage exceed 50 percent, and on more than 300 days in 1993, fluoride levels were lower than 0.5 ppm.

The only fluoridated water district in the Portland metro locale is the Tualatin Valley, OR. Compliance there was moderately good: the percentage of days each year that the water was fluoridated ranged from 58 to 98 percent. During 5 of the 6 study years, water was fluoridated at optimum levels (between 0.5 and 1 ppm) on at least 76 percent of the days. Thus, this area was intermediate between Clark and Marion counties in fluoridation compliance.

Fluoridation Status. To determine the fluoridation status of members, addresses of KPDCP subscribers were provided to the Metro Data Resource Center (DRC) in Portland, OR. The DRC linked water provider information to each address (geocoded) using geographic information systems. Subscribers whose address was located within 100 feet of a city, county, or water district boundary were excluded ($n = 137$). Subscribers whose address was located in a water district with a known fluoridation status were assigned to that status group. Dependents of a subscriber were classified by the subscriber's residence address locale and fluoridation status.

Outcome Measures and Variable Acquisition. Outcome measures were dental services that fluoridation could directly influence, costs and number of procedures, including prescribed fluorides, derived from KPNW administrative, dental treatment, and outpatient pharmacy databases. These databases also were used to identify continuous membership and dental office visits.

Number of Procedures. The primary utilization measure was the number of procedures per member among those with any dental visits in the 6-year period (and hence nonzero costs). We separately examined counts of restorative procedures and two primarily preventive procedures – first, pit-and-fissure sealants and preventive resin restorations (S/PRR), and second, supplemental (other than over the counter) fluoride dispensings. To measure supplemental fluoride dispensings, the KPDCP list of products containing fluoride was compared with dispensing records to determine the number of members who had any dispensings of such products during the study period (either prescribed or administered in-office).

Costs. We used nonmember fees as the basis for setting costs of all procedures listed above. Nonmember fees were those that would have been charged a non-KPDCP member who used KPDCP services in the year that the procedure was carried out. Procedure fees for all years were converted to 1995 dollars using the dental component of the Consumer Price Index (CPI). Procedure codes in the treatment database for each member were linked to the procedure fees to obtain costs for dental services and per-visit costs. The cost of supplemental fluorides was based on nonmember product and dispensing fees and converted to 1995 dollars using the drug component of the CPI. We analyzed costs after applying a normalizing transformation, the natural logarithm (ln) of $x+1$, where x was the raw dollar amount, to correct for extreme skewing. In tables and figures, estimates were converted back from ln units to dollar units for ease of interpretation.

Data Analysis. Because the three geographic locales contain both CWF and NF water districts, we have a factorial design, which allows the evaluation of the interaction of locale and fluoridation status. Because the distribution of age differed between locales, we also entered age into the models as a covariate. All analyses were carried out using SAS 8.2 (SAS Institute, Inc., Cary, NC, USA).

We used analysis of covariance models to evaluate the impact of fluoridation, locale, and age (and their interactions) on costs and utilization, with error models that matched the three types of dependent variable. Transformed (normalized) cost data were modeled using ordinary least squares (PROC GLM). Proportions were analyzed using logistic regression, and the counts of number of procedures or visits were modeled using Poisson regression (PROC GENMOD for both).

Analysis of covariance has important assumptions that we tested (18) before settling on a final model. We evaluated the assumption that the relationship between age and each dependent variable was linear; if it was not, we planned to analyze a nonlinear function of age that more accurately represented the relationship (e.g., age-squared, age-cubed). We tested two homogeneity assumptions: a) that age has the same association with outcome in all of the six groups (three locales by two fluoridation statuses) and b) that the differences between NF and CWF areas were proportional across different locales. We set α at 0.20 in tests on interactions to reduce the probability of missing an interaction that would modify interpretation of the main effects. We set α at .05 for all other tests.

When a significant interaction indicated that the assumption of homogeneous effects was not met, we followed up with estimates of the means to understand the pattern of differences better. For an interaction between locale and fluoridation status, we compared means in fluoridated versus NF areas separately for each locale. In some cases, we also examined differences between locales within a fluoridation status. If there was an interaction between age and locale and/or fluoridation status, we estimated the predicted value of the dependent variable in the six cells at three arbitrarily selected values of age, in order to illustrate how costs varied as a function of age. We selected the mean: age 10, the midpoint of the youngest 10 percent, and age 80, about the middle of the oldest 10 percent.

Results

Sample Identification. We identified 60,732 eligible members, each of whom was linked to the address of an HMO subscriber ($n = 28{,}887$). Duplicate, post office box, and "in care of" addresses, and addresses outside the study locales were eliminated, leaving 25,685 addresses. DRC was able to place 24,729 unique addresses in the water districts, which represented 51,683 dental HMO members who met all of the eligibility criteria. Table 1 shows the sample sizes by locale and fluoridation status. As of December 31, 1995, age ranged from 5 to 98 years (mean = 40.0, standard deviation = 20.3). We grouped several youngsters born on January 1, 1990 with 6-year-olds. KPNW members were predominantly (over 90 percent) a White population, consistent with the KPNW service area, and 52.3 percent were female.

Table 1
Proportions of Participants with One or More Dental Visits by Locale and Fluoridation Status, at Selected Ages

Locale	Estimated at member age	Proportion with >1 visit: NF	Proportion with >1 visit: CWF	$P<$*
Portland metro		$n = 33{,}657$	$n = 3{,}405$	
	10	0.95	0.96	0.34
	40	0.92	0.94	0.02
	80	0.85	0.88	0.08
Marion County		$n = 1{,}568$	$n = 4{,}006$	
	10	0.96	0.96	0.44
	40	0.95	0.94	0.31
	80	0.91	0.91	0.85
Clark County		$n = 4{,}264$	$n = 4{,}783$	
	10	0.98	0.95	0.01**
	40	0.94	0.92	0.01**
	80	0.83	0.86	0.07

* P-value for difference in age-adjusted proportions between NF and fluoridated, within locale, at the specified age; ** $P < 0.0001$.
CWF, community water fluoridated; NF, nonfluoridated.

Table 2
(A) Total Six-Year Costs and (B) Number of Visits for Members with One or More Visits

A. Total costs

Locale	Estimated at member age	NF ($)	CWF ($)	Difference ($)†	Model 1 P<‡	Model 2 P<¶
Portland metro		n = 30,967	n = 3,185			
	10	1,054	1,108	(54)	0.01	0.91
	39	1,224	1,300	(76)	0.24	0.01*
	80	2,101	2,253	(152)	0.07	0.73
Marion County		n = 1,482	n = 3,763			
	10	1,097	1,086	11	0.08	0.95
	39	1,236	1,200	37	0.50	0.21
	80	1,882	1,686	196	0.01	0.01
Clark County		n = 4,006	n = 4,404			
	10	1,261	1,130	131	0.01*	0.01
	39	1,408	1,287	121	0.06	0.74
	80	2,059	1,978	81	0.12	0.44

B. Number of visits (same sample as A)

Locale	Age	NF	CWF	Difference†	Model 1 P<‡
Portland metro					
	10	12.7	13.5	−0.8	0.04
	39	14.3	14.9	−0.5	0.04
	80	20.3	20.9	−0.6	0.47
Marion County					
	10	12.6	12.0	0.7	0.28
	39	13.1	13.6	−0.5	0.26
	80	18.9	16.6	2.3	0.04
Clark County					
	10	14.4	13.0	1.4	0.01
	39	14.7	14.2	0.4	0.17
	80	20.7	19.3	1.4	0.16

P-values are for the difference in age-adjusted proportions between NF and CWF, within locale, at the specified age (and in Model 2, number of visits).
* $P < 0.0001$.
† Difference is NF − CWF, negative differences (in parentheses) indicate CWF > NF. Differences may not match the NF mean − CWF mean because of rounding.
‡ Model 1 includes only age and age^2 as covariates.
¶ Model 2 includes age, age^2, and ln(number of visits) as covariates.
NF, nonfluoridated; CWF, community water fluoridated; ln, natural logarithm of cost + $1.

Tables 1 to 6 present the results of modeling for the various outcome measures. The means presented in the tables are model-based least-squares estimates. The *P*-values in Tables 1 to 6 are for the difference between members with CWF and those with NF in the specified locale; those that we judged significant are underlined. We present the predicted value of the dependent variable at three levels (low, mean, high) of age in order to illustrate how the costs or utilization varied with age. Because the subsamples vary in size and membership, they also vary in mean age.

Proportion of Members with a Dental Visit. Table 1 shows the proportion of members by locale, fluoridation status, and selected ages who had one or more dental visits during the study period (n = 51,683). The relative proportion of members with a visit at various ages differed significantly between the six combinations of locale and fluoridation status (i.e., the three-way interaction of age, locale, and fluoridation status was significant, $P < 0.09$). The *P*-values for contrasts between NF and CWF in the three locales at ages 10, 40 (the mean overall subjects), and 80 are given in the last column of Table 1. In the Portland metro area, the proportion with one or more visits was generally higher among Portland metro members with CWF than with NF, but this difference was significant only at age 40 ($P < 0.02$). In Marion County, the contrasts were not significant at any age. In Clark County, more members with NF had a visit than those with CWF overall, but the difference between fluoridation status groups is significant only at ages 10 ($P < 0.001$) and 40 ($P < 0.001$).

Cost of Dental Care. Table 2A shows the total costs over the study period for members who had one or

Table 3
(A) Proportion of Members with One or More Restorative Procedures and (B) Counts of Restorative Procedures among Members with One or More Dental Visits

A. Proportion with restorative treatment

Locale	Age	NF	CWF	Difference†	P<
Portland metro	$n = 30{,}967$	$n = 3{,}185$			
	10	0.62	0.64	−0.02	0.35
	39	0.84	0.84	0.00	0.83
	80	0.81	0.86	−0.05	0.01
Marion County	$n = 1{,}482$	$n = 3{,}763$			
	10	0.69	0.64	0.05	0.03
	39	0.84	0.80	0.04	0.01
	80	0.83	0.84	−0.01	0.67
Clark County	$n = 4{,}006$	$n = 4{,}404$			
	10	0.70	0.66	0.04	0.02
	39	0.87	0.85	0.02	0.01*
	80	0.78	0.80	−0.02	0.47

B. Estimated mean number of restorative procedures (same sample as A)

Locale	Age	NF	CWF	Difference†	P<
Portland metro					
	10	4.15	4.18	−0.03	0.80
	39	6.61	6.46	0.15	0.26
	80	12.79	11.96	0.83	0.04
Marion County					
	10	4.24	4.13	0.11	0.55
	39	6.36	6.01	0.35	0.10
	80	11.28	10.20	1.08	0.02
Clark County					
	10	5.18	4.73	0.45	0.01
	39	8.00	7.08	0.92	0.01**
	80	14.79	12.52	2.27	0.01**

* $P < 0.001$; ** $P < 0.0001$.
† Difference is NF − CWF, negative value indicates CWF > NF.
CWF, community water fluoridated; NF, Nonfluoridated.

Table 4
Six-Year Costs for Restorative Procedures among Members with One or More Restorative Procedures

Locale	Age	NF	CWF	Difference*	P<
Portland metro		$n = 24{,}418$	$n = 2{,}513$		
	10	226	268	(42)	0.01
	41	361	330	31	0.01
	80	550	483	67	0.15
Marion County		$n = 1{,}199$	$n = 2{,}892$		
	10	255	213	42	0.06
	41	302	358	(56)	0.01
	80	503	395	107	0.07
Clark County		$n = 3{,}275$	$n = 3{,}504$		
	10	293	237	55	0.01
	41	407	388	20	0.18
	80	590	523	67	0.26

* Difference is NF − CWF, negative differences (in parentheses) indicate CWF > NF. Difference may not match NF mean − CWF mean because of rounding.
CWF, community water fluoridated; ln, natural logarithm of restoration cost; NF, nonfluoridated.

more visits ($n = 47{,}807$), by locale, fluoridation status, and age. Initially (Model 1), we examined only age as a covariate. Age has a quadratic relationship with ln(costs + 1); that is, the rate of increase in costs over changing ages was relatively small before about age 40, then climbed more rapidly at older ages. There were significant three-way interactions between age-squared, locale, and status ($P < 0.01$) and between age, locale, and status ($P < 0.001$). We report predicted costs and P-values for contrasts at ages 10, 39 (the mean for this sample), and 80, which reveal the inconsistent differences between CWF and NF across locales and ages, indicated by the significant interactions. Portland metro had higher costs in CWF areas than in NF areas, the opposite of Marion County and Clark County, although not all differences are significant. Differences between CWF and NF in total costs were significant only among children (age 10) in Portland metro ($P < 0.01$) and Clark County ($P < 0.001$) (but in opposite directions), and in Marion County only in elderly members (age 80, $P < 0.01$).

Number of Dental Visits. Table 2B shows the effects on visit counts for the same factors and subject sample as in Table 2A. As for costs, age had a quadratic association with visit count, with a parallel pattern of higher frequency of visits at older ages. The three-way interactions involving age-squared and age were significant at $\alpha = 0.20$ ($P < 0.11$ and 0.09, respectively). Fit statistics indicated overdispersion of the data (higher variance than expected for a Poisson distribution), and standard errors were scaled using the deviance (generalized Poisson). We found the same overall pattern of differences in visit counts that we found in modeling costs (Table 2A). In Portland metro, members in the NF areas had fewer visits than those in the CWF areas; this was significant only at ages 10 and 39. In Marion and Clark counties, the pattern generally showed more visits in NF than CWF areas, but these contrasts reached significance

Table 5
Proportion Receiving S/PRR in Members Ages 6 to 17 Years Old with One or More Dental Visits

Locale	Age	NF	CWF	Difference†	*P*<
Portland metro		*n* = 6,706	*n* = 747		
	8	0.51	0.59	−0.08	0.02
	12	0.70	0.81	−0.11	0.01**
	16	0.51	0.70	−0.19	0.01**
Marion County		*n* = 298	*n* = 822		
	8	0.57	0.65	−0.08	0.17
	12	0.76	0.78	−0.02	0.47
	16	0.57	0.56	0.01	0.71
Clark County		*n* = 1,003	*n* = 986		
	8	0.73	0.67	0.06	0.08
	12	0.89	0.85	0.04	0.01*
	16	0.84	0.76	0.08	0.01

* $P < 0.001$; ** $P < 0.0001$.
† Difference is NF − CWF, negative value indicates CWF > NF.
CWF, community water fluoridated; NF, nonfluoridated.

only at age 80 in Marion County and at age 10 in Clark County.

We hypothesized that differences in the number of dental visits might account for the differences in costs noted in Table 2A. Therefore, we added visit count as a covariate in the costs model (Model 2). The three-way interactions of age-squared, age, and visit count with locale and status are all significant at $\alpha = 0.20$ ($P < 0.01$, 0.01, and 0.08, respectively). In Portland metro, the effect of adjusting for visit count was a shift in the age at which significant differences were observed, from age 10 ($P < 0.91$) to age 39 ($P < 0.001$). No other change in the pattern of significance was observed.

Prevalence and Volume of Restorative Procedures. Table 3A shows the proportion of members with one or more visits who had a restoration ($n = 47{,}807$). The association of this proportion with age is quadratic; in this outcome measure, the proportion having visits increased from youth to middle age, then either stopped increasing or decreased in older members. The three-way interactions were not significant, but all two-way interactions were significant (locale × status, $P < 0.001$; age × status, $P < 0.17$; age × locale, $P < 0.03$; age-squared × status, $P < 0.08$; age-squared × locale, $P < 0.02$). In Portland metro, proportions receiving any restorative treatments were the same or higher in the CWF areas than in the NF areas, but only among older members is this significant (age 80, $P < 0.01$). In contrast, in Marion and Clark counties, members aged 10 and 39 (the mean for this sample) in NF areas were significantly more likely to have a restoration than were members with CWF (see Table 3A for *P*-values); at age 80, the NF and CWF areas did not differ.

The number of restorative procedures (Table 3B) in the same sample was significantly higher among older members living in the NF areas in all locales. In Clark County, the difference (NF > CWF) was significant at ages 10 and 39 also. The form of the association with age was linear (increasing steadily with age), and the three-way interaction was not significant, so only two-way interactions with age were included in the final model (locale × fluoridation status, $P < 0.01$; age × locale, $P < 0.05$; age × status, $P < 0.12$). The fit statistics indicated overdispersion of the data, and the standard errors were scaled using the deviance (generalized Poisson).

Cost of Restorative Procedures. We evaluated whether costs of restorative procedures were related to fluoridation status in members who had at least one restoration ($n = 37{,}801$). Figure 1 displays mean restorative costs [estimated on ln(restoration cost) and converted back to dollars] on age deciles calculated in the whole subsample. Decile points close together indicate a high density of members in that age range, whereas those far apart indicate that there are relatively few members in that age range. As the figure shows, the form of the association with age appears to be cubic, with decrease from early years to teens, increase during the middle years, and decrease or flattening late in life. The three-way interactions of locale and status with the three age terms were all significant (age-cubed $P < 0.001$, age-squared $P < 0.001$, and age $P < 0.001$). As shown in Table 4, model-based means at ages 10, 41 (the mean for this subsample), and 80 indicate a complex pattern. In Portland metro, the pattern of differences between NF and CWF areas is significant but inconsistent at ages 10 (CWF > NF) and 41 (CWF < NF). In Clark County, only at age 41 was there a significant difference (CWF > NF). In Marion County, significance was seen only at age 10 (CWF < NF). The oldest members had the highest restorative costs and the largest NF–CWF differences; however, with small *n*s and larger standard errors, fluoridation status did not contribute a significant effect in any locale. We observed the same pattern of results when we excluded S/PRR from restorative costs.

S/PRR. Table 5 shows the association between age and proportion receiving S/PRR in the age range 6 to 17. The association of age with S/PRR is quadratic. Use of S/PRR peaked at about ages 12-14 and then declined among older teens. No two-way or three-way interactions involving age-squared significant, although age-squared by itself was significant ($P < 0.0001$). The three-way interaction involving age was significant ($P < 0.03$). In Portland metro, significantly more children in the CWF area received S/PRR than in the NF area (age 8 $P < 0.01$, age 12 $P < 0.001$, age 16 $P < 0.001$). The opposite pattern

Table 6
Supplemental Fluoride Dispensing among Child Members with One or More Dental Visits

	NF			CWF		
Locale/age group	n	Proportion with 1+ dispensings	Mean (SD) number of dispensings*	n	Proportion with 1+ dispensings	Mean (SD) number of dispensings*
Portland metro						
6-11	2,734	0.52	3.8 (4.2)	322	0.22	2.8 (3.4)
12-17	3,972	0.14	2.8 (3.7)	425	0.04	2.9 (3.5)
Marion County						
6-11	120	0.36	3.1 (2.8)	338	0.07	1.8 (1.3)
12-17	178	0.12	1.3 (0.9)	484	0.03	1.3 (0.6)
Clark County						
6-11	387	0.27	2.6 (2.8)	394	0.12	2.8 (3.2)
12-17	616	0.07	2.9 (3.5)	592	0.02	2.6 (3.4)

* Among members with one or more dispensings.
CWF, community water fluoridated; NF, nonfluoridated; SD, standard deviation.

was found in Clark County (significant at ages 12, $P<0.001$, and 16, $P<0.01$), which also had a markedly high prevalence of S/PRR use overall. In Marion County, the NF–CWF difference was not significant at any age.

Supplemental Fluoride Dispensing. Among members who had one or more dental visits ($n=47,807$), about 7 percent in the NF areas and 2 percent in the CWF areas had at least one supplemental fluoride dispensing. Table 6 shows the percentage of members in the 6 to 11 and 12 to 17 age groups who received supplemental dispensings, and the mean number of dispensings. Less than 2 percent of members over 18 years of age received any dispensings. In the NF group, 48.5 percent of 6- to 11-year-olds and 12.8 percent of 12- to 17-year-olds received one or more supplemental dispensings. In the CWF group, 13.6 percent of 6- to 11-year-olds and 2.9 percent of 12- to 17-year-olds received one or more supplemental dispensings. Among members with NF water who received one or more dispensings, means ranged from 3.82 dispensings for 6- to 11-year-olds in Portland metro to 1.29 for 12- to 17-year-olds in Marion County. The cost of supplemental dispensing was small – less than 0.1 percent of total costs.

Preventive Procedures and Restorative Services. We evaluated whether a) the number of restorative procedures and b) restorative costs in children (ages 6 to 11 or 12 to 17) with one or more restorations could be predicted by fluoride dispensings or placement of S/PRR. These two models (not shown) controlled for fluoridation status and locale. We found that S/PRR was significantly associated with the number of restorations in both the 6- to 11- and 12- to 17-year-old groups ($P<0.001$). However, the direction of the association was the opposite of what we would have expected – in every locale and fluoridation status, children with S/PRR had more restorations. Costs were not consistently higher in NF than CWF areas. There were significant two- and three-way interactions in all four models, making it difficult to generalize the specific contribution of these interactions beyond confirming the overall substantial association with S/PRR use.

Discussion

This project evaluated the impact of CWF on treatment and associated costs for a group of HMO members in the US Northwest between 1990 and 1995. In terms of total costs of dental treatment (Table 2A), Portland metro had lower treatment costs for the NF area, while the other two areas showed costs marginally higher for the NF status. For the intermittently fluoridated Marion County and the consistently fluoridated Clark County, CWF was generally associated with lower costs.

The ordering of treatment cost and utilization in CWF areas was not consistent with their ordering on compliance with intended fluoridation levels. The fact that Clark County, the most reliably fluoridated locale, often had the highest costs overall, the highest number and cost of restorative procedures, and the highest number of S/PRR (Tables 2A, 3B, 4, and 5) suggests that characteristics of members in these communities rather than fluoridation of water may be the primary driver of dental utilization. This is consistent with the overdispersion observed in counts of visits and of procedures, which can result when unobserved variables (i.e., important predictors of utilization) are missing from a model. Theoretically, the variance should equal the mean of a Poisson-distributed variable. In these data, however, the variance was much larger. One possible way to improve model fit is to add covariates that might account for more of the variance. It was beyond the scope of the present study to identify these, and so this remains a potentially fruitful area of inquiry. Candidates for inclusion as covariates include socioeconomic status (SES), chronic health conditions, and long-term use of medications leading to salivary gland hypofunction.

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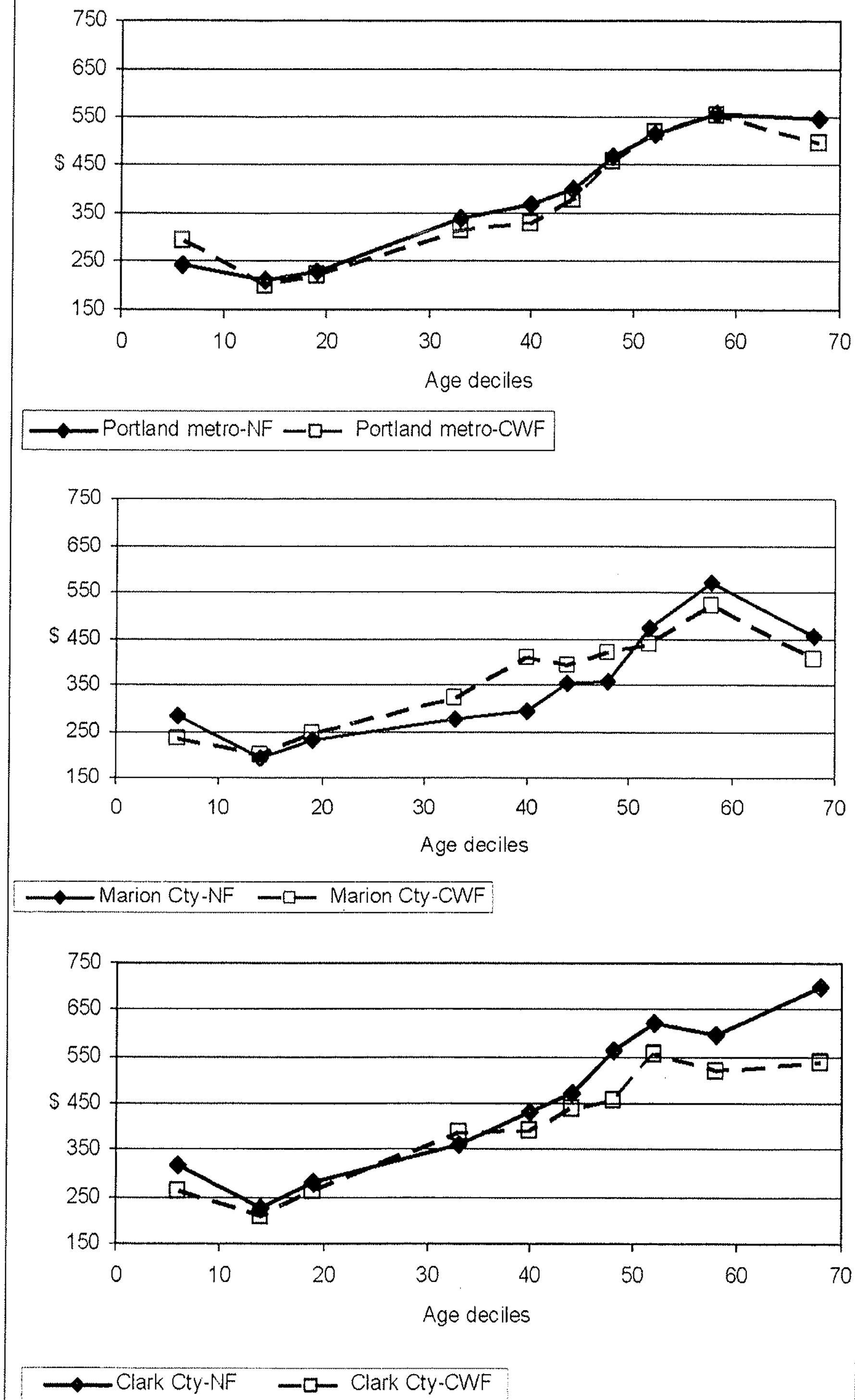
Figure 1
Age group breakout of restorative costs by locale and fluoridation status (exponentiated average natural logarithm of restorative costs). CWF, community water fluoridated; NF, nonfluoridated



Dentists' decisions on treatments and preventive services may also be affected by knowledge of the member's home fluoridation status. The extent of this effect was beyond the scope of this data-only study. The fact that dentists were all members of one group-model practice seems likely to ameliorate differences in practice decisions and thus minimize such impact.

Differences in caries experience between NF and CWF locales may have been diluted by variations between NF and CWF groups with respect to two preventive therapies. First, far more children in NF areas received one or more supplemental fluoride dispensings than did those in CWF areas (Table 6). The fluoride treatments received by children in NF areas could thus reduce the experience of caries and lessen the differences between NF and CWF. Such treatments also could signal better knowledge and behaviors related to dental and general health in their recipients or their families. Also, the application of S/PRR among members 6 to 17 years of age was dramatically greater than that reported in national surveys (19) – 60.6 percent in the NF regions and 70.5 percent in the CWF regions had at least one S/PRR. Differences between NF and CWF areas for S/PRR were inconsistent between locales, however. This situation may be partly attributable to some pediatric dentists who were particularly aggressive in their use of S/PRR during this time period. As indicated earlier, children with S/PRR had more restorations than those without S/PRR for each combination of locale and fluoridation status; hence, the use of S/PRR may depend to a large extent on observed caries risk regardless of fluoridation status, as previously reported (20).

In the CWF area of Clark County, where fluoridation compliance was good, overall costs were lower than in the NF area of Clark County. The same relationship held within Marion County, although the effect of fluoridation here was only marginally significant when not controlling for number of visits. Marion County differs from Clark County in the age at which the impact of water fluoridation is strongest: in Marion County it is in the oldest members, whereas in Clark County it is in the youngest members. In Portland metro, there was no evidence of a beneficial effect of fluoridation on total costs; in fact, costs were generally higher among members living in the CWF than in the NF districts of the metropolitan area. (However, as noted, the Portland metro area's CWF compliance with guideline levels was not optimal.)

Across the three locales, the overall differences in total costs with one or more dental visits between the CWF and NF areas (NF – CWF) ranged from *negative* $152.31 (Portland, age 80) to $196.02 (Marion County, age 80). (Note that *negative* in this context connotes the direction of the relationship between CWF and NF – see table legends). The cost of the supplemental fluoride dispensing was not included in the comparisons of total dental cost. If included, the difference in mean total cost per person with one or more dental visits would increase by $0.94 over the 6-year period. Restorative cost differences (NF – CWF) per member with at least one dental visit over the study period ranged from *negative* $55.94 (Marion County, age 41) to $107.26 (Marion County, age 80). Taking into consideration the varying impact of age and locale, it seems reasonable to conclude that, as a general rule, costs were lower in the fluoridated areas.

As expected, total restorative costs increased with member age. The youngest and oldest members in the CWF areas had lower restorative costs and lower overall costs than same-age members in NF areas. Of note, in the older half of our sample (ages 43 to 98), mean difference in costs between the CWF and NF areas increased steadily and was highest in the 10th decile, centered at age 75 (NF > CWF, about $75, unweighted means across locales on deciles of age, Figure 1). The higher costs in older adults probably were associated with several factors, including use of anticholinergic medications, gingival recession and emergence of root caries, and impaired ability to practice self-care derived from frailty and illness in the oldest members (those over 90, for instance). We had no diagnostic codes available to investigate these possibilities, but against these risk factors, fluoridation appears to have some protective effect.

Various methodological considerations suggest that our findings may not be directly generalizable to the overall US population. The participants were primarily a relatively stable group in terms of employment. Having health insurance in the United States, in particular dental insurance, greatly depends on having employment. About 92 percent of members had one or more dental visits during the study period, with an average of more than two visits/year. Given what is known from national surveys, this population may be at relatively lower risk for dental disease and is likely to have higher-than-average dental utilization. (Generally speaking, the effect of CWF may be larger on persons with less stable employment and housing and lower SES.) Thus, if CWF were to have an effect on dental disease in an HMO population, one might expect the effect to be small.

This study was further limited by having available HMO pharmacy data restricted to what was already available for other purposes. While clinical records and diagnostic criteria were not standardized, quality audits and guidelines were in place. Because only disease recorded and/or treated can be ascertained, early or subclinical stages of disease may not have been recorded.

Another caveat is that our data do not capture actual time spent living in a particular water district (whether CWF or NF) because our administrative records included only members' current address. (Taking this discussion to the extreme, we could argue that water fluoridation status of school or place of work might differ from that of home, but the impact of this unknown factor is impossible to gauge in the current study design.) However, there may not have been much moving between water districts as this sample of HMO members with stable dental benefits over 5 years are also unlikely to have moved very far during this period. We are aware that fluoride levels fluctuated over time and varied between locales. However, the CWF areas in the three locales were not ordered consistently with the level of fluoridation compliance, indicating that such compliance accounts for little of the variation observed between locales. Examining the reasons for the fluoride-level fluctuation over time and across locales is beyond the scope of the present study.

A strength of our sample and our study is that data from a group-model HMO are likely to exhibit less variation in clinical decisions, patients' deferral of needed treatment because of out-of-pocket cost, and potential for overtreatment decisions than data from other systems of organizing and financing dental care – the opposite of limitations noted/assumed in previous studies (17,21). Furthermore, use of bottled water was much less popular in the 1990s, and thus the relative importance of this factor in overall exposure to CWF in the 1990s was probably less important then, compared with what it is today. Another strength is that although these data represent costs and utilization that occurred more than a decade ago, the practice of dentistry, such as the availability of effective preventive treatment, has varied relatively little since then. There has been sparse research addressing this question in a sample of comparable size in the United States.

In conclusion, we found evidence that CWF was associated with reduced total and restorative costs among members with one or more dental visits, particularly in older adults. The effect we observed was generally small, likely because of this insured population's access to care and the higher use of preventive procedures, in particular supplemental fluorides, in the NF areas. Differences in treatment costs (savings) associated with CWF should be estimated and included in future cost-effectiveness analyses of CWF. Direct cost of CWF, based on equipment replacement costs, was estimated to be ~$0.67 person/year in 1989 and ranged from $0.15 to $1.53 (converted to 1995 dollars) (22). Reductions in dental treatment costs in the CWF areas compare favorably with the estimated costs of CWF (15,23-25), suggesting that CWF may in fact have been cost saving at the time the study was carried out.

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Children First for Oregon

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Mayor Adams and Commissioners,

My name is Stacy Michaelson. I am a Policy Associate at Children First for Oregon. We work to improve the lives of all children and families through long-term systemic changes. We support public policies and programs that keep children and families healthy and safe. And this is why we endorse water fluoridation.

Portland is the largest city in the US that does not yet fluoridate its water, and this is damaging the health of children and families. Fluoridation is a sound, evidence-based public health policy that reduces tooth decay by about 25 percent across the population. It is the best form of prevention: it is safe, it reaches everybody, it is highly cost-effective, and it works. There is no down-side.

Oregon's childhood tooth decay rates are among the worst in the nation. This is true among all income groups, and even worse among the least privileged. Our children, at 35 percent, have more than double the rate of untreated cavities as children in Washington, at 15 percent. While Oregon and Washington children have the same rate of access to dental healthcare, at 58 percent, the major difference between the two states in that most of Washington is fluoridated and most of Oregon is not.

Tooth decay is a major reason why children miss school and have difficulty learning, which in turn affects their ability to succeed in life. National data show that low-income children miss 12 times more school days due to tooth decay than children in higher income families. Low-income children suffer twice the rate of untreated tooth decay and are three times more likely to suffer rampant decay, which means seven or more decayed teeth. Water fluoridation would prevent these cavities before they start, halt their progress, and even help reverse the damage.

Addressing the dental health crisis is crucial to addressing the cycle of poverty. Tooth decay interferes with learning and poses a major financial burden on families who are already struggling. Dental health care accounts for 30 percent of all childhood healthcare costs. Emergency dental care is expensive, and can cause parents to miss work and jeopardize their jobs. Many low-income workers do not have any paid leave. Children who grow into adults with missing teeth have greater difficulty finding and keeping jobs. Water fluoridation is a preventive strategy that would reduce these burdens and help keep families on their feet.

Water fluoridation is far less expensive than school programs, which are too costly to serve all children and do not reach children before they enter kindergarten. Unlike brushing your teeth or taking tablets, water fluoridation provides protection throughout the day, constantly maintaining a low level of fluoride in the mouth that neutralizes the acids that eat away at your tooth enamel.

Water fluoridation reduces tooth decay by about 25 percent in both children and adults, over and above dental care, diet, and brushing and flossing. Regardless of age, income, or access to dental care, water fluoridation would be a "win" for all Portlanders.

185612 PROVIDENCE Health & Services

Providence Health & Services –Testimony in support for City of Portland water fluoridation

Dear Commissioners Fish, Fritz, Leonard and Saltzman,

Providence Health & Services takes great pride in supporting efforts that improve the health of our communities and with a special concern for those that are our most vulnerable neighbors. As part of this work we continually focus on implementing the Triple Aim objectives of improving health outcomes, enhancing patient experience, and making care more affordable for the whole community. Good oral health is part of that vision.

Currently, one in five Oregon children have 7 or more cavities, making oral disease and premature tooth loss the number one preventable disease among our children. If 20% of our children had the swine flu – we would call it a pandemic and call for international relief agencies to help us treat them. Fortunately, we have easier remedies at hand in fluoride.

Oral health and water fluoridation is a social justice issue that adversely impacts disadvantaged populations in Portland. In 2011 Providence completed a Community Health Needs Assessment to help focus our community benefit efforts. One of the most striking findings from the CHNA was that more than three-quarters (77%) of the low income and vulnerable individuals surveyed reported that they did not get the dental care they needed in the last six months.

We see the suffering caused by untreated dental disease every day in our Emergency Departments – where dental pain and dental disease is the most common complaint of community members coming to our emergency rooms for non-emergent care. In 2011, we saw over 3,000 visits to our Portland area Emergency Departments for dental disease – and as a health system, we have very limited options to assist these community members. The cost of providing this care last year exceeded $660,000.00. And again, this is by no means complete care but antibiotics and pain management until the appropriate care can be found. This unmet need for dental services is even more profound among communities of color and those who are poor, who frequently seek emergency dental care services through hospital emergency departments because that is their only option.

Access to fluoridated water is a simple, safe and effective public health intervention that will improve oral health for all persons in our city, particularly the poor and vulnerable. For this reason, Providence strongly supports this effort to bring Portland into the public health mainstream by fluoridating the public water system.

Providence thanks you for your consideration of this simple, safe and effective public health intervention. We look forward to supporting the city in this and future goals that bring increased value and improved quality of life to all members of our community.

Respectfully submitted,

Priscilla Lewis,
Executive Director of Community Services
Providence Health & Services

My name is Carlos Crespo, and I am the Director of the School of Community Health at Portland State University and Director of a World Health Organization Collaborating Center in Urban Health Sustainability. I also serve in the board of the Oregon Public Health Institute, Oregon Latino Agenda for Action, and the Oregon Health Policy Board. My comments represent my most objective and scientific opinion as a public health practitioner for more than 20 years.

1. Water fluoridation is a safe and effective intervention to prevent tooth decay, especially among members of the community that do not have access to oral health care.
2. More than 72 percent of the U.S. population served by public water systems has access to fluoridated water without any adverse effects.
3. Fluoride has beneficial effects on teeth at low concentrations in the drinking water.
4. Dental caries disproportionately impact those living below the poverty line. Children living below the poverty level have a 75 percent higher rate of dental caries when compared with the general population.

I believe water fluoridation will have a positive impact in improving the state of oral health for all members of the community.

Testimony for the Public Record submitted 09/06/12
A Plea for Justice and Individual Private Rights

Claire Darling Andrews
contrabandcuisine@canby.com
503.317.4873
8215 S Vale Garden Rd., Canby, OR 97013
11501 SW Pacific Highway, #100-08, Tigard, OR 97223

To: Mayor Sam Adams; Council Members: Randy Leonard, Amanda Fritz, Nick Fish, and Dan Saltzman

My name is Claire Darling Andrews. I am a native Portlander. I recently moved to a home with a well, but my daughter, parents, clients and friends are still on Bull Run water. I'm here because I care about our Watershed and all the people and other creatures that live here. I grew up believing in all kinds of wonderful traditions like Family Planning, Honoring Diversity, Women's Suffrage, and Water Fluoridation. In the mean time, however, I've re-examined some beliefs I used to have in light of new information and new perspectives. **I've actually changed my mind on a number of issues, including water fluoridation**, (though I still support women's right to vote). We are all free to change our minds in light of new information and new perspectives.

I'mproud to be a Portlander. I'm proud that this City Council has made efforts on behalf of education and the arts. My heart glows all warm and fuzzy that Portland has a reputation for being progressive and tolerant. We have houseless citizens, but we also have Street Roots and Dignity Village. We have struggling veterans, but we are home to the Returning Veterans Project. We support the Food Bank with our incomparable Blues Festival every summer. We have Free Summer Concerts in the parks, Shakespeare, Guardian Angels, KBOO, Occupy, outrageous farmers markets and amazing restaurants supporting small local farmers. Sisters of the Road says it best though I'm paraphrasing, "Portland is full of friends we've never met". I feel like we all belong here. I feel welcome and at home here. We share a history that includes environmental protections and social justice. We Portlanders CARE about each other.In many ways Portland does a great job of feeling like an enormous Village.

That's why I'm heartbroken by the manner in which this issue has been handled. Excluding one side of a conversation is not a good way to achieve creative solutions to complicated problems. It's not a good way **to honor diversity of biology or belief**. Child poverty, poor nutrition status, economic hardships for families are not easy or simple problems to solve. We need more stakeholders chiming in with ideas, needs, desires, goals and creativity, not fewer. Adding fluoridation chemicals to everyone's bathing, drinking, flushing and showering water will not resolve the issues of poverty or malnutrition facing our children or our elderly. I wish it were that easy, but it isn't.

What good is any policy or program if the wayto it has been paved by silencing respectful dialogue and censoring objective debate and creative solution forming? Offering me 2 minutes is not letting me "have my say". It's aninsult to due process and the principles of fair governance.

Portlanders respect private rights to marry, regardless of sexuality. Why would we respect private rights in the bedroom, but not private rights in the kitchen?

Please reconsider your positions to fluoridate our shared water supply before you vote next week.

Respectfully submitted,
Claire Darling Andrews.

PDA
PERMANENTE
DENTAL ASSOCIATES

185612

September 6, 2012

RE: Support for Water Fluoridation

Mayor, City Commissioners of Portland,

My name is Dr. John Snyder. I am the Dental Director and CEO of Permanente Dental Associates. I lead a dental practice with more than 130 dentists that provide care in 17 Kaiser Permanente dental offices from Longview to Salem.

With all due respect, and as a dental professional, I must point out that we have just heard a lot of misinformation. I have read the research on water fluoridation, and I can tell you there is no evidence showing that optimal water fluoridation causes a single health problem. Opponents to fluoridation have raised a long list of possibilities, but the science doesn't bear them out. At optimal levels, the only health outcome is fewer cavities.

If water fluoridation did any of these things, we would see it in the populations that have water fluoridation. Public health, medical, and dental professionals are obligated to protect and promote health, and that is why we support water fluoridation.

The fact is, fluoridation has been thoroughly researched. There have been over 3000 articles and 65 years of experience with fluoridation in this country. It is supported by the World Health Organization and is used in many countries around the world. Water fluoridation is one of the most basic, common-sense public health services there is. When evaluating a public health intervention, we must look at the evidence. We must look at the science. We cannot base public policy on websites set up to scare people.

We cannot solve the oral health crisis in our community by simply filling more holes in teeth. We must focus on prevention. Water fluoridation is the most cost-effective and most equitable way to reduce tooth decay across the community.

The practice is safe, effective, and economical. In light of Portland's current oral health crisis, water fluoridation offers a clear cut path to curbing cavities, reducing dental pain, and preventing tooth loss for thousands of Portlanders, especially children.

John F. Kennedy stated during his presentation at Yale University on June 11, 1962: "The greatest enemy of truth is very often not the lie—deliberate, contrived, and dishonest, but the myth—persistent, persuasive, and unrealistic." Please do not allow the myths around community fluoridation to prevail.

Water fluoridation is one of the greatest public health achievements of the last century. And now it's time to bring it to Portland. Your support will make water fluoridation one of the greatest public health achievements in our community, too.

Thank you for your support,

John Snyder, DMD

Health Department
MULTNOMAH COUNTY OREGON

Office of the Director
426 SW Stark Street
Portland, Oregon 97204
(503) 988-3674 phone
(503) 988-3676 fax

185612

Testimony of Dr. Gary Oxman, Multnomah County Health Officer

Portland City Council, September 6, 2012

Mayor Adams, Members of the City Council:

I'm Dr. Gary Oxman, Health Officer for Multnomah County. Thank you for the opportunity to testify today. I am here to express Multnomah County's strong support for the proposal before you to fluoridate Portland's water supply. Multnomah County Health Department supports fluoride as an evidence-based practice for preventing tooth decay. The Multnomah County Commissioners, who serve as the County Board of Health, informed you of their support in a letter dated August 29th.

Poor oral health is not a simple matter of getting a cavity and having it filled at a routine dental visit. For many in our community, cavities and their complications impair daily functioning. For children, cavities cause pain and interfere with good nutrition. Cavities can interfere with successful participation in school. For adults, missing and decayed teeth can limit job opportunities, impair job performance, impact financial status, and interfere with living a healthy, productive life.

One of the things we know about poor oral health is that it is not evenly distributed in our community. Data from the metropolitan area shows that poor oral health is more common in neighborhoods with lower economic status. Other research has shown that children whose parents have a lower level of education, and people who face financial barriers to receiving dental care are also at higher risk for cavities. Community water fluoridation is fair; it makes the health benefits of fluoride available to all community members.

I expect that you will hear a wide range of testimony today about the safety and effectiveness of water fluoridation. The following is a very brief summary of what mainstream science says about community water fluoridation.

First, community water fluoridation is effective. It decreases the number of people in the community who have decayed, missing or filled teeth, and increases the number who are cavity-free. These results have been seen since water fluoridation began in the 1940's and 1950's. More recent systematic reviews that are based on multiple studies in the US and elsewhere show that community water fluoridation still makes an important contribution to oral health. This occurs even with the widespread availability of fluoride through other sources such as toothpaste and foods and beverages manufactured in communities with fluoridated water.

Public Health
Prevent. Promote. Protect.

Second, fluoride is safe. The one adverse effect of fluoridation that is consistently observed is dental fluorosis - a discoloration and pitting of teeth that results from excessive fluoride exposure during certain stages of tooth development. About 22% of children have some fluorosis. The great majority of cases – about 21% – is not apparent to the person with fluorosis or to others. A little over 1% have fluorosis of a degree that obviously impacts the appearance of the teeth.

None of the other health concerns related to fluoride have been verified by rigorous scientific scrutiny despite generations of people consuming fluoridated water. Concerns about adverse health effects are no reason to delay. Instead, a responsible public health approach is to move ahead with fluoridation, and continue to actively seek out and evaluate emerging scientific evidence about potential adverse consequences of fluoridation.

Thank you again for the opportunity to speak to you today. I will be happy to answer any questions you have.

185612

September 6, 2012

My name is Dr. Teran Colen. I am here today as a physician, a parent and SE Portland community member. I strongly support the fluoridation of our water supply.

I work as a Radiologist at Kaiser Permanente. I diagnose and follow cancer patients almost on a daily basis. Throughout my career at Kaiser, during my training at Harvard Medical School and elsewhere (University of Washington and Stanford University), I have never seen, been involved with or even heard about a single case of cancer or osteosarcoma being subscribed to water fluoridation. Despite *being* a Harvard-trained physician, it is not prudent to hold off one of the top ten public health advances of the 20th century due to a flawed, partial study from any one institution. The CDC, US Public Health Service, National Research Council have all examined dozens of human studies WITHOUT concluding a link between optimal water fluoridation and cancer.

As a physician at Kaiser, I strongly believe that prevention, more than anything else we do in medicine is ultimately what saves lives and makes people healthier. Fluoridation is safe, effective, and lowers health care costs.

As a father, if I had even the slightest concern that fluoride in our water supply would give my wife cancer or lower the IQ of our children, I would not support it.

I want to thank Upstream Public Health, the Portland City Council, Mayor Sam Adams, and Governor Kitzhaber for demonstrating leadership on this important issue affecting our communities, especially the most vulnerable among us.

Thank you.

Dr. Teran Colen

185612

September 6, 2012

As a new member of the Portland community and a new parent, this issue really hits home for me.

I have always lived in communities with a fluoridated water supply and frankly, have taken it for granted.

I was both shocked and dismayed when I found out that Portland denies its residents access to fluoridated water, and for reasons I truly don't understand.

When I moved to Portland in 2009, I was 32 years old and had never had a cavity in my life. When I first went to see a dentist in Portland, he looked in my mouth and immediately said, "You must not be from around here. You don't have Portland teeth!"

That was surprising. It was also the first time I realized something bad was going on with Portland's dental health.

It's now 2012. After 3 years of living in SE Portland, I now have my first cavity. I get regular dental care and take very good care of my teeth and gums. The only thing that has changed is that I no longer have access to fluoridated water.

As a new mom, I now am far more concerned about my children's dental health than my own.

I work in public health and I am married to a Kaiser physician. ~~We are both people of color~~. I come from a family of immigrants and my husband is African American. Both of us have parents who have suffered from ill effects of poor dental health. My husband and I both have healthy teeth and gums, but now we are concerned that our children won't-- simply because of where we live.

We shouldn't be moving backwards when it comes to dental health.

Thank you for your time.

Claudia Colen
CLAUDIAZONE@YAHOO.COM

PUBLIC HEALTH DIVISION
Office of Disease Prevention and Epidemiology
John A. Kitzhaber, MD, Governor

185612

Oregon Health Authority
800 NE Oregon Street
Portland, OR 97232
Voice: (971) 673-1222
FAX: (971) 673-1299
Nonvoice – TTY: (971) 673-0372

September 6, 2012

TO: Mayor Sam Adams
Portland City Council members

FROM: Katrina Hedberg, M.D., M.P.H.,
State Epidemiologist, and Chief Science Officer
Public Health Division, Oregon Health Authority

Subject: Support for fluoridation of Portland's drinking water

Mayor Adams and Portland City Council members; I am Dr. Katrina Hedberg, State Epidemiologist and Chief Science Officer at the Public Health Division of the Oregon Health Authority. I am here today to offer strong support for fluoridation of Portland's drinking water as an evidence-based method to prevent tooth decay.

Tooth decay is a serious problem and fluoridation is an effective, affordable and, most importantly, ***safe*** way to improve the public's health. It is also consistent with the state's effort to focus health care on prevention rather than after-the-fact acute care.

Despite Oregon's advancements in improving health and access to health care services, we rank 48th among states in the percent of our population on fluoridated public drinking water systems.

As a result, we are in a dental health crisis in Oregon. Our "Smile Survey" results show that among Oregon first- through third-grade children, 64 percent of kids had cavities, 36 percent had untreated tooth decay, and 20 percent, or one in five, had rampant decay (seven or more decayed teeth). We rank near the bottom of states in the U.S. on children's dental health.

Community water fluoridation can make huge improvements in oral health. Fluoridation is the most important intervention we have at our disposal to ensure optimal dental health in the community, particularly of children.

Thank you for the opportunity to testify.

Jonathan Eder @hotmail.com (503)415-8803

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185612

Fluoride content of solid foods impacts daily intake

Scott J. Rankin, DDS, MS[1]; Steven M. Levy, DDS, MPH[2]; John J. Warren, DDS, MS[2]; Julie Eichenberger Gilmore, PhD, RD[3]; Barbara Broffitt, MS[2]

1 US Army, Fort Sam Houston, San Antonio, TX
2 College of Dentistry, University of Iowa, Iowa City, IA
3 Institute for Clinical & Translational Science, University of Iowa, Iowa City, IA

Keywords
fluoride content; solid foods; daily intake; fluorides; eating.

Correspondence
Dr. Scott J. Rankin, US Army, 2050 Worth RD, MCDS, Fort Sam Houston, TX 78249. Tel.: 210-221-7839; Fax: 210-221-8810; e-mail: scott.rankin@us.army.mil. Steven M. Levy, John J. Warren, Barbara Broffitt are with the College of Dentistry, University of Iowa. Julie Eichenberger Gilmore is with the Institute for Clinical & Translational Science, University of Iowa.

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Abstract

Objective: To determine the amount of fluoride received from solid foods for a cohort of children.

Methods: Parents were asked to complete questionnaires for the preceding week and dietary diaries for 3 days for their children. Data collected at 6, 9, 12, 16, 20, 24, 36, 48, and 60 months were analyzed cross-sectionally.

Results: At 6 months of age, children ingested an estimated mean of 8 percent of dietary fluoride from solid foods. At 12 months of age, children ingested an estimated 39 percent of dietary fluoride from solid foods. Although the percentage of fluoride intake from solid foods stabilized from 24 to 60 months (means of 36-39 percent), some children received as much as 85-88 percent of their dietary fluoride from solid foods.

Conclusions: Some children receive a substantial portion of dietary fluoride from solid foods.

Despite the advances in oral health care, dental caries remains one of the most common chronic diseases (1). Fluoride has been established as one of the most important preventive tools against dental caries. Public water fluoridation and the availability of fluoridated water have been associated with a great decline in the prevalence of dental decay for many populations and have been credited with being one of the greatest disease prevention methods of all time (2). The US Centers for Disease Control and Prevention has listed water fluoridation as one of the 10 great public health achievements of the 20th century (3).

Current evidence suggests that fluoride prevents caries primarily through its presence in the oral cavity and that its primary mechanism of action occurs posteruptively (1). Fluoride helps to prevent demineralization and to promote remineralization of early carious lesions. Due to fluoride's posteruptive effects, exposure to low levels of fluoride provides dental benefits to people of all ages.

Exposure to high levels of fluoride can lead to the development of dental fluorosis. Dental fluorosis is the result of excessive systemic intake of fluoride during enamel formation. Due to the fact that fluorosis can only occur during enamel formation, it is important to better understand the fluoride intake of young children (1). Excessive intake of fluoride can come from dietary sources (water, foods, and other beverages) and non-dietary sources, such as ingested toothpaste. There is evidence that the prevalence of dental fluorosis has increased (4).

Early researchers empirically determined and described an "optimal" fluoride intake of 0.05-0.07 mg of fluoride per kilogram of body weight (F/kg bw) (5-7). McClure estimated that children who ingested water optimally fluoridated at 1.0 ppm, in addition to other dietary sources, received about 0.05 mg F/kg bw, which later became the basis for the so-called "optimal" fluoride intake. It is unclear exactly how the upper limit of that range came into existence. This range has since been designated or stated as the optimal level for fluoride intake by many researchers, although there has been no scientific validation of this range for being considered "optimal." There has never been a clear definition as to what the range is optimal for; is it for caries prevention or is it for the prevention of fluorosis?

This "optimal" range was estimated before the widespread use of topical fluorides and other fluoride exposures, and prior to the generalized, widespread distribution of beverages. Historically, tap water has been the primary source of fluoride for most children. However, with improved access to a wide variety of other beverages, water may no longer be the primary beverage consumed. Contemporary US dietary intakes suggest there has been an increase in the consumption of prepackaged foods and beverages, and children are now exposed to a wide variety of fluoride containing foods, beverages, and supplements (8,9). It is important to look at many of these different sources of fluoride intake in light of the increasing prevalence of dental fluorosis and greater emphasis on esthetic perceptions currently being seen in the United States and other developed nations (4).

In 1997, the Institute of Medicine (IOM) released its upper limit recommendations for dietary intake of fluoride (10). The upper limit is defined as the level below which there is unlikely to be any adverse health effects in healthy people. The IOM recommended these upper limits to be: 0.7 mg/day for children from birth to 6 months of age, 0.9 mg/day for 7 to 12 months of age, 1.3 mg/day for 1 to 3 years of age, and 2.2 mg/day for 4 to 8 years of age. These upper limits based on 0.1 mg F/kg body weight and average weights for children of those ages are meant to avoid the adverse cosmetic effect of moderate enamel fluorosis. The IOM also released adequate intakes (AIs) for fluoride ingestion (10). AIs are used as guides for nutrient intakes for individuals and are generally regarded as compatible with health. The IOM AIs for fluoride are: 0.01 mg F/day from birth to 6 months, 0.5 mg F/day for 7 to 12 months, 0.7 mg F/day for 1 to 3 years of age, and 1 mg F/day for children 4 to 8 years of age.

Few studies have looked at the amount of fluoride consumed by children from solid foods. Most of the previous dietary fluoride studies looked primarily or exclusively at the estimated fluoride intake from beverages, with or without foods, commonly consumed by children. These studies generally did not examine the *actual* foods being consumed by a group of children, but instead used a "market basket" approach or linked fluoride level assay results to dietary surveys (5-7). More recent studies estimated the amount of fluoride consumed from foods by children, but they were done in countries that have different diets, climates, and standards of living than our own, thus precluding generalizability to US children (4,11-13). A few studies have looked at the dietary fluoride intake of samples of populations more similar to the United States, but only included a small number of children and the data were only collected at one point in time (14,15).

The purposes of this paper are to describe fluoride intake from birth to 60 months of age from dietary sources using data collected from diet diaries and to assess relationships of demographic characteristics with patterns of fluoride intake. These dietary sources consist of only solid and liquid food items, and not fluoride supplements or therapies. An emphasis has been placed on the fluoride intake from solid foods, as previous studies, including our own, have focused more on fluoride intake from beverages (8,16,17).

Methods

This was a secondary data analysis conducted on data collected as part of the Iowa Fluoride Study (IFS). The overall goal of the IFS has been to investigate the dietary (foods, beverages, and supplements) and non-dietary (dentifrices, dental rinses, and gels) fluoride exposures and intake and their relationships with dental fluorosis and caries in both the primary and permanent dentitions. The IFS is a prospective, longitudinal investigation concerning a cohort recruited at birth from eight Iowa hospitals from March 1992 to February 1995, and has been discussed in more detail previously (8,16,17). Institutional review board approval and parental consents were obtained. At recruitment, the following initial baseline data were collected from the mothers while they were still in the hospital with their newborns: their age, educational level, family income, number of children in the household, water sources, and infant feeding plans. A composite socioeconomic status (SES) was estimated for each child as follows: a) low SES was defined as family income ≤$30,000 and mother not having a 4-year college degree; b) high SES was defined as family income ≥$50,000 and/or mother having graduate or professional schooling; and c) middle SES was defined as everything else. Food frequency questionnaires and 3-day food and beverage diaries were sent to the mothers when the children were aged 6 weeks and at ages 3, 6, 9, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 54, 60, 66, and 72 months (8,9).

Parents were asked to complete 3-day food and beverage diaries. They were to record all foods and beverages that the child consumed during a 72-hour period, including one weekend day and two weekdays. For each day that dietary data were recorded, the parents were asked to list the day, date, if the child was in day care, and if the child was ill that day or not. The parents were instructed to list the time of day the foods and/or beverages were consumed, the location where the foods or beverages were consumed (i.e., at home, day care, or out), type of food or beverage, brand name, and other details, such as the size of the container, method of preparation, and the amount the child ate and drank. If water was consumed as a beverage or used during food preparation, the parents were requested to indicate the water source (i.e., tap, bottled, etc.). For mixed dishes such as casseroles, sandwiches, etc., the parent was requested to list the individual ingredients and their amounts. If the child went to day care, then the parents were requested to ask the day care provider to record everything that the child ate and drank while at the day care. A summary was included to instruct parents and providers on how to record portion sizes. A contact number was included in case the parents had any further questions (18).

Individual water sources and those using filtration were analyzed for fluoride concentration annually and when water sources changed. Nonfiltered public water sources' fluoride concentrations were obtained from the Iowa state health department on a monthly basis. Ready-to-drink beverages and ready-to-eat foods were purchased and assigned fluoride levels based on extensive analyses by category conducted as part of the IFS. The IFS research team has analyzed thousands of food and beverage items for fluoride content (19-22). Parents also provided children's body weights, allowing the IFS team to calculate fluoride intake per unit body weight for each time period (9).

The 3-day food and beverage diaries provided the ability to capture specific details regarding the fluoride exposures of the children. The diaries included the brand name of the product consumed, the flavor of the product, whether it was diet or regular (if applicable), container size, etc. The 3-day food and beverage diaries were product-specific, allowing the IFS team to assign specific fluoride values to each food and beverage listed in the diaries (18).

Statistical methods

Basic descriptive statistics are reported at each of the analyzed time points. Dietary fluoride intakes were not normally distributed. Distributions of dietary fluoride intake were described in percentiles.

Data were analyzed using SAS (Version 9.1.3 Service Pack 4, 2008, SAS Institute Inc., Cary, NC, USA).

Table 1 Demographics of the Entire Recruited Population (n = 1,882)

Variable	Category	Percentage
Sex	Male	48.5
	Female	51.5
Race	White	97.2
	Other	2.8
Mother's age	≤20 years old	10.6
	21-25 years old	22.1
	26-30 years old	32.6
	31-35 years old	24.6
	>35 years old	10.1
Income	≤$19,999	23.8
	$20,000-$39,999	35.6
	$40,000-$59,999	26.4
	>$60,000	14.2
Mother's education	High school or less	21.9
	Some college	33.9
	College graduate or more	44.1
Father's education	High school or less	26.7
	Some college	27.0
	College graduate or more	39.0
Socioeconomic status (SES)*	Low	20.5
	Middle	40.1
	High	35.9
	Not listed	3.5

* SES was defined from recruitment questionnaires from 1992 to 1995. Low SES was defined as family income ≤$30,000 and mother did not have a 4-year college degree. High SES was defined as family income ≥$50,000 and/or mother had graduate or professional schooling. Middle SES was defined as everything else.

Results

Demographics of the entire recruited population are summarized in Table 1. Parents overall were relatively well educated and of higher SES. The study sample was predominantly white, similar to the population of Iowa.

The sample sizes at each analyzed time point are reflective of the children for whom 3-day food and beverage diaries were completed at each analyzed time point. Sample sizes ranged from 376 to 670. Response rates were higher at younger ages and trended lower with ongoing attrition as the age of study participants increased. Table 2 shows the estimated daily total fluoride intakes (in milligrams) from food and beverage sources by age as analyzed from the 3-day food and beverage diaries. The distributions were positively skewed, with the means being consistently higher than the medians. The largest absolute and proportional differences between the means and medians were found at 6 and 9 months of age. Maximum intakes tended to be four to five times as great as the means. When evaluating estimated dietary fluoride intakes as reported in the diaries, about 25 percent of children at 6 months of age ingested amounts greater than the tolerable upper intake level (UL) of 0.7 mg/day. Again, using dietary fluoride intakes as reported from the diaries at 12 months of age, about 5 percent of the children ingested amounts greater than the tolerable UL of 0.9 mg/day. At 24 and 36 months of age, using intakes reported from the diaries, less than 5 percent of children ingested amounts of fluoride greater than the tolerable UL of 1.3 mg/day. At 48 and 60 months of age, using intakes reported from the diaries, less than 1 percent of the children ingested amounts of fluoride greater than the tolerable UL of 2.2 mg/day.

Tables 3 and 4 present the estimated fluoride intakes from all beverages and all solid foods (excluding beverages), respectively, as analyzed from the diaries. Again, the distributions are skewed, with means being consistently higher than the medians. This is more pronounced in the total fluoride from beverage data than the total fluoride from solid foods data, as well as the 6- and 9-month intakes. For example, at 6 months of age, children in the 90th percentile and above received more than 2.3 times the amount of fluoride from beverages as the mean. At 9 months of age, children in the 90th percentile and above received more than 2.2 times the amount of fluoride from beverages as the mean. At 6 months of age, children in the 90th percentile and above received more than 2.6 times the amount of fluoride from solid foods as the mean.

Table 5 illustrates the distribution of estimated percentages of daily total dietary fluoride intake from solid foods as

Table 2 Estimated Daily Total Fluoride Intake (in Milligrams) from All Dietary Sources*

Age at diary mailing (in months)	*n*	Mean	SD	Min	1st percentile	5th percentile	10th percentile	25th percentile	Median	75th percentile	90th percentile	95th percentile	99th percentile	Max
6	670	0.479	0.430	0.005	0.009	0.017	0.037	0.121	0.330	0.793	1.107	1.257	1.700	2.076
9	658	0.518	0.399	0.011	0.036	0.062	0.096	0.178	0.407	0.812	1.077	1.268	1.651	1.900
12	602	0.349	0.292	0.022	0.041	0.074	0.105	0.160	0.251	0.449	0.756	0.904	1.465	1.880
16	571	0.369	0.231	0.047	0.074	0.112	0.142	0.210	0.326	0.462	0.637	0.797	1.143	2.103
20	523	0.442	0.248	0.043	0.080	0.146	0.180	0.277	0.392	0.556	0.742	0.900	1.289	1.972
24	492	0.483	0.278	0.032	0.117	0.182	0.217	0.301	0.418	0.592	0.809	1.021	1.554	1.986
36	413	0.520	0.294	0.059	0.123	0.202	0.242	0.329	0.452	0.620	0.873	1.118	1.552	2.152
48	378	0.530	0.310	0.117	0.141	0.195	0.232	0.333	0.470	0.643	0.868	1.087	1.601	2.774
60	376	0.551	0.313	0.118	0.152	0.215	0.247	0.337	0.490	0.683	0.919	1.136	1.859	2.451

* This includes both solid foods and beverages.

recorded in the 3-day food and beverage diaries. Means were consistently higher than the medians. Mean solid intakes were about 40 percent of total dietary intakes for ages 12-60 months. About 25 percent at each age from 12 to 60 months received ~50 percent+ of intake from solids, and ~10 percent received 60-70 percent+ from solids from 12 to 60 months.

When estimating daily fluoride from specific solid food categories, at 6 months of age, baby foods provided the highest levels of daily fluoride intake with a mean value of 0.01 mg F/day. At 12 and 24 months of age, grains, cereals, and starches (with or without water) provided the highest levels of fluoride intake (mean values of 0.05 mg F/day and 0.07 mg F/day, respectively). Grains, cereals, and starches (with or without water) provided the highest levels of fluoride intake from solid foods for 36 months (mean value of 0.08 mg F/day), 48 months (mean value of 0.08 mg F/day), and 60 months (mean value of 0.09 mg F/day) of age as well.

Table 3 Estimated Daily Total Fluoride Intake (in Milligrams) from All Beverages

Age at diary mailing (in months)	*n*	Mean	SD	Min	1st percentile	5th percentile	10th percentile	25th percentile	Median	75th percentile	90th percentile	95th percentile	99th percentile	Max
6	670	0.464	0.430	0.005	0.008	0.012	0.028	0.104	0.309	0.776	1.094	1.247	1.693	2.076
9	658	0.466	0.399	0.003	0.008	0.022	0.047	0.121	0.351	0.751	1.031	1.234	1.623	1.830
12	602	0.252	0.280	0.006	0.001	0.017	0.031	0.070	0.152	0.330	0.655	0.816	1.429	1.656
16	571	0.242	0.208	0.003	0.001	0.028	0.048	0.103	0.196	0.319	0.485	0.598	0.994	1.912
20	523	0.299	0.228	0.005	0.017	0.048	0.072	0.149	0.250	0.379	0.568	0.695	1.079	1.813
24	492	0.333	0.256	0.012	0.021	0.060	0.094	0.170	0.272	0.434	0.632	0.779	1.382	1.778
36	413	0.358	0.268	0.006	0.017	0.071	0.104	0.177	0.298	0.447	0.688	0.917	1.220	2.017
48	378	0.358	0.284	0.010	0.018	0.076	0.103	0.179	0.294	0.468	0.674	0.855	1.365	2.627
60	376	0.368	0.289	0.002	0.027	0.075	0.099	0.171	0.298	0.478	0.692	0.828	1.679	2.252

Table 4 Estimated Daily Total Fluoride Intake (in Milligrams) from All Solid Foods Excluding Beverages

Age at diary mailing (in months)	*n*	Mean	SD	Min	1st percentile	5th percentile	10th percentile	25th percentile	Median	75th percentile	90th percentile	95th percentile	99th percentile	Max
6	670	0.015	0.023	0	0	0	0	0.002	0.007	0.016	0.039	0.054	0.115	0.222
9	658	0.052	0.054	0	0	0.009	0.011	0.021	0.037	0.066	0.105	0.139	0.241	0.785
12	602	0.097	0.071	0	0.012	0.025	0.034	0.053	0.082	0.123	0.172	0.223	0.366	0.740
16	571	0.128	0.068	0	0.031	0.050	0.061	0.080	0.114	0.157	0.211	0.245	0.399	0.532
20	523	0.143	0.076	0	0.037	0.055	0.066	0.095	0.129	0.174	0.236	0.272	0.411	0.690
24	492	0.150	0.076	0	0.042	0.064	0.078	0.102	0.135	0.180	0.245	0.286	0.472	0.636
36	413	0.162	0.080	0	0.048	0.075	0.089	0.111	0.148	0.196	0.246	0.291	0.452	0.765
48	378	0.172	0.088	0.038	0.062	0.089	0.100	0.122	0.158	0.202	0.258	0.291	0.480	1.001
60	376	0.183	0.091	0.049	0.067	0.086	0.101	0.128	0.167	0.210	0.289	0.316	0.506	0.949

Table 5 Distribution of Estimated Percentages of Daily Total Dietary Fluoride Intake from Solid Foods

Age at diary mailing (in months)	*n*	Mean	SD	Min	1st percentile	5th percentile	10th percentile	25th percentile	Median	75th percentile	90th percentile	95th percentile	Max
6	670	7.66	12.57	0	0	0	0.11	0.68	2.60	8.57	22.59	34.35	66.76
9	658	19.06	20.99	0	0.10	1.14	1.93	4.45	10.44	26.18	51.24	69.58	91.61
12	602	38.54	23.36	0	2.08	6.49	10.43	19.29	35.43	54.23	72.72	82.36	92.73
16	571	41.41	20.06	0	6.48	12.78	17.55	25.29	39.31	55.25	69.85	80.57	93.08
20	523	37.63	17.88	0	6.67	13.60	16.86	24.45	34.40	49.35	64.20	72.40	81.86
24	492	36.37	17.78	0	6.45	12.75	15.66	23.03	33.64	47.92	61.85	68.06	86.68
36	413	36.42	17.44	0	8.68	13.05	17.19	23.42	33.42	45.31	60.36	69.87	84.85
48	378	37.86	17.02	5.10	10.67	14.73	18.13	25.16	34.52	48.26	60.21	69.61	87.69
60	376	38.64	17.36	7.65	9.03	13.59	18.56	25.78	35.58	49.37	63.31	72.16	85.56

When estimating daily fluoride intake from specific beverage categories, at 6 and 12 months of age, powdered concentrate infant formula prepared with water provided the highest levels of daily fluoride intake (mean values of 0.34 mg F/day and 0.09 mg F/day, respectively). At 24 and 36 months of age, water by itself provided the highest levels of daily fluoride intake (mean values of 0.09 mg F/day and 0.10 mg F/day, respectively). At 48 and 60 months of age, water by itself provided the highest levels of daily fluoride intake from specific beverages as well (0.11 mg F/day and 0.12 mg F/day, respectively).

Discussion

When considering the results from this study, one can see that some children received substantial amounts of fluoride from dietary sources alone, not taking into consideration the amount of fluoride that is ingested from non-dietary sources (supplements, dentifrices, etc.), which has also been shown to be substantial. This high level of fluoride ingestion from dietary sources alone places these children at increased risk for developing dental fluorosis.

At 12 months of age, we found that children ingested an estimated mean of 0.35 mg of fluoride from beverages and solid foods per day. Chowdhury *et al.* used the duplicate plate technique, as well as estimations of the amount of breast milk consumed, during a 3-day period to estimate that children 11 to 13 months of age residing in a fluoridated area of New Zealand ingested a mean amount of 0.26 mg of F/day. Chowdhury *et al.* found that there was a high degree of breast-feeding for the infants. This could account for the lower levels of fluoride when compared to the results of this study, since human milk is very low in fluoride (23).

Very few of the children were exclusively breast-fed (i.e., did not receive other beverages or food except water). At 6, 9, and 12 months of age, only 1.4 percent, 0.1 percent, and 0.1 percent of the sample, respectively, were exclusively breast-fed. A larger percentage of children received at least some breast milk at 6, 9, and 12 months of age (27.1 percent, 18.4 percent, and 11.8 percent, respectively). Fluoride intake during infancy probably would be lower for other samples with much higher breast-feeding rates.

At 24 months of age, we found that children ingested an estimated daily mean of 0.48 mg of fluoride from beverages and solid foods, as calculated from diet diaries. de Almeida *et al.* used the duplicate plate technique, on two separate days over a 1-week period in two seasons (winter and summer). They found that 33 Brazilian children, living in fluoridated areas (mean of 0.76 ppm water fluoride level), with a mean age of 27 months, ingested a mean of 0.31 mg of fluoride per day from dietary sources, with most of the children's fluoride intake from water and milk (mainly powdered milk reconstituted with fluoridated water). The differences between our results and these are most likely attributed to different assessment techniques and other sources of fluoride, such as beverages containing fluoride, that were consumed by the children in this study. This would explain the relatively large discrepancy in the means between the two studies (24).

Rojas-Sanchez *et al.* found that children with a mean age of 28 months residing in optimally fluoridated Indianapolis ingested a mean daily amount of 0.54 mg of fluoride from foods and beverages, as collected by the duplicate plate technique on 2 or 3 separate days over a 1-week period (25). For children residing in fluoridated areas, this study found mean daily amounts of 0.52 and 0.54 mg of fluoride ingested from solid foods and beverages at 24 and 36 months of age, respectively, which corresponds very well with the findings of Rojas-Sanchez *et al.* despite the differences in assessment techniques.

Martínez-Mier *et al.* found, through collection of duplicate plates on two weekdays and one weekend day, that 21 children with a mean age of 30 months residing in Mexico City (which does not have water fluoridation, but does have an optimal level of salt fluoridation) ingested a mean daily amount of 0.52 mg of fluoride from diet only (4). Again, this amount is in close approximation to the mean daily amounts of fluoride found in this study for children residing in fluoridated areas at 24 and 36 months, 0.48 mg and 0.52 mg, respectively.

This study has several limitations. The initial study sample, while recruited from eight different hospitals, was a convenience sample and not truly representative of a defined population. This cohort is a more general representation of healthy children born in those hospitals from mothers who were planning on living in the area for at least 4 years, in order to be able to track dental outcomes. Based on the previously defined SES categorization, the initial sample at recruitment was mostly middle/high SES (76 percent), and the children who stayed in the study long term were of even higher SES, with approximately 80 percent being in the middle or high SES categories. The study sample was predominantly white (97 percent). The feeding habits of children in Iowa, as well the years of data collection also present possible differences from other study populations and time periods. These sample characteristics limit the generalizability of the results.

Another limitation that needs to be mentioned is that data were collected through self-report. It was not possible to validate data on the food and beverage diaries. Since data were only analyzed up to 60 months of age, it is important not to generalize the results beyond this age. Sample sizes varied at the different time points due to attrition and period-specific nonresponse.

This study provided a more detailed look at dietary fluoride intake, in particular fluoride intake from solid foods, when compared to previous studies. Previous studies mostly have reported on solid foods as one general category and were not able to achieve the level of detail found in this study. The nature of data collection and analysis allowed this study to report on specific solid foods that made significant contributions to total dietary fluoride intake.

Conclusion

This study showed that there was substantial variation in dietary fluoride intake across subjects and across ages. Very few subjects ingested levels of dietary fluoride greater than the tolerable upper limit, which might place them at elevated risk of developing dental fluorosis. A small percentage of subjects had very low levels of dietary fluoride intake. A majority of dietary fluoride intake came from beverages. A smaller percentage of subjects received substantial amounts of fluoride from solid foods, showing that solid foods can be important contributors to dietary fluoride intake, and possibly the risk of developing fluorosis, for some subjects.

Further research is needed in this area to confirm these findings. It would also be beneficial to see if these findings hold true with study populations and age groups different than in these analyses.

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Impact of water fluoride concentration on the fluoride content of infant foods and drinks requiring preparation with liquids before feeding

Fatemeh V. Zohoori[1], Paula J. Moynihan[2,3,4], Narges Omid[1], Lamis Abuhaloob[2,3] and Anne Maguire[2]

[1]Health & Social Care Institute, Teesside University, Middlesbrough, UK, [2]Centre for Oral Health Research, School of Dental Sciences, Newcastle University, Newcastle upon Tyne, UK, [3]Institute for Ageing and Health Newcastle University, [4]Human Nutrition and Research Centre, Newcastle University, Newcastle upon Tyne, UK

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Abstract – *Objectives:* To measure the fluoride (F) content of infant foods and drinks requiring reconstitution with liquids prior to consumption and to determine the impact of water F concentration on their F content, as consumed, by measuring F content before and after preparation. *Methods:* In total, 58 infant powdered formula milks, dry foods and concentrated drinks were prepared with deionized water (<0.02 ppm F) nonfluoridated (0.13 ppm F) and fluoridated (0.90 ppmF) water. The F concentrations of drink samples were measured directly using a fluoride-ion-selective electrode after addition of TISAB III, and food samples and formula milks measured indirectly by an acid diffusion method. *Results:* The overall range of F concentrations of all the nonreconstituted samples, in their prepreparation dry or concentrated forms, was from 0.06 to 2.99 μg/g with the highest F concentration for foods found in the dry 'savoury meals' (a combination of vegetables and chicken or cheese or rice) group. However, when the samples were reconstituted with nonfluoridated water, the mean F concentrations of prepared 'concentrated juices', 'pasta and rice', 'breakfast cereals', 'savoury meals' and 'powdered infant formula milks' were 0.38, 0.26, 0.18, 0.16 and 0.15 μg/g, respectively. The corresponding mean F concentrations were 0.97, 1.21, 0.86, 0.74 and 0.91 μg/g, respectively, when the same samples were prepared with fluoridated water. *Conclusion:* Although some nonreconstituted infant foods/drinks showed a high F concentration in their dry or concentrated forms, the concentration of F in prepared foods/drinks primarily reflected the F concentration of liquid used for their preparation. Some infant foods/drinks, when reconstituted with fluoridated water, may result in a F intake in infants above the suggested optimum range (0.05–0.07 mg F/kg body weight) and therefore may put infants at risk of developing dental fluorosis. Further research is necessary to determine the actual F intake of infants living in fluoridated and nonfluoridated communities using reconstituted infant foods and drinks.

Key words: fluoride; infant; food & drink

Fatemeh V Zohoori, School of Health and Social Care, Teesside University, Middlesbrough TS1 3BA, UK
Tel: +44 0 1642 342973
Fax: +44 0 1642 342770
e-mail: v.zohoori@tees.ac.uk

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Fluoride (F) exposure is important for oral health, although excessive ingestion of fluoride in infancy and early childhood can increase the risk of dental fluorosis. It has been suggested that the developmental period when a child is aged 6–9 months is the most important in dental fluorosis aetiology for the primary dentition (1), while in the permanent dentition, Hong et al. (2006) (2) have reported that the first 24 months of life is the most important period for the development of dental fluorosis in

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the permanent maxillary central incisors. In addition, several studies including meta-analyses have identified the duration of F exposure during amelogenesis, rather than specific risk periods, to be of key importance in the development and severity of dental fluorosis (3–5).

A total daily F intake of 0.05–0.07 mg/kg body weight (bw), in children younger than 12 years of age, has long been suggested as optimal for dental health benefit while minimizing the risk of dental fluorosis (6, 7). However, it is important to recognize that the so-called optimal F intake is only an estimate and the precise level of F exposure that might result in fluorosis is not known. There is no consensus on the maximum safe daily exposure of F, although the US Institute of Medicine (IoM) (8) has defined a F intake of 0.1 mg F/kg bw/day as the Tolerable Upper Intake Level (UL) for children aged 1–8 years.

On the basis of the current evidence, the prevalence of dental fluorosis has increased in industrialized countries, in both fluoridated and nonfluoridated areas over the last two decades (9–11). A study in the UK (12) reported that the prevalence of dental fluorosis at any level of severity was 54% in a fluoridated area and 23% in a nonfluoridated area. However, the reported prevalence of dental fluorosis of aesthetic concern was 3% (12) and 1% (12, 13) in fluoridated and nonfluoridated areas, respectively. A multicentred European study (14) showed that the prevalence of very mild fluorosis (TFI grade 1) in 8-year-olds ranged from 61% in nonfluoridated Oulu (Finland) to 43% in nonfluoridated Almada (Portugal), with the prevalence in a fluoridated area of Cork (Ireland) being 59%. The prevalence of dental fluorosis of aesthetic concern (TFI grade $\geq$ 3) ranged from 4% in fluoridated Cork and nonfluoridated Haarlem (The Netherlands) to zero in nonfluoridated Oulu and Athens (Greece) (14). Very mild fluorosis as well as low caries experience has been shown to have a positive impact on child and parental oral health-related quality of life, while having a TFI grade $\geq$3 had a negative impact (15, 16).

The increase in the prevalence of dental fluorosis has been due, in part, to increased exposure to fluoride through widespread use of fluoridated toothpastes, significant proportions of which can be ingested when used by young children. In addition, with increasing globalization, there may be substantial movement of processed food and drink products from fluoridated regions of manufacture to regions of consumption, which might not be fluoridated and *vice versa* (17). To understand 'fluoride-flow' and minimize any detrimental dental effects from overexposure, it is important to determine and monitor F exposure in infants and young children as suggested by the World Health Organization and other key organizations (18, 19).

Diet is reported as the predominant source of F intake for infants up to age of 12 months (20). The contribution of dietary F to total ingested F can range from almost 100% in 6-week-old infants to 85% in 12-month-old infants (20, 21). However, proportionally, the dietary contribution to total fluoride exposure is higher in populations not exposed to F in toothpaste (20). The dietary F intake of infants depends on their feeding patterns as well as the F concentration of infant formula milks and timing of weaning.

Exclusive breastfeeding for the first 4–6 months after birth has been recommended in most European countries (22). According to the 2005 UK 'Infant Feeding Survey', 45% of infants in the UK were exclusively breastfed at 1 week, while this percentage decreased to 21% at 6 weeks. At 4 months, the proportion of infants being breastfed exclusively was 7%, while at 6 months, it was negligible (23). According to national data from 20 European countries, in 2003–2007, rates of exclusive breastfeeding at 6 months ranged from 1% in Finland to 42% in the Slovak Republic (22). In the United States, the 2005 'Breastfeeding Survey' conducted by the US Centre for Disease Control and Prevention also showed that only 32% and 12% of infants were breastfed through the age of 3 and 6 months, respectively (24).

At weaning age, cereals are usually recommended as the first introduced solid food for babies. The global ready-to-feed (RTF) infant food market is growing very rapidly due, in part, to the increasing number of working parents (25). Reports on the market size of baby food products in 2009 indicated that, in developed countries, baby cereals occupied the second largest market segment after jars of baby food (25). Singer and Ophaug reported infant milk formula, water and cereals as the three most important sources of dietary F for infants (26). Therefore, infant formula milks and commercially available beverages and foods such as cereals could be primary contributors to F ingestion during the first year of life. Estimating dietary F exposure at any age is difficult because very few manufacturers record the F content of their products. While 'Food Composition Tables' provide nutritional values for food and drinks including details of energy, protein, fat, carbohydrate, vitamins and minerals, they do not contain data on the F content of foods and drinks needed to facilitate estimation of dietary F exposure in populations. The development of a 'Fluoride Database' in the United States (27) is a welcome tool in the estimation of F exposure, which reports F concentrations of selected beverages, waters and foods, although maintaining the currency of its dataset will be a challenge.

While a number of studies have reported the F concentration of RTF infant foods and drink, there are a few reports on the F contents of dry infant products despite their popularity and affordability. On the basis of cost per feeding, RTF infant milks and foods are usually 2–3 times more expensive than powdered/dry infant formula and dry weaning foods (28).

Regarding infant dry cereals requiring reconstitution, most reports on their F concentration are more than 10 years old. Vlachou and colleagues, in 1992, reported a range of F concentrations from 0.04 to 0.79 μg/ml for 15 infant dry cereals reconstituted with distilled water drinks in the UK (29). This was close to the range of 0.05-0.52 μg/ml reported for 32 infant dry cereals reconstituted with distilled water drinks in the Iowa, US, in 1997 (30). Two separate more recent studies in Brazil have reported a F concentration range of 0.43-6.64 (31) and 0.20–7.80 μg/ml (32) for three and six different types of dry cereals, respectively.

The F content of prepared/reconstituted infant milk formula, concentrated drinks and dry foods, including breakfast cereals, is very dependent on the F concentration of the water used both in processing and in reconstitution. In fluoridated communities, it has been shown that water is a primary source of F, not just from drinking tap water but also because many foods consumed are prepared with fluoridated water. A study conducted on Australian infant formula milks showed F concentrations ranging from 0.13 to 0.63 μg/ml when reconstituted with nonfluoridated water (0.1 ppm) compared with a range of 1.03-1.53 μg/ml when reconstituted with fluoridated water (1.0 ppm F) (33).

While there is only one European report (29) on the F concentrations of reconstituted infant milk formula and other drinks and foods requiring preparation before feeding, this information is now more than 15 years old. Besides, that single study (29), conducted in Leeds – UK, did not investigate the effect of the F concentration of the water used in reconstitution on the F content of infant foods and drinks. Because of the potential bidirectional correlation between F exposure and oral health (i.e. caries prevention and dental fluorosis) during the first 2 years of life, monitoring F exposure in infancy is very important (34). As an important component variable for the estimation of F intake in infants, this study aimed to measure the F content of infant foods and drinks requiring reconstitution with liquid prior to consumption and determine the impact of water F concentration on their F content.

Materials and methods

A convenience sample of 14 major supermarkets, grocery stores and health food shops in three cities in northeast England were visited between November 2008 and May 2009 to identify and purchase infant foods and drinks requiring reconstitution, preparation or cooking prior to consumption. The majority of these foods were confined to a small number of food groups because increasing numbers of infant foods are sold 'RTF'. In total, across this full range of outlets visited, 18 powdered infant formula milks manufactured by the main national and international companies including Heinz (USA), Milupa Aptamil (Germany), Cow and Gate owned by Danone (France), HiPP (Germany) and SMA owned by Pfizer (UK) were identified and all were purchased. In addition, all 30 dry infant breakfast cereals, four infant dry pastas and rices, three infant dry savoury meals (a combination of vegetables with chicken, cheese or rice) and three concentrated juices, specifically formulated for infants, identified across the same range and number of retail outlets were purchased. Almost all of these foods and juices were manufactured in one size only in the UK and included products by Annabel Karnel, Bebivita, Boots, Cow and Gate, Ella's Kitchen, Heinz, HiPP, Mumtaz, Organix and Plum. Overall, they represented the majority of this category of products available on the UK market.

Three different batch numbered items for each of the 58 total products were purchased ($n = 174$ items). For each item, an equal amount was weighed and mixed with the other two items for that product. A mixed sample comprises the three batch items was then prepared by adding water, milk or both, according to the manufacturers' instructions. Prior to analysis, deionized distilled water (DDW: <0.02 ppm F), nonfluoridated tap water from Middlesbrough (NFW: 0.13 ppm F) and fluoridated tap water from Newcastle upon Tyne (FW: 0.9 ppm F) were used to prepare the samples that required water for preparation. On the basis of manufacturers' instructions, 17 samples of dry breakfast cereals required addition of water only, while 10 cereal samples required addition of milk only and three required addition of equal volumes of water and milk. For these latter 13 cereal samples, a single batch numbered RTF infant milk (SMA, Gold) with a F concentration of 0.03 μg/ml was used.

The F content of each nonmilk-based drink sample, in both its concentrated form and when prepared with water, was measured directly using a fluoride-ion-selective electrode (Orion Research, model 96-09) after adding TISAB III (35). Milk-based drink, infant milk formula and food samples, in their dry form and prepared with water, were analysed using the HMDS-facilitated diffusion method (36–38).

All 58 mixed products were analysed in their dry/concentrated forms, in triplicate (number of assays: 58 × 3 = 174). The reconstituted samples were then prepared with DDW, NFW and FW and analysed in triplicate [Total number of assays = 522 (58 products in triplicate × 3 types of water for preparation)]. The F content (μg) of each sample was then obtained from the average of triplicate determination and reported per g weight of reconstituted or diluted product as well as per g weight of product in its original dry or concentrated form.

A known concentration of F standard was added to approximately 10% (n = 6) of the samples and reanalysed, in triplicate, to measure the recovery of the added F to check the validity of the analytical method used.

The dry food samples were categorized into three groups: (i) breakfast cereals including oat/fruit porridge, fruit cereals; (ii) pasta and rice; and (iii) dry savoury meals (a combination of vegetables with chicken, cheese or rice).

Descriptive analysis using SPSS for Windows (version 17) was undertaken to report mean, standard deviation (SD) and median (range) of F concentration of different food and drink groups.

Results

The mean (SD) recovery of F added to food/drink samples was 98.5% (2.4%). The mean and range of F concentrations (μg/g) of the 58 infant formula milks, foods and drinks based on their dry weights are summarized in Table 1. Based on dry weight, the 'savoury meals' (a combination of vegetables with chicken, cheese or rice) were considerably higher in F than the foods in the other groups and ranged from 0.89 to 2.99 μg F/g with a mean of 1.64 μg F/g.

Table 2 shows the mean F concentration of the 58 products when prepared with waters with different F concentrations. The 'pasta and rice' products (n = 4) had the highest mean F concentration (0.21 μg/g) with a range from 0.19 to 0.22 μg F/g, followed by 'juices' (n = 3), with a mean F concentration of 0.11 μg/ml, when diluted with DDW. The mean F concentrations of the 'breakfast cereals' and 'savoury meals', when reconstituted with DDW, were similar (0.08 and 0.09 μg/g, respectively). The infant formula milk group showed the greatest variation in F concentration, from 0.02 to 0.18 μg/g. The F concentrations and contents of these infant foods and drinks increased as the water used to prepare or cook them increased from <0.02 ppm F to 0.13 and 0.90 ppm F; the F concentration being very close to that of the NFW or FW with which they had been prepared and/or cooked.

In addition to the 20 cereal samples that were prepared by adding only water (n = 17) or 'water and milk' (n = 3), shown in Table 2, there were another 10 samples that were prepared with infant milk, according to the manufacturers' instructions.

Table 1. Mean (SD) and median (range) F concentration of 58 dry infant foods (μg/g) and drinks (μg/ml) as packaged.

Infant food/drink items	No. of samples	F concentration of dry foods and drinks (μg/g or μg/ml) Mean (SD)	Median (Range)
Food groups			
Breakfast cereals	30[a]	0.47 (0.42)	0.36 (0.11–1.61)
Pasta and rice	4	0.51 (0.74)	0.16 (0.10–1.62)
Savoury meals[b]	3	1.64 (1.17)	1.03 (0.89–2.99)
Drink groups			
Juices	3	0.22 (0.05)	0.19 (0.19–0.28)
Infant formula milks[c]	18[c]	0.28 (0.29)	0.18 (0.06–1.09)

[a]17 required reconstitution with water, 3 with milk and water and 10 with milk only.
[b]A combination of vegetables with chicken, cheese or rice.
[c]15 were cow's milk-based, 3 were soy-based.

Table 2. Mean (SD) and median (range) of *F* concentration of infant foods (μg/g) and drinks (μg/ml), which required reconstitution with water, prepared with distilled deionized (DDW), nonfluoridated (NFW) and fluoridated (FW) water.

Infant food/drink items	No. of samples	Mean (SD) and median (range) of *F* concentration (μg/g or μg/ml) as consumed		
		DDW (<0.02 ppmF)	NFW (0.13 ppmF)	FW (0.90 ppmF)
Food groups				
Breakfast cereals	20	0.08 (0.05)	0.18 (0.06)	0.86 (0.21)
		0.08 (0.02–0.17)	0.16 (0.11–0.34)	0.86 (0.49–1.23)
Reconstituted with water	17	0.09 (0.05)	0.19 (0.06)	0.91 (0.19)
		0.11 (0.02–0.17)	0.16 (0.11–0.34)	0.91 (0.49–1.23)
Reconstituted with milk[a] and water	3	0.04 (0.02)	0.12 (0.01)	0.58 (0.02)
		0.04 (0.02–0.07)	0.11 (0.11–0.14)	0.59 (0.55–0.59)
Pasta and rice	4	0.21 (0.01)	0.26 (0.08)	1.21 (0.18)
		0.21 (0.19–0.22)	0.28 (0.16–0.33)	1.22 (0.99–1.43)
Savoury meals[b]	3	0.09 (0.02)	0.16 (0.04)	0.74 (0.13)
		0.09 (0.07–0.11)	0.15 (0.13–0.20)	0.78 (0.60–0.85)
Drink groups				
Juices	3	0.11 (0.03)	0.18 (0.03)	0.97 (0.36)
		0.09 (0.08–0.14)	0.17 (0.16–0.21)	0.81 (0.71–1.39)
Infant formula milks	18	0.06 (0.04)	0.15 (0.07)	0.91 (0.22)
		0.04 (0.02–0.18)	0.14 (0.07–0.32)	0.92 (0.49–1.40)
Cow's milk-based	15	0.05 (0.02)	0.14 (0.07)	0.87 (0.21)
		0.04 (0.02–0.08)	0.14 (0.07–0.32)	0.88 (0.49–1.40)
Soy-based	3	0.13 (0.08)	0.20 (0.08)	1.11 (0.17)
		0.16 (0.00–0.18)	0.22 (0.12–0.27)	1.11 (0.93–1.28)

[a]Ready-to-feed infant milk: SMA-Gold (0.030 μg F/ml).
[b]A combination of vegetables with chicken, cheese or rice.

These cereals were prepared using RTF infant milk 'SMA-Gold' with a F concentration of 0.03 μg/ml. Their mean (SD) F concentration was 0.08 (0.01) μg/g, equal to the mean F concentration of the 20 cereals requiring reconstitution involving water when prepared using DDW. This aspect is discussed further in relation to RTF cereals analysed by Maguire et al. (In press).

With regard to manufacturer, as Fig. 1 shows, there were some between-manufacturer variations in F concentration (μg/g) for dry breakfast cereals (manufacturers; $n = 4$) and cow's milk-based infant formula (manufacturers; $n = 7$) with the mean F concentration ranging from 0.18 to 0.54 μg/g for dry cereals and 0.12 to 0.27 μg/g for infant formula.

Discussion

Infancy and early childhood are critical times for calcification of the crowns of developing permanent teeth, particularly the most visible permanent

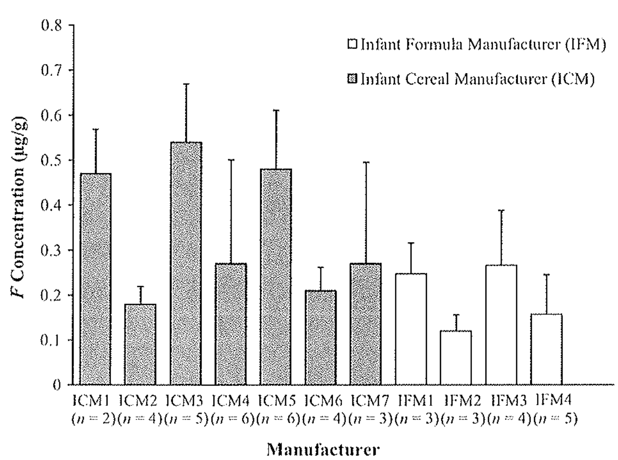

Fig. 1. The mean (SD) F concentrations (μg/g) of infant breakfast cereals (ICM) in dry form and cow's milk-based infant formula (IFM) in powder form, by manufacturer. (n = number of products according to manufacturer); bars indicate standard deviation.

front teeth. Therefore, evaluation and monitoring of F intake by infants is needed when planning or undertaking any caries prevention programme to maximize benefit and minimize risk of dental fluorosis. To undertake this process accurately and effectively, quality data on the sources and F concentrations of food and drink items are needed. According to the data from the UK Avon Longitudinal Study of Parents and Children (ALSPAC) (39), 25% of 4-month-old infants had at least one serving of a commercial RTF infant food daily (including ready-to-feed meat-, fish- and egg-based foods and infant desserts), whereas 76% and 100% of these infants were recorded as having at least one serving per day of a commercial instant dried food and infant formula, respectively. The same study also reported a mean daily consumption of 51, 29 and 387 g for RTF infant foods, infant dried foods and infant formula, respectively, for all 4-month-old infants. In view of the widespread use of these products, it is important that current information on nutritional components including trace elements is maintained. By providing recent information on the F content of most common infant foods, infant drinks and formula milks, requiring preparation with water and/or milk, available in the UK market, this present study serves a useful function. The F content of RTF infant food and drinks analysed as part of the same study has been reported elsewhere (40). Within the global baby food market, baby meals (wet and dry) now account for the majority of sales followed by infant milks and finger foods (25). The analysed products in the present study were manufactured by the leading companies in the European baby food market. Therefore, these data could be useful when estimating the F intake of infants in the UK as well as in other European countries.

The range of 0.11–1.61 μg F/g for dry cereals obtained in the present study is slightly narrower than the ranges of 0.01–2.16 μg F/g reported for infant dry cereals in a study carried out in Leeds, UK, more than 17 years ago (29), and much smaller than the range of 0.20–7.84 μg F/g reported for similar products in Brazil in 2004 (32). The range of F concentrations of dry infant cereals when prepared by DDW, in the present study, was from 0.02 to 0.17 μg/g, which is substantially lower than the 0.05–0.52 μg/g and 0.04–0.79 μg/g reported for dry infant cereals reconstituted with DDW in the Iowa, US (30), and Leeds, UK studies (29), respectively, more than 10 years ago. In the present study, the mean F concentration of infant cereals prepared with DDW and 0.13 and 0.90 ppm F waters was 0.08, 0.18 and 0.86 μg F/g, respectively, compared with a mean of 0.11 μg F/g reported for RTF infant cereals in the UK (40).

In this study, a wide intermanufacturer variation in fluoride concentrations of infant foods and drinks was observed (Fig. 1). A wide intramanufacturer variation in fluoride concentrations of infant drinks produced on different manufacturing sites was also reported in the Iowa study (41). In addition, Fomon and Ekstrand reported a range of 0.09–0.20 μg F/ml for dry cereals produced with <0.3 ppm F water compared with 4–6 μg F/ml for those produced with 1 ppm F water (42), which appears high. Variations in the reported F concentrations may be attributed to different methods of processing, use of different ingredients as well as the areas of origin of the ingredients (including water used in manufacture). One of the main limitations of the present study was that despite purchasing three different batch samples of each food and drink item, they were mixed together before F analysis owing to the limited time and funding available to conduct the study. As a result, batch consistency for F concentration was not investigated. In addition, owing to time and funding constraints, samples were only purchased from the UK market. The majority of analysed products were produced by a number of different European manufacturers, but the production site was not labelled on the products studied and consequently it was not possible to explore the source of water. Further research and analysis of the F content of infant products marketed in different EU countries would provide a better understanding of the variation in F concentration of similarly labelled products from the same manufacturer.

Although the F content of savoury meals (vegetables in combination with chicken, cheese or rice), in their dry weight form, was relatively high (up to 2.99 μg/g dry weight) in the present study, when prepared with water, their F concentration was second lowest (after the infant formula milks), (Tables 1 and 2). In general, pastas and rices, when cooked with water, had the highest F concentrations (0.21, 0.26 and 1.21 μg/g when cooked with DDW, 0.13 and 0.90 ppmF waters, respectively) but there are no data in the literature on the F concentration of dried pasta, rice and mixed food/savoury meals for comparison with the present results. Analysis of RTF infant mixed foods in Iowa, US (30), and the UK (40), showed a mean F concentration of 0.21 and 0.15 μg/g, respectively, compared with the means of 0.09, 0.16 and 0.74 μg F/g estimated in this study for those savoury meals prepared with DDW and 0.13 and 0.90 ppm F waters, respectively. Infant foods containing chicken have been reported to contain a higher F concentration owing to mechanical deboning of chicken, which can leave residual bone particles in the food (26, 30, 43). In the present study, one savoury meal containing chicken (17% by weight) did have a relatively high F concentration in its dry weight form (2.99 μg/g); however, when reconstituted with water, its F concentration was similar to the other savoury meals. A recent UK study on F concentrations of RTF infant food and drinks reported a mean F concentration of 0.125 μg/g, with a range from 0.070 to 0.271 μg/g, for RTF savoury meals containing chicken (40). The high F concentration of dry savoury meal containing chicken, in the present study, could be due to powdered or particulate bone present in the dry form, which might not have been mixed homogenously when reconstituted with water.

This study supports previous reports that the F concentration of water used to prepare infant foods and drinks has an important effect on the F concentration of the food and drink as consumed (44). For example, in the present study, when prepared with 0.9 ppmF water, the mean F concentration of infant milk formula was six times higher than the same formula prepared with 0.13 ppmF water, which clearly reflected the ratio of F concentrations in waters used in preparation. Additionally, in the current study, only 2% of the food and drink samples reconstituted with nonfluoridated water had a F concentration higher than 0.70 μg/g. However, this proportion increased to 81% when the same samples were prepared with fluoridated water. Reconstituting infant foods/drinks with fluoridated water may produce foods/drinks, which when consumed in typical amounts may result in a fluoride intake in infants above the suggested so-called optimal F intake of 0.05–0.07 mg F/kg bw (6, 7). For example, an infant could ingest up to 0.11 mg F/kg bw/day if they consume 150 ml of infant milk formula/kg bw/day prepared with fluoridated water (0.9 ppmF).

In this study, the F concentrations of the 15 powdered infant formula milks, when reconstituted with DDW, ranged from 0.02 to 0.18 μg/ml; a narrower range than the 0.03-0.27 μg/ml recently reported in the United States for 21 powdered concentrate milks prepared with DDW (44).

When 0.13 ppm F water was used to reconstitute powdered infant formula milks in this study, F concentrations ranged from 0.07 to 0.32 μg/ml, while with 0.90 ppm F water, they ranged from 0.49 to 1.40 μg/ml. This contrasts with the 0.12 to 0.17 μg F/ml and 0.22 to 0.85 μg F/ml for liquid concentrate milks reconstituted with nonfluoridated and fluoridated water, respectively, reported in the United States (26). In addition, Silva and Reynolds reported that F concentrations of infant formula milks used in Australia, when reconstituted with 0.1 ppmF and 1.0 ppmF water, ranged from 0.13 to 0.63 μg/ml and 1.03 to 1.53 μg/ml, respectively (33).

In 1970, Ericsson and Ribelius (45) showed that some infant formula milks prepared with 1 ppm F water could contain up to 53 times more fluoride than human breast milk. Other investigators in the 1970s also reported relatively high fluoride concentrations of some infant formulas and foods. Krishnaswami, in 1971 (46), reported that the chemical quality of waters used in processing and formulation of infant foods should be carefully monitored and evaluated. Following these reports, in the 1980s, manufacturers of infant formula milks in the USA agreed to produce these milks with water containing <0.15 mg F/l (47). On this basis, if ≤0.15 ppm F water was used for their processing and formulation and the infant formula was then prepared for consumption using nonfluoridated water, the F concentration would be <0.10 mg/l (48). However, almost 40% of the milk samples tested in the present study had F concentrations higher than 0.10 mg/l when reconstituted with 0.13 ppm F water according to the manufacturers' instructions. UK manufacturers' instructions recommend that infant formula, foods and drinks are prepared using fresh tap water but there are no recommendations to avoid the use of fluoridated tap waters.

Despite breastfeeding being the best feeding practice for infants, some may be fed exclusively on formula milk for the first 6 months of life. According to recent clinical guidelines produced by the American Dental Association (ADA) in 2011, the parents of infants who consume reconstituted infant formula as the main source of nutrition can be advised to continue preparing the formula with optimally fluoridated drinking water while being mindful of the potential risks of development of dental fluorosis. However, the ADA guidelines suggest that parents resident in a fluoridated area who are concerned about the potential risk of developing fluorosis of their children prepare powdered formula with F-free or low-F water or use RTF infant milk (49). The British Fluoridation Society has also employed the ADA approach and recommended using a RTF infant milk or powdered formula reconstituted with a suitable bottled water (as listed on their website) for those infants living in fluoridated areas whose parents express concern about the potential risk of fluorosis development (50).

It is total F ingestion from dietary and nondietary sources (e.g. inadvertent ingestion of toothpaste by young children) that constitutes the true risk factor for the occurrence of dental fluorosis. However, the evidence base for the so-called optimal F intake needs to be developed, through well-designed and controlled life-course studies to determine a body F 'burden' for the development of dental fluorosis. In relation to dietary F, fluoride dose or exposure is related to the concentration of F in foods/drinks as well as the quantities consumed. For example, an infant could ingest F in supraoptimal amounts if they eat large quantities of breakfast cereals prepared with fluoridated water. To avoid this, the alternative options would be to use either a RTF breakfast cereal or a nonfluoridated water in the preparation of a breakfast cereal requiring reconstitution with water. Therefore, it is important that parents receive appropriate information on the F content of infant foods and drinks as well as guidelines regarding appropriate waters suitable for the preparation of infant food and drinks. This information would be most appropriately disseminated through health professionals supported by appropriate manufacturers' instructions and clear labelling of products. There would appear to be a need for the relevant guidelines for infant feeding practices to be reviewed, based on recent studies as well as the recommendations of expert bodies. However, it would be important to ensure that any refinements of the guidelines were based on actual F intake of infants from all sources. With this in mind, further research is necessary to determine the actual F intake of infants living in fluoridated and nonfluoridated communities.

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Patterns of dental caries following the cessation of water fluoridation

Gerardo Maupomé[1], D. Christopher Clark[1], Steven M. Levy[2] and Jonathan Berkowitz[3]

[1]Faculty of Dentistry, University of British Columbia, Vancouver, BC, Canada, [2]College of Dentistry, University of Iowa, Iowa City, IA, USA, [3]Faculty of Commerce and Business Administration, University of British Columbia, Vancouver, BC, Canada

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Abstract – *Objectives:* To compare prevalence and incidence of caries between fluoridation-ended and still-fluoridated communities in British Columbia, Canada, from a baseline survey and after three years. *Methods:* At the baseline (1993/4 academic year) and follow-up (1996/7) surveys, children were examined at their schools. Data were collected on snacking, oral hygiene, exposure to fluoride technologies, and socio-economic level. These variables were used together with D1D2MFS indices in multiple regression models. *Results:* The prevalence of caries (assessed in 5927 children, grades 2, 3, 8, 9) decreased over time in the fluoridation-ended community while remaining unchanged in the fluoridated community. While numbers of filled surfaces did not vary between surveys, sealed surfaces increased at both study sites. Caries incidence (assessed in 2994 life-long residents, grades 5, 6, 11, 12) expressed in terms of D1D2MFS was not different between the still-fluoridating and fluoridation-ended communities. There were, however, differences in caries experienced when D1D2MFS components and surfaces at risk were investigated in detail. Regression models did not identify specific variables markedly affecting changes in the incidence of dental decay. *Conclusions:* Our results suggest a complicated pattern of disease following cessation of fluoridation. Multiple sources of fluoride besides water fluoridation have made it more difficult to detect changes in the epidemiological profile of a population with generally low caries experience, and living in an affluent setting with widely accessible dental services. There are, however, subtle differences in caries and caries treatment experience between children living in fluoridated and fluoridation-ended areas.

Key words: caries; epidemiology; fluoridation; incidence; prevalence

Gerardo Maupomé, Center for Health Research, 3800 N. Interstate Ave., Portland, Oregon 97227-1110, USA
Tel: (503) 335 6625
Fax: (503) 335 2428
e-mail: gerardo.maupome@kp.org

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In the last 30 years, oral health in North America has improved dramatically (1, 2), although there are still significant oral health needs in some subgroups (3, 4). Much of the improvement in dental caries is attributed to the widespread use of fluorides (5, 6). Despite this generally held opinion, the literature fails to provide good current estimates for the effectiveness of water fluoridation, either alone or when used in conjunction with the many other available fluoride technologies (7–9). During the 1980s and 1990s, considerable attention has been paid to the safety and effectiveness of fluorides (5–11). This renewed scientific concern is being driven by the fragmented but constantly-present opposition to water fluoridation (12, 13), the changing trends of caries (2, 3, 14, 15), the complex exposures and ingestion patterns of fluoride (16–18), the need to balance fluorosis risk through adjusting the total amount of fluoride ingested from numerous sources (12, 19–23), the (still poorly-understood) effects of fluoride on bone (11), and the paucity of current data on fluorides (6, 8, 19, 24). Accordingly, there is still a need to estimate the caries-preventive benefits from fluoridated water (25). Considerably less attention has been devoted to the issue of cessation of fluoridation.

While historically the evidence for the effectiveness of water fluoridation was substantial, it is increasingly difficult to conduct controlled research on this topic due to ethical and logistical considerations. An opportunity is offered when the exposure is removed (26). There are relatively few studies reporting changes in decay in primary teeth after the fluoridation of water supplies is stopped (27–30) but, similar to the results in permanent teeth, the removal of fluoride was historically associated with increases in caries. A recent study reporting only permanent tooth data (31) found that, after fluoridation ceased in 1990, caries levels continued to decrease. This result, unexpected in relation to earlier findings (28), might be ascribed to diverse fluoride technologies that possibly mask the effect of water fluoridation being discontinued. Therefore, a re-examination of the current relevance of the association between fluoride in water and caries seems warranted, since this link was established mostly using pre-1975 data (32, 33). Consequently, the relationship between levels of dental caries and varying fluoride exposures may have changed. The opportunity to re-examine such relationship after cessation of water fluoridation occurred in British Columbia (BC), Canada. Results of referenda in 1992 in Comox/Courtenay and Campbell River led to the discontinuation of water fluoridation after being fluoridated for approximately 25 years. Kamloops voted to continue to fluoridate, and thus served as a positive control.

The present report outlines the results for caries D1D2MFS prevalence for participants living in the fluoridation-ended and the fluoridated sites between baseline and after 3 years, as well as a comparison of the incidence accrued during the 3 years from 1993/4 to 1996/7.

Material and methods

Procedure

This multi-site study is both a repeated cross-sectional prevalence survey and a longitudinal investigation. The baseline survey was carried out during the 1993/4 academic year and the follow-up occurred in 1996/7. On average, children were re-examined 36 months after baseline. All children were examined at their schools using methods previously reported (34, 35). Informed consent was sought from parents and children at baseline and at the follow-up, as approved by the Ethical Review Board of the University of British Columbia.

For dental caries, the clinical examination utilized a modified D1D2MFS Index (36) for incipient and cavitated lesions. Briefly, an incipient lesion (D1) was scored when there was evidence of (i) incipient decay on a pit-and-fissured (PF) surface (white chalky enamel or softness) or (ii) a chalky white spot on a smooth surface that did not appear glossy after drying. A cavitated lesion was scored (D2) on both PF and smooth tooth surfaces. No cleaning of teeth was undertaken before examinations. The same four examiners participated at the same sites at both examinations. Examiners were trained and calibrated twice during each examination series. Inter- and intra-examiner duplicate examinations were performed on randomly selected participants. A pre-tested questionnaire was employed for collecting data on snacking, oral hygiene, exposure to diverse fluoride technologies, and socio-economic status.

Prevalence and incidence data

Attempts were made to contact all participants from the 1993/4 survey for the follow-up, hoping to examine all original participants who were in grades 2, 3, 8 and 9 in 1993/4, and who were in grades 5, 6, 11 and 12 in 1996/7. We also targeted all new children in grades 2, 3, 8 and 9 in 1996/7. The actual fluoridation of water had been terminated approximately 14 months prior to initiation of the baseline examinations, which took about 5 months to complete. Therefore, at baseline children were examined anywhere from 14 to 19 months after the fluoridation stopped.

Prevalence figures were thus obtained for children in grades 2, 3, 8 and 9 at baseline and at the follow-up survey, and incidence figures obtained for continuous participants in the study in grades 5, 6, 11 and 12 in the 1996/7 survey.

Only permanent teeth were included in this study. Because the proportion of tooth surfaces at risk appeared to change over the study interval (due mainly to increased sealant use (35)), caries attack rates were calculated as proportions per 100 surfaces at risk during the 36 months of the follow-up (37). Surfaces at risk were those surfaces which had erupted and which were not sealed at baseline. Since recurrent decay was found to be minuscule overall (<0.1%) (35), whether a surface was filled or not was deemed not to affect caries attack rates. Prevalence and incidence variables were D1D2MFS, D1S, and D2S (all surfaces); D1D2MFS, D1S, and D2S per 100 tooth surfaces at risk (100AR); and D1D2MFS, D1S, and D2S per 100 pit-and-fissured tooth surfaces at risk (100PFAR). The separate inclusion of indices only for surfaces at risk aimed to reduce the effects of professional treatment on incidence data.

Data were analyzed as required using descriptive statistics, Cohen's kappa, one-way ANOVA and Student's *t*-test. Level of statistical significance was 0.05.

Regression analyses

Step-wise (backward elimination) multiple regression models were developed with the D1D2MFS indices and their components as dependent variables. These were used in three series of analyses. One included all subjects and prevalence data. The second series included all lifelong residents in the longitudinal cohort. The last one included incidence data for only those lifelong residents whose D1D2MFS was greater than zero at the baseline examination. This latter series was included in an attempt to explain the pattern of disease in study subjects with caries, and to reduce possible dilution of effects from subjects with no caries activity. Independent variables included residence in either fluoridated or fluoridation-ended study sites (SITE), AGE and gender (SEX). Generated Variables derived from questionnaire data included:

1. A composite measure of socio-economic level attained through separate appraisals of parental levels of schooling, and frequency of dental attendance (SES);
2. pre- and post-eruptive exposure to fluorides through the use of fluoride supplements (FSUPTOT);
3. post-eruptive exposure to fluorides through assessing the frequency of mouthrinsing and toothbrushing with home care products containing fluoride (REGIME);
4. a picture-based evaluation of the amount of toothpaste used in the first 4 years of life as a proxy measure for swallowing toothpaste, either considering a combination of toothbrushing frequency with amount of toothpaste reportedly used (SWALLOW1) or just the amount of toothpaste (SWALLOW2); and
5. an assessment of overall snacking practices (including beverages) (SNACKS).

Results

Basic results

Basic demographic information is presented in Table 1, depicting actual numbers of participants

Table 1. D1D2MFS, FS and sealed surfaces prevalence in participants from fluoridation-ended (F-E) and still-fluoridated (S-E) sites by grade – all residents

Study site/grades	Measure	1993/4 Survey	1996/7 Survey	*P*-value[‡]
F-E 2 & 3	Actual number	1468	1067	n/a[*]
	Mean age	8.3	8.2	NSSD[†]
	D1D2MFS	1.29±2.10	0.63±1.69	$P<0.01$
	FS	0.41	0.36	NSSD[†]
	Surfaces sealed	1.97±1.76	2.39±2.24	$P<0.0001$
S-E 2 & 3	Actual number	1239	1111	n/a[*]
	Mean age	8.3	8.3	NSSD[†]
	D1D2MFS	0.37±1.11	0.30±0.94	NSSD[†]
	FS	0.20	0.17	NSSD[†]
	Surfaces sealed	1.29±1.73	1.67±1.96	$P<0.0001$
F-E 8 & 9	Actual number	1716	1144	n/a[*]
	Mean age	14.3	14.3	NSSD[†]
	D1D2MFS	4.93±6.43	3.68±5.67	$P<0.01$
	FS	3.05	2.71	NSSD[†]
	Surfaces sealed	4.82±4.91	5.96±5.36	$P<0.0001$
S-E 8 & 9	Actual number	1504	608	n/a[*]
	Mean age	14.4	14.3	NSSD[†]
	D1D2MFS	2.27±3.88	2.41±4.58	NSSD[†]
	FS	1.91	1.98	NSSD[†]
	Surfaces sealed	4.21±4.94	5.41±5.34	$P<0.0001$

[*] Not applicable.
[†] Not statistically significantly different.
[‡] Student's *t*-test.

Table 2. D1D2MFS, D1S, D2S and sealed surfaces prevalence for all participants from fluoridation-ended (F-E) and still-fluoridated (S-E) sites by grade – 1996/7 survey*

	All surfaces				100 Surfaces at risk			100 Pit-and-fissured surfaces at risk		
Study sites/grades	Surfaces sealed	D1D2MFS	D1S	D2S	D1D2MFS 100AR	D1S 100AR	D2S 100AR	D1D2MFS 100PFAR	D1S 100PFAR	D2S 100PFAR
F-E 2 & 3	2.39±2.24	0.63±1.69	0.22±0.82	0.04±0.45†	0.92±2.56	0.42±1.49	0.10±1.39	7.02±18.42	1.14±6.51	0.35±2.93
S-F 2 & 3	1.67±1.96	0.30±0.94	0.06±0.35	0.07±0.35†	0.46±1.47	0.12±0.73	0.15±0.80	4.07±12.88	0.59±4.56	0.96±4.95
F-E 8 & 9	5.96±5.36	3.68±5.67	0.87±2.38	0.08±0.44	2.13±3.20	0.68±1.81	0.06±0.32	13.59±18.59	0.72±2.92	0.22±1.24
S-F 8 & 9	5.41±5.34	2.41±4.58	0.25±1.14	0.18±0.70	1.37±2.57	0.19±0.89	0.13±0.53	9.60±14.53	0.42±1.94	0.66±2.65

* Differences in prevalence scores between the F-E and the S-F sites were statistically significant.
† Difference was not statistically significant (P=0.082).
P-value=0.082.

by study site; grade; and mean age of each group in the two surveys. Overall gender distribution was 51% females in the 1996/7 survey.

Combined intra-examiner reliability for D1D2MFS (98 cases) at follow-up was high (kappa=0.80), as was combined inter-examiner reliability (155 cases) (kappa=0.74). Reliability data for baseline were also high and have been reported elsewhere (38).

Prevalence results

D1D2MFS prevalence scores were significantly lower in 1996/7 than 1993/4 only for the fluoridation-ended site for participants attending grades 2, 3, 8 and 9 (P<0.01) (Table 1). Prevalence data on filled surfaces did not vary significantly between surveys. The number of sealed surfaces, however, increased significantly in both study sites between the surveys.

D1S, D2S and D1D2MFS prevalence results for the 1996/7 survey are emphasized further in Table 2. Comparisons of the scores between fluoridated and fluoridation-ended sites indicated that most scores were statistically significantly different, except for D2S in grades 2 and 3. D1S and D1D2MFS scores were consistently higher at the fluoridation-ended sites while D2S scores were consistently higher at the fluoridated site.

Incidence results

Follow-up rate at 3 years was 64.2%. Under a framework whereby only 79.8% of baseline participants were lifelong residents, we were able to gather information usable at follow-up for 51.2% of the entire baseline population (57.5% still-fluoridated site, 45.1% fluoridation-ended site). Almost 90% of all eligible children in the study sites were examined at baseline (35), and showed similar SES and demographic features.

Incidence rates for components of the D1D2MFS indices are shown in Tables 3 to 5 only for participants who were lifelong residents of the study sites (39). Tables 4 and 5 include only those tooth surfaces that had erupted, and were not sealed, at baseline.

Data for all tooth surfaces, 100AR, and 100PFAR suggested that, in general, the untreated decay components of caries incidence were lower in the fluoridation-ended sites for both incipient and cavitated decay. While trends from both sites suggested that changes over time were generally small, the fluoridation-ended site always had small negative changes while the fluoridated site remained static

Table 3. D1D2MFS incidence for lifelong residents from fluoridation-ended (F-E) and still-fluoridated (S-E) sites by age group – all surfaces

Study site/grades	Caries incidence after three years					
	n	D1	D2	FS	D1D2MFS	D1D2MFS Percent difference
F-E 5 & 6	775	−0.21*	−0.05*	0.89*	0.63±2.37	
S-F 5 & 6	701	0.02*	0.06*	0.42*	0.50±1.59	20.6%
F-E 11 & 12	640	−0.33*	−0.06*	2.68*	2.29±5.60	
S-F 11 & 12	878	0.07*	0.06*	1.69*	1.82±4.21	20.5%

* Differences in incidence scores between F-E and S-F communities that were statistically significant.

Table 4. D1D2MFS incidence for lifelong residents from fluoridation-ended (F-E) and still-fluoridated (S-E) sites by age group – 100 tooth surfaces at risk*

Study site/grades	Caries incidence after three years – 100AR					
	n	D1	D2	FS	D1D2MFS	D1D2MFS Percent difference
F-E 5 & 6	775	−0.01	−0.04†	1.11†	1.06†±2.91	
S-F 5 & 6	701	0.05	0.07†	0.53†	0.65†±1.93	38.6%
F-E 11 & 12	640	−0.24†	−0.04†	2.01†	1.73±4.10	
S-F 11 & 12	878	0.05†	0.05†	1.28†	1.38±3.10	20.2%

* 100 tooth surfaces at risk indicate the caries attack rate over the 36 months of follow-up for all tooth surfaces combined.
† Differences in incidence scores between F-E and S-F communities that are statistically significant.

Table 5. D1D2MFS incidence for lifelong residents from fluoridation-ended (F-E) and still-fluoridated (S-E) sites by age group – 100 Pit-and-Fissured tooth surfaces at risk*

Study site/grades	Caries incidence after 3 years – 100PFAR					
	n	D1	D2	FS	D1D2MFS	D1D2MFS Percent difference
F-E 5 & 6	775	−1.14†	−0.59†	8.19†	6.46†±19.34	
S-F 5 & 6	701	0.07†	0.34†	3.50†	3.91†±12.68	39.4%
F-E 11 & 12	640	−0.51	−0.43†	9.34†	8.40†±13.79	
S-F 11 & 12	878	−0.23	0.14†	6.44†	6.35†±11.74	24.4%

* 100 Pit-and-Fissured tooth surfaces at risk indicate the caries attack rate over the 36 months of follow-up only for pit-and-fissured tooth surfaces.
† Differences in incidence scores between F-E and S-F communities that are statistically significant, $P<0.01$.

or had little increment. These phenomena were offset by more surfaces being filled in children living in the fluoridation-ended site (for all tooth surfaces, 100AR, and 100PFAR). In other words, most of the decay incidence overall was detected in the Filled component, while the Decayed component was usually small.

The summing of D1S and D2S changes with the overall increase in FS led to no significant differences between sites when D1D2MFS for all surfaces was compared (Table 3). This contrast was modified when 100AR were used to assess caries incidence (only the group in grades 5 and 6 was different – Table 4), as well as in the case of 100PFAR (groups in grades 5, 6, 11 and 12 were different – Table 5): D1D2MFS patterns suggested that the fluoridation-ended site had higher D1D2MFS incidence figures than the fluoridated site. It is noteworthy that these trends were particularly apparent when the protective effect of sealants was controlled for through the separate appraisal of only surfaces at risk (Tables 4 and 5).

Regression analysis results

Prevalence model/all subjects

Twelve exploratory multiple stepwise models re-

Table 6. Multiple stepwise regression analyses, regressing prevalence D1D2MFS and its components on socio-demographic and generated variables – all residents

Dependent variable	(Constant)	Age	Sex	SES	Site	Snacks	Swal1	Swal2	Regime	FSUPTOT	R^2
D1D2MFS All surfaces	$-0.199^{\S}$	$0.184^{\ddagger}$	–	$-0.083^{\ddagger}$	$-0.353^{\ddagger}$	0.05*	–	–	–	–	0.058
D1S All surfaces	$0.535^{\ddagger}$	$0.038^{\ddagger}$	–	$-0.035^{\ddagger}$	$-0.259^{\ddagger}$	–	$-0.012^{\ddagger}$	$0.017^{\ddagger}$	–	–	0.052
D2S All surfaces	0.071*	–	–	$-0.015^{\ddagger}$	$0.048^{\ddagger}$	–	–	–	–	–	0.009
D1D2MFS Pit-and-fissured surfaces	$-0.200^{\S}$	$0.127^{\ddagger}$	–	$-0.055^{\ddagger}$	$-0.128^{\dagger}$	–	–	–	–	–	0.044
D1S Pit-and-fissured surfaces	$0.178^{\ddagger}$	$0.008^{\dagger}$	$-0.304^{\dagger}$	$-0.013^{\ddagger}$	$-0.054^{\ddagger}$	–	–	–	–	–	0.019
D2S Pit-and-fissured surfaces	$0.019^{\S}$	–	–	$-0.010^{\ddagger}$	$0.055^{\ddagger}$	–	–	–	–	–	0.012
D1D2MFS100AR	$1.079^{\ddagger}$	$0.089^{\ddagger}$	–	$-0.089^{\ddagger}$	$-0.431^{\ddagger}$	–	–	–	–	–	0.032
D1S100AR	$0.821^{\ddagger}$	0.021*	–	$-0.041^{\ddagger}$	$-0.289^{\ddagger}$	–	$-0.013^{\dagger}$	$0.017^{\dagger}$	–	–	0.042
D2S100AR	$0.061^{\S}$	–	–	$-0.016^{\ddagger}$	$0.068^{\ddagger}$	–	–	–	–	–	0.010
D1D2MFS100PFAR	$3.585^{\S}$	$0.699^{\ddagger}$	–	$-0.566^{\ddagger}$	$-2.885^{\ddagger}$	–	–	–	1.864*	–	0.022
D1S100PFAR	$3.053^{\ddagger}$	–	–	$-0.173^{\ddagger}$	$-0.800^{\ddagger}$	–	–	–	–	–	0.010
D2S100PFAR	$-0.067^{\S}$	–	–	$-0.093^{\dagger}$	$0.708^{\ddagger}$	–	–	–	–	0.045*	0.013

* $P<0.05$.
† $P<0.01$.
‡ $P<0.001$.
§ Non-significant.

Table 7. Multiple stepwise regression analyses, regressing incidence D1D2MFS and its components on socio-demographic and generated variables – all lifelong residents

Dependent variable	(Constant)	Age	SES	Site	Snacks	Swal1	Swal2	Regime	FSUPTOT	R^2
D1D2MFS All surfaces	$-2.136^{\dagger}$	$0.413^{\ddagger}$	$-0.143^{\dagger}$	–	–	–	–	–	−0.087*	0.092
D1S All surfaces	$0.290^{\S}$	–	–	−0.268*	–	–	–	–	–	0.012
D2S All surfaces	$-0.433^{\ddagger}$	$0.047^{\ddagger}$	–	–	–	–	–	–	−0.014*	0.035
D1D2MFS Pit-and-fissured surfaces	$-0.708^{\S}$	$0.173^{\ddagger}$	−0.074*	–	–	–	–	–	–	0.057
D1S Pit-and-fissured surfaces	$0.050^{\S}$	–	–	−0.144*	–	–	0.010*	–	–	0.027
D2S Pit-and-fissured surfaces	–	–	–	–	–	–	–	–	–	–
D1D2MFS100AR	$-1.250^{\S}$	$0.197^{\dagger}$	−0.124*	$0.624^{\dagger}$	–	–	–	–	–	0.045
D1S100AR	$-0.273^{\S}$	–	–	–	–	−0.014*	–	–	–	0.011
D2S100AR	$-0.278^{\dagger}$	$0.028^{\dagger}$	–	–	–	–	–	–	–	0.017
D1D2MFS100PFAR	$-2.424^{\S}$	–	–	$4.675^{\dagger}$	–	–	–	–	–	0.019
D1S100PFAR	$-1.613^{\dagger}$	–	–	–	–	–	$0.173^{\dagger}$	–	–	0.023
D2S100PFAR	–	–	–	–	–	–	–	–	–	–

* $P<0.05$.
† $P<0.01$.
‡ $P<0.001$.
§ Non-significant.

gressed the various D1D2MFS indices and their components on the socio-demographic variables and Generated Variables (Table 6). Besides SITE and SES and to a lesser extent AGE, few other independent variables were significant in the models. The extent of the variation explained was usually small. Lower SES and higher AGE were associated with higher caries activity. The effect of SITE depended on which caries index was examined: in the still-fluoridated site, higher scores were found for non-cavitated lesions (D1) and the complete D1D2MFS indices. By contrast, in the fluoridation-ended site, higher scores were present for cavitated lesions (D2) (Table 6).

Incidence model/all subjects

The most significant variable was AGE. The proportion of variation explained by this variable, however, was small. Other significant variables were whether the study SITE was fluoridated or not, and SES. Most independent variables were, however, not significant. Significant models can be summarized by saying that age, socio-economic status and, to a lesser extent, past use of fluoride supplements were

Table 8. Multiple stepwise regression analyses, regressing incidence D1D2MFS and its components on socio-demographic and generated variables – only for lifelong residents who were not D1D2MFS=0 at baseline

Dependent variable	(Constant)	Age	SES	Site	Snacks	Swal1	Swal2	Regime	FSUPTOT	R^2
D1D2MFS All surfaces	−2.992§	0.632†	−0.366*	–	–	–	–	–	–	0.156
D1S All surfaces	–	–	–	–	–	–	–	–	–	–
D2S All surfaces	−1.039‡	0.102‡	–	–	–	–	–	–	0.038*	0.099
D1D2MFS Pit-and-fissured surfaces	−1.902*	0.281‡	–	–	–	–	–	–	–	0.821
D1S Pit-and-fissured surfaces	−0.572‡	–	–	–	–	–	0.032*	–	–	0.043
D2S Pit-and-fissured surfaces	–	–	–	–	–	–	–	–	–	–
D1D2MFS100AR	–	–	–	–	–	–	–	–	–	–
D1S100AR	–	–	–	–	–	–	–	–	–	–
D2S100AR	−0.723‡	0.064†	–	–	–	–	–	–	–	0.058
D1D2MFS100PFAR	–	–	–	–	–	–	–	–	–	–
D1S100PFAR	−5.232‡	–	–	–	–	–	0.485†	–	–	0.069
D2S100PFAR	–	–	–	–	–	–	–	–	–	–

* $P<0.05$.
† $P<0.01$.
‡ $P<0.001$.
§ Non-significant.

associated with the overall D1D2MFS increment (Table 7). D1D2MFS100PFAR was also related to socio-economic status. Increments for early carious lesions overall and on pit-and-fissured surfaces were indeed associated with the fluoridation status of the communities under study, but this relationship was not significant when cavitated lesion increments were analyzed. Age and past use of fluoride supplements were associated with this more advanced stage of decay overall, but not on pit-and-fissured surfaces. As with the prevalence results, lower SES and higher AGE were associated with higher caries activity. The effect of SITE for incidence results was not as clear cut as in the case of prevalence results. SITE was only a significant predictor in four of the 12 models – two of the models indicated that the still-fluoridated site had lower caries experience, while the other two had higher experience; however, the latter models were limited to at-risk surfaces (Table 7).

Incidence model/subjects who at baseline had D1D2MFS>0

Most independent variables were not significant (Table 8). Age appeared in four models; higher AGE was associated with higher caries activity. SES only appeared in the models once, again in relation to D1D2MFS, and SITE was never significant.

Discussion

This study investigated the impact of stopping water fluoridation using concurrent positive controls and a longitudinal design. This study was unique in that it used a modified D1D2MFS index that permitted detailed investigation of the relative changes in smooth and PF surfaces over time. Furthermore, caries attack rates were calculated which adjusted for the number of surfaces at risk and presented a more accurate measurement of disease activity than traditional DMFT or DMFS indices. Despite these strengths, a possible disadvantage was the likelihood that the questionnaire information may be suspect on account of recall bias. Another shortcoming was the hiatus between actual cessation of water fluoridation and the beginning of data collection. The fact that examiners were different for each study site and were not blinded to its fluoridation status detracts from an ideal design. Moreover, the very low levels of decay found at baseline and at follow-up suggest that, while valuable, findings from the present age cohorts may not be depicting the situation in the segments of the population more severely affected by caries activity. It is not a rhetorical question to ask ourselves if continued epidemiologic attention to the younger age groups in this day and age is wasting an opportunity to re-focus such attention to other groups, perhaps at increased caries risk, such as middle-aged adults and dentate elderly people.

The current context in which these results are presented differs greatly from the North American context of widespread dental decay 50 years ago, in which the benefit of water fluoridation could be unequivocally appreciated. The fact that caries experience has changed over time has led to new perceptions with regard to the trade-off between risk of decay and use of fluorides. There is no doubt that diminishing benefits in dental decay prevention associated with fluoridation measures warrant a re-examination of the issue, in particular in the epidemiological context of developed countries with widespread use of fluoride in many forms. Such re-examination of the evidence should take into account the public health nature of the measure. Since the ranges of treatment and preventive needs are wide, some segments of the population derive small direct benefits from having controlled exposure to fluorides while others benefit greatly from it. Dental caries is not only unequally distributed but also can be a serious problem in the younger age groups (2, 3) in North America. While great variation exists in this regard from one country to another, and within the same country, the groups that would benefit the most from the preventive effect of fluorides are usually the least able to access rehabilitative care to deal with established disease.

A direct comparison of our results with other publications is not straightforward. Some reports on the cessation of water fluoridation in settings still affected by relatively high caries activity have indicated that, after stopping fluoridation, caries experience increases (27, 29, 30). While such a phenomenon appears to be more common in primary teeth, this feature may be ascribable to the indices used in studies, or their cross-sectional designs, rather than clear-cut age differences. In some cases, cessation of water fluoridation has taken place within changing environments characterized by diminishing caries experience (26, 29, 31). The impact of stopping fluoridation is more difficult to assess accurately under those circumstances, in particular if the study design encompassed several cross-sectional samples. The decrease in caries levels reported by Künzel & Fischer (31) could be attributed to a partial offset of the effect of stopping fluoridation by introducing fluoridated domestic salt, and increased availability of fluoridated toothpastes. It is difficult to appraise the impact of these measures when more cariogenic snacks became simultaneously available and changes in the dental care system occurred. Lacking a positive control town, Kalsbeek et al. (26) found that, during a 10-year follow-up, decay levels first increased and then decreased in both a fluoridation-ended town and a never-fluoridated control town. More recently, Seppä et al. (40) found no increase in caries experience after fluoridation stopped between two cross-sectional samples of 6-, 9-, 12- and 15-year-olds who have had access to comprehensive dental services. A contrast of the roles of lay and professional preventive activities with the Finnish study is unfeasible.

How do we place the results of the present study in the larger context of the cessation of water fluoridation? British Columbia enjoys a high standard of living, with approximately 70% of the population having dental insurance (41). In adult dental office attendees, less than 5% of DMFT was DT; and 55% of people 16–45 years old were considered regular patients (41). While the last epidemiological survey in children undertaken in this affluent province of Canada took place in 1980, a comparison of those findings with another epidemiological survey in 1968–74 showed DMFT reductions of about a third of DMFT levels between the two surveys for 9-, 13- and 15-year-olds (42). Not only has the percentage of decayed teeth declined by well over 50, but also the percentage of filled teeth decreased markedly. In our investigation, although the FS prevalence figures remained similar between the baseline survey and the follow-up (Table 1), the D1D2MFS prevalence figures were substantially reduced only in the fluoridation-ended site. In general, caries experience was small (Table 2). The incidence of both non-cavitated and cavitated decay had negative increments in the fluoridation-ended site while positive incidence rates occurred consistently in the fluoridated site (with one exception, D1S in 100PFSAR) (Tables 3–5). Traditionally, after fluoridation ceases, caries experience would have been expected to increase. In the absence of professional intervention, more untreated decay would have been expected to be detectable. We postulate that, together with increasing utilization of sealants in both study sites during the follow-up interval, earlier and/or more common restorative intervention in the fluoridation-ended areas may have supported a negative trend for the D1S and D2S rates. According to this explanation, clinicians working in a fluoridated area may have different thresholds for intervention compared to clinicians whose patients no longer enjoy the benefit of fluoridated water. Under this hypothetical scenario, the clinicians in fluoridated areas would be more "comfortable" leaving certain lesions undisturbed between recalls, in contrast with the substantially higher incidence of FS in fluoridation-ended areas. Under this scenario, a surface would be filled as soon as an incipient lesion was suspected of progressing (Tables 3 to 5). Hence, the increase in the filled components accounted for a substantial proportion of the change in D1D2MFS figures. This scenario is only tenable if a more aggressive treatment philosophy evolved in the fluoridation-ended site. We lack direct evidence to that effect.

Regression analyses hinted at the general direction that variables seem to influence caries experience. Caries modeling, however, often shows that independent variables are not strong predictors of outcome. It was our expectation that whether the site of residence was fluoridated or not would explain a larger proportion of the changes to the indices (as has been found in other settings, such as the United Kingdom [27, 29, 30, 43]). This was not the case. Even socio-economic status failed to explain a substantial proportion of these changes, a link more commonly found (44). Some reports have indicated that a re-examination of the relationship between SES and caries is difficult to follow over long periods of time due to SES changes in the populations under study (29, 45). Results were as expected concerning subject age, since increasing age would lead to an increasing opportunity for a tooth to decay. Our results highlight a complicated and somewhat new picture derived from the cessation of fluoridation. Apparently, the changes in the patterns of dental caries observed in the earlier days of fluoridation as a single source of fluoride no longer apply. With multiple sources of fluoride present in modern life, it is becoming more difficult to detect changes in the epidemiological profile in a low-risk population such as ours. When assessment of the specific roles of dental and non-dental variables in shaping the epidemiological changes was attempted, we found that the predictive power of independent variables was limited. This is only to be expected if we take into account that not only was caries experience low generally, but also the variation within the independent variables failed to provide clear-cut differences between segments of the population. In the BC setting of relatively homogeneous exposure to fluorides, widespread use of fluoride toothpastes and good adherence to oral hygiene regimens, and good access to oral health care generally, the independent variables may fail to highlight substantial differences in caries experience simply because they do not exist. A contrast could be more apparent if markedly dissimilar situations prevailed to differentiate segments of the population under study, such as in the scenarios in pre-WWII North America; current situations in industrializing countries (46–48); or sub-groups within developed societies disproportionately affected by oral diseases, either young (30, 43) or mature (49).

It would appear that the intervention of the dental profession, and perhaps improved customs of oral health care at home, played an important role in shaping the epidemiological profile of this population during the follow-up interval. The use of sealants in both sites was very high (at baseline, 60% of subjects had one or more sealants present, with a mean 3.2 sealants per subject) (35) and certainly much higher than other published relevant studies. Most subjects in these communities were covered by third party dental plans, and as such are likely to be regular visitors to dental offices. While our primary focus was not to determine the effects of professional intervention on caries experience, data point to this factor as being important. A marked contrast between the present results and Finnish data (40) was that while no increase in caries took place after fluoridation had ceased, the use of sealants decreased sharply in Kuopio, Finland between the cross-sectional surveys (1992 and 1995).

Our findings suggest there are subtle differences in dental caries, and caries treatment experience, between people living in fluoridated areas and in areas in which fluoridation had ceased. We found that D1D2MFS incidence was not significantly different between communities, with large numbers of sealants placed overall, and more surfaces filled in the fluoridation-ended sites. The question after a 3-year longitudinal follow-up remains whether those changes have an impact on caries experience and its rate of progression when all other sources of fluoride, as well as preventive/rehabilitative dental care measures, are taken into account. The preventive impact of water fluoridation is of necessity different in a place with comprehensive, widely accessible dental services, and which also enjoys the benefits of various sources of fluoride that contribute to substantial overall exposure for most children. This is in agreement with the recent findings by Seppä et al. (40). In the larger scheme of things, it appears that the role of water fluoridation in supporting good oral health must be weighed against other measures that may achieve similar success but at a higher cost, such as the widespread utilization of sealants. Moreover, it is unwise to resort to restorative interventions to meet the challenge of dental decay when a primary prevention measure such as water fluoridation preserves the integrity of dental tissues overall, is less expensive, and is more effective.

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Jonathan Eder @hotmail.com (503) 415-0803

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A Comparison of Dental Treatment Utilization and Costs by HMO Members Living in Fluoridated and Nonfluoridated Areas

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Gerardo Maupomé, BDS, MSc, PhD; Christina M. Gullion, PhD; Dawn Peters, PhD; Sally Jo Little, RDH, MS

Abstract

Objectives: *To compare dental treatment experiences and costs in members of a health maintenance organization (HMO) in areas with and without community water fluoridation.* ***Methods:*** *HMO members with continuous dental eligibility (January 1, 1990 to December 31, 1995) who resided in Oregon and Washington were identified using administrative databases. Fluoridation status was determined by geocoding subscriber address. Measures were utilization of dental procedures, fluoride dispensings, and associated costs. Costs were based on nonmember fees, adjusted to 1995 dollar values. Data were analyzed using analysis of covariance, controlling for age and interactions.* ***Results:*** *About 85 percent of eligible members (n = 51,683) were classified as residing either in a fluoridated (n = 12,194) or nonfluoridated (n = 39,489) area. Mean age was 40.0 years; 52.3 percent were women. More than 92 percent of members had one or more dental visits. Community water fluoridation was associated with reduced total and restorative costs among members with one or more visits, but the magnitude and direction of the effect varied with locale and age and the effects were generally small. In two locales, the cost of restorations was higher in nonfluoridated areas in young people (<age 18) and older adults (>age 58). In younger adults, the opposite effect was observed. The impact of fluoridation may be attenuated by higher use of preventive procedures, in particular supplemental fluorides, in the nonfluoridated areas.* ***Conclusions:*** *These results are particularly relevant to insured populations with established access to dental care. Differences in treatment costs (savings) associated with water fluoridation should be estimated and included in future cost-effectiveness analyses of community water fluoridation.*

Key Words: fluoridation, cost, dental care utilization, dental restorations, health maintenance organizations

Introduction

Dental caries remains a prevalent disease. Nearly 80 percent of adolescents have had one or more carious lesions (1), and 93.8 percent of adults have evidence of treated or untreated caries (2). While optimal water fluoridation has long been known to reduce caries experience (3-6), by 1992 only 62 percent of the US community water systems were fluoridated, short of the relevant goal of at least 75 percent in *Healthy People 2000* (7) and *Healthy People 2010* (8). With the proliferation of fluoride technologies applied to individual patients, smaller differences exist in caries experience between community water fluoridated (CWF) and nonfluoridated (NF) areas (9). Given the changing epidemiological profile of caries, however, data are needed on the cost-effectiveness and health consequences of CWF and other fluoride technologies.

Cost-effectiveness analysis – assessment of the comparative impacts of expenditures on different health interventions (10) – can inform resource allocation decisions to improve health. One major evaluation aspect of any preventive program is to estimate the net cost or savings realized through preventing disease and reducing the need for treatment. Net dental treatment costs associated with prevention of caries should be included in the economic analysis of CWF programs. Estimates of net treatment costs should include the initial restoration, replacement costs, cast restorations, endodontic therapy, extractions, bridges, and so on (11).

CWF cost-effectiveness analyses have not typically included reduced caries treatment costs, thereby overestimating the marginal change in health care costs attributable to CWF (12). Cost-effectiveness guidelines are based on the appraisal of the performance of preventive programs (13,14), but no consensus has been reached on whether to include treatment savings or not (11), and very few estimates have been done of the potential cost savings associated with CWF.

Send correspondence and reprint requests to Dr. Gerardo Maupomé, Oral Health Research Institute, Indiana University School of Dentistry, 415 Lansing Street, Indianapolis, IN 46202-2876. Tel.: 317-274-5529; Fax: 317-274-5425; e-mail: gmaupome@iupui.edu. Gerardo Maupomé is with the Oral Health Research Institute, Indiana University School of Dentistry, and The Regenstrief Institute, Inc. Christina M. Gullion is with the Center for Health Research, Kaiser Permanente Northwest. Dawn Peters is with the Oregon Health and Science University. Sally Jo Little is with the Center for Health Research, Kaiser Permanente Northwest and Pacific University, School of Dental Health Science. **Source of support:** Support provided by a contract with the Centers for Disease Control and Prevention through a contract with The HMO Group (Alliance for Community Health Plans), New Brunswick, NJ. Contract Number 200-95-0953; Task Order Number 0953-005. Support for Dr. Peters through NIDCR K25 DE14093. **Previously presented:** White BA, Little SJ, and Martin JA. Fluoridation and its impact on the use and cost of dental care. *Journal of Public Health Dentistry* 1998;58(2):181. Manuscript received: 3/6/06; accepted for publication: 5/13/07.

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One study found that in adults aged 20-34 years with private dental insurance, CWF reduced disease but may or may not have reduced the use of restorative services (12). The researchers speculated that in CWF regions with a large number of dentists, less disease and more dentist competition might have resulted in supplier-induced restorative demand. Another study used epidemiological data from national surveys to model the reduction in dental treatment and associated costs. It found that the reduction in restorative care costs as a result of averted disease attributed to CWF exceeded the cost of water fluoridation in communities of any size (15). A third study found differences ascribable to caries prevalence and community size (16). A recent study estimated costs (and savings) associated with CWF in permanent teeth, including patients' time spent while obtaining care and the cost of CWF (17). While the results were robust under a variety of assumptions, these reports did not use actual treatment experience or longitudinal restorative cost data to estimate costs and/or savings.

The objective of this study was to identify the dental treatment experiences of persons living in CWF and NF areas and to evaluate differences in dental treatment costs using a 1990-95 dataset from a dental health maintenance organization (HMO). While the data collection was contemporary, data analyses and publication were unfortunately delayed for years.

Materials and Methods

Institutional review board approval was obtained for this data-only study.

Study Population and Its Environment. Kaiser Permanente Northwest region (KPNW) is a not-for-profit, federally qualified HMO that served about 162,800 dental plan members in 1990 in Northwest Oregon and Southwest Washington. The KPNW Dental Care Program (KPDCP) offers comprehensive preventive and restorative services. Dentists, who are not employees of KPDCP, contract their salaried services exclusively to KPDCP as a self-governing, independent professional group; they use their professional judgment in deciding what care to provide, within the guidelines set by the group.

Administrative data from dental HMO subscribers and their dependents (collectively, members) were included in the study if members: a) were continuously eligible for dental services from January 1, 1990 through December 31, 1995; and b) had the then-current subscriber residence address in the Portland, OR, metropolitan area (Clackamas, Multnomah, and Washington counties), Marion County, OR (primarily Salem), or Clark County, WA (primarily Vancouver), that could be classified as having a fluoridated or NF water supply (HMO administrative data sets provide only current address, precluding ascertainment of historical changes).

Fluoridated and NF Regions. Each of the three geographic locales contained both CWF and NF water districts, and we observed three levels of fluoridation compliance across the three locales. This variation was an important factor in designing the analyses, which evaluated the contribution of locale as well as fluoridation status to costs and number of procedures.

In Clark County, water districts with CWF (primarily Vancouver) consistently had fluoride levels within the optimum range of 0.8 to 1.3 parts per million (ppm).

In contrast, in Marion County water districts (primarily Salem), CWF optimum criteria for fluoridation were only intermittently met. For 3 of the 6 years of the study period, the percentage of days each year that the fluoride level in the water supply was equal to or greater than 0.5 ppm was less than 25 percent. In only 2 of the 6 years did this percentage exceed 50 percent, and on more than 300 days in 1993, fluoride levels were lower than 0.5 ppm.

The only fluoridated water district in the Portland metro locale is the Tualatin Valley, OR. Compliance there was moderately good: the percentage of days each year that the water was fluoridated ranged from 58 to 98 percent. During 5 of the 6 study years, water was fluoridated at optimum levels (between 0.5 and 1 ppm) on at least 76 percent of the days. Thus, this area was intermediate between Clark and Marion counties in fluoridation compliance.

Fluoridation Status. To determine the fluoridation status of members, addresses of KPDCP subscribers were provided to the Metro Data Resource Center (DRC) in Portland, OR. The DRC linked water provider information to each address (geocoded) using geographic information systems. Subscribers whose address was located within 100 feet of a city, county, or water district boundary were excluded ($n = 137$). Subscribers whose address was located in a water district with a known fluoridation status were assigned to that status group. Dependents of a subscriber were classified by the subscriber's residence address locale and fluoridation status.

Outcome Measures and Variable Acquisition. Outcome measures were dental services that fluoridation could directly influence, costs and number of procedures, including prescribed fluorides, derived from KPNW administrative, dental treatment, and outpatient pharmacy databases. These databases also were used to identify continuous membership and dental office visits.

Number of Procedures. The primary utilization measure was the number of procedures per member among those with any dental visits in the 6-year period (and hence nonzero costs). We separately examined counts of restorative procedures and two primarily preventive procedures – first, pit-and-fissure sealants and preventive resin restorations (S/PRR), and second, supplemental (other than over the counter) fluoride dispensings. To measure supplemental fluoride dispensings, the KPDCP list of products containing fluoride was compared with dispensing records to determine the number of members who had any dispensings of such products during the study period (either prescribed or administered in-office).

Costs. We used nonmember fees as the basis for setting costs of all procedures listed above. Nonmember fees were those that would have been charged a non-KPDCP member who used KPDCP services in the year that the procedure was carried out. Procedure fees for all years were converted to 1995 dollars using the dental component of the Consumer Price Index (CPI). Procedure codes in the treatment database for each member were linked to the procedure fees to obtain costs for dental services and per-visit costs. The cost of supplemental fluorides was based on nonmember product and dispensing fees and converted to 1995 dollars using the drug component of the CPI. We analyzed costs after applying a normalizing transformation, the natural logarithm (ln) of $x+1$, where x was the raw dollar amount, to correct for extreme skewing. In tables and figures, estimates were converted back from ln units to dollar units for ease of interpretation.

Data Analysis. Because the three geographic locales contain both CWF and NF water districts, we have a factorial design, which allows the evaluation of the interaction of locale and fluoridation status. Because the distribution of age differed between locales, we also entered age into the models as a covariate. All analyses were carried out using SAS 8.2 (SAS Institute, Inc., Cary, NC, USA).

We used analysis of covariance models to evaluate the impact of fluoridation, locale, and age (and their interactions) on costs and utilization, with error models that matched the three types of dependent variable. Transformed (normalized) cost data were modeled using ordinary least squares (PROC GLM). Proportions were analyzed using logistic regression, and the counts of number of procedures or visits were modeled using Poisson regression (PROC GENMOD for both).

Analysis of covariance has important assumptions that we tested (18) before settling on a final model. We evaluated the assumption that the relationship between age and each dependent variable was linear; if it was not, we planned to analyze a nonlinear function of age that more accurately represented the relationship (e.g., age-squared, age-cubed). We tested two homogeneity assumptions: a) that age has the same association with outcome in all of the six groups (three locales by two fluoridation statuses) and b) that the differences between NF and CWF areas were proportional across different locales. We set α at 0.20 in tests on interactions to reduce the probability of missing an interaction that would modify interpretation of the main effects. We set α at .05 for all other tests.

When a significant interaction indicated that the assumption of homogeneous effects was not met, we followed up with estimates of the means to understand the pattern of differences better. For an interaction between locale and fluoridation status, we compared means in fluoridated versus NF areas separately for each locale. In some cases, we also examined differences between locales within a fluoridation status. If there was an interaction between age and locale and/or fluoridation status, we estimated the predicted value of the dependent variable in the six cells at three arbitrarily selected values of age, in order to illustrate how costs varied as a function of age. We selected the mean: age 10, the midpoint of the youngest 10 percent, and age 80, about the middle of the oldest 10 percent.

Results

Sample Identification. We identified 60,732 eligible members, each of whom was linked to the address of an HMO subscriber ($n = 28{,}887$). Duplicate, post office box, and "in care of" addresses, and addresses outside the study locales were eliminated, leaving 25,685 addresses. DRC was able to place 24,729 unique addresses in the water districts, which represented 51,683 dental HMO members who met all of the eligibility criteria. Table 1 shows the sample sizes by locale and fluoridation status. As of December 31, 1995, age ranged from 5 to 98 years (mean = 40.0, standard deviation = 20.3). We grouped several youngsters born on January 1, 1990 with 6-year-olds. KPNW members were predominantly (over 90 percent) a White population, consistent with the KPNW service area, and 52.3 percent were female.

Table 1
Proportions of Participants with One or More Dental Visits by Locale and Fluoridation Status, at Selected Ages

Locale	Estimated at member age	Proportion with >1 visit: NF	Proportion with >1 visit: CWF	$P<$*
Portland metro		$n = 33{,}657$	$n = 3{,}405$	
	10	0.95	0.96	0.34
	40	0.92	0.94	0.02
	80	0.85	0.88	0.08
Marion County		$n = 1{,}568$	$n = 4{,}006$	
	10	0.96	0.96	0.44
	40	0.95	0.94	0.31
	80	0.91	0.91	0.85
Clark County		$n = 4{,}264$	$n = 4{,}783$	
	10	0.98	0.95	0.01**
	40	0.94	0.92	0.01**
	80	0.83	0.86	0.07

* P-value for difference in age-adjusted proportions between NF and fluoridated, within locale, at the specified age; ** $P < 0.0001$.
CWF, community water fluoridated; NF, nonfluoridated.

Table 2
(A) Total Six-Year Costs and (B) Number of Visits for Members with One or More Visits

A. Total costs

Locale	Estimated at member age	NF ($)	CWF ($)	Difference ($)†	Model 1 P<‡	Model 2 P<¶
Portland metro		$n = 30{,}967$	$n = 3{,}185$			
	10	1,054	1,108	(54)	0.01	0.91
	39	1,224	1,300	(76)	0.24	0.01*
	80	2,101	2,253	(152)	0.07	0.73
Marion County		$n = 1{,}482$	$n = 3{,}763$			
	10	1,097	1,086	11	0.08	0.95
	39	1,236	1,200	37	0.50	0.21
	80	1,882	1,686	196	0.01	0.01
Clark County		$n = 4{,}006$	$n = 4{,}404$			
	10	1,261	1,130	131	0.01*	0.01
	39	1,408	1,287	121	0.06	0.74
	80	2,059	1,978	81	0.12	0.44

B. Number of visits (same sample as A)

Locale	Age	NF	CWF	Difference†	Model 1 P<‡
Portland metro					
	10	12.7	13.5	−0.8	0.04
	39	14.3	14.9	−0.5	0.04
	80	20.3	20.9	−0.6	0.47
Marion County					
	10	12.6	12.0	0.7	0.28
	39	13.1	13.6	−0.5	0.26
	80	18.9	16.6	2.3	0.04
Clark County					
	10	14.4	13.0	1.4	0.01
	39	14.7	14.2	0.4	0.17
	80	20.7	19.3	1.4	0.16

P-values are for the difference in age-adjusted proportions between NF and CWF, within locale, at the specified age (and in Model 2, number of visits).

* $P < 0.0001$.

† Difference is NF − CWF, negative differences (in parentheses) indicate CWF > NF. Differences may not match the NF mean − CWF mean because of rounding.

‡ Model 1 includes only age and age^2 as covariates.

¶ Model 2 includes age, age^2, and ln(number of visits) as covariates.

NF, nonfluoridated; CWF, community water fluoridated; ln, natural logarithm of cost + $1.

Tables 1 to 6 present the results of modeling for the various outcome measures. The means presented in the tables are model-based least-squares estimates. The *P*-values in Tables 1 to 6 are for the difference between members with CWF and those with NF in the specified locale; those that we judged significant are underlined. We present the predicted value of the dependent variable at three levels (low, mean, high) of age in order to illustrate how the costs or utilization varied with age. Because the subsamples vary in size and membership, they also vary in mean age.

Proportion of Members with a Dental Visit. Table 1 shows the proportion of members by locale, fluoridation status, and selected ages who had one or more dental visits during the study period ($n = 51{,}683$). The relative proportion of members with a visit at various ages differed significantly between the six combinations of locale and fluoridation status (i.e., the three-way interaction of age, locale, and fluoridation status was significant, $P < 0.09$). The *P*-values for contrasts between NF and CWF in the three locales at ages 10, 40 (the mean overall subjects), and 80 are given in the last column of Table 1. In the Portland metro area, the proportion with one or more visits was generally higher among Portland metro members with CWF than with NF, but this difference was significant only at age 40 ($P < 0.02$). In Marion County, the contrasts were not significant at any age. In Clark County, more members with NF had a visit than those with CWF overall, but the difference between fluoridation status groups is significant only at ages 10 ($P < 0.001$) and 40 ($P < 0.001$).

Cost of Dental Care. Table 2A shows the total costs over the study period for members who had one or

Table 3
(A) Proportion of Members with One or More Restorative Procedures and (B) Counts of Restorative Procedures among Members with One or More Dental Visits

A. Proportion with restorative treatment

Locale	Age	NF	CWF	Difference†	P<
Portland metro	$n = 30{,}967$	$n = 3{,}185$			
	10	0.62	0.64	−0.02	0.35
	39	0.84	0.84	0.00	0.83
	80	0.81	0.86	−0.05	0.01
Marion County	$n = 1{,}482$	$n = 3{,}763$			
	10	0.69	0.64	0.05	0.03
	39	0.84	0.80	0.04	0.01
	80	0.83	0.84	−0.01	0.67
Clark County	$n = 4{,}006$	$n = 4{,}404$			
	10	0.70	0.66	0.04	0.02
	39	0.87	0.85	0.02	0.01*
	80	0.78	0.80	−0.02	0.47

B. Estimated mean number of restorative procedures (same sample as A)

Locale	Age	NF	CWF	Difference†	P<
Portland metro					
	10	4.15	4.18	−0.03	0.80
	39	6.61	6.46	0.15	0.26
	80	12.79	11.96	0.83	0.04
Marion County					
	10	4.24	4.13	0.11	0.55
	39	6.36	6.01	0.35	0.10
	80	11.28	10.20	1.08	0.02
Clark County					
	10	5.18	4.73	0.45	0.01
	39	8.00	7.08	0.92	0.01**
	80	14.79	12.52	2.27	0.01**

* $P < 0.001$; ** $P < 0.0001$.
† Difference is NF − CWF, negative value indicates CWF > NF.
CWF, community water fluoridated; NF, Nonfluoridated.

Table 4
Six-Year Costs for Restorative Procedures among Members with One or More Restorative Procedures

Locale	Age	NF	CWF	Difference*	P<
Portland metro		$n = 24{,}418$	$n = 2{,}513$		
	10	226	268	(42)	0.01
	41	361	330	31	0.01
	80	550	483	67	0.15
Marion County		$n = 1{,}199$	$n = 2{,}892$		
	10	255	213	42	0.06
	41	302	358	(56)	0.01
	80	503	395	107	0.07
Clark County		$n = 3{,}275$	$n = 3{,}504$		
	10	293	237	55	0.01
	41	407	388	20	0.18
	80	590	523	67	0.26

* Difference is NF − CWF, negative differences (in parentheses) indicate CWF > NF. Difference may not match NF mean − CWF mean because of rounding.
CWF, community water fluoridated; ln, natural logarithm of restoration cost; NF, nonfluoridated.

more visits ($n = 47{,}807$), by locale, fluoridation status, and age. Initially (Model 1), we examined only age as a covariate. Age has a quadratic relationship with ln(costs + 1); that is, the rate of increase in costs over changing ages was relatively small before about age 40, then climbed more rapidly at older ages. There were significant three-way interactions between age-squared, locale, and status ($P < 0.01$) and between age, locale, and status ($P < 0.001$). We report predicted costs and P-values for contrasts at ages 10, 39 (the mean for this sample), and 80, which reveal the inconsistent differences between CWF and NF across locales and ages, indicated by the significant interactions. Portland metro had higher costs in CWF areas than in NF areas, the opposite of Marion County and Clark County, although not all differences are significant. Differences between CWF and NF in total costs were significant only among children (age 10) in Portland metro ($P < 0.01$) and Clark County ($P < 0.001$) (but in opposite directions), and in Marion County only in elderly members (age 80, $P < 0.01$).

Number of Dental Visits. Table 2B shows the effects on visit counts for the same factors and subject sample as in Table 2A. As for costs, age had a quadratic association with visit count, with a parallel pattern of higher frequency of visits at older ages. The three-way interactions involving age-squared and age were significant at $\alpha = 0.20$ ($P < 0.11$ and 0.09, respectively). Fit statistics indicated overdispersion of the data (higher variance than expected for a Poisson distribution), and standard errors were scaled using the deviance (generalized Poisson). We found the same overall pattern of differences in visit counts that we found in modeling costs (Table 2A). In Portland metro, members in the NF areas had fewer visits than those in the CWF areas; this was significant only at ages 10 and 39. In Marion and Clark counties, the pattern generally showed more visits in NF than CWF areas, but these contrasts reached significance

Table 5
Proportion Receiving S/PRR in Members Ages 6 to 17 Years Old with One or More Dental Visits

Locale	Age	NF	CWF	Difference†	P<
Portland metro		$n = 6{,}706$	$n = 747$		
	8	0.51	0.59	−0.08	0.02
	12	0.70	0.81	−0.11	0.01**
	16	0.51	0.70	−0.19	0.01**
Marion County		$n = 298$	$n = 822$		
	8	0.57	0.65	−0.08	0.17
	12	0.76	0.78	−0.02	0.47
	16	0.57	0.56	0.01	0.71
Clark County		$n = 1{,}003$	$n = 986$		
	8	0.73	0.67	0.06	0.08
	12	0.89	0.85	0.04	0.01*
	16	0.84	0.76	0.08	0.01

* $P < 0.001$; ** $P < 0.0001$.
† Difference is NF − CWF, negative value indicates CWF > NF.
CWF, community water fluoridated; NF, nonfluoridated.

only at age 80 in Marion County and at age 10 in Clark County.

We hypothesized that differences in the number of dental visits might account for the differences in costs noted in Table 2A. Therefore, we added visit count as a covariate in the costs model (Model 2). The three-way interactions of age-squared, age, and visit count with locale and status are all significant at $\alpha = 0.20$ ($P < 0.01$, 0.01, and 0.08, respectively). In Portland metro, the effect of adjusting for visit count was a shift in the age at which significant differences were observed, from age 10 ($P < 0.91$) to age 39 ($P < 0.001$). No other change in the pattern of significance was observed.

Prevalence and Volume of Restorative Procedures. Table 3A shows the proportion of members with one or more visits who had a restoration ($n = 47{,}807$). The association of this proportion with age is quadratic; in this outcome measure, the proportion having visits increased from youth to middle age, then either stopped increasing or decreased in older members. The three-way interactions were not significant, but all two-way interactions were significant (locale × status, $P < 0.001$; age × status, $P < 0.17$; age × locale, $P < 0.03$; age-squared × status, $P < 0.08$; age-squared × locale, $P < 0.02$). In Portland metro, proportions receiving any restorative treatments were the same or higher in the CWF areas than in the NF areas, but only among older members is this significant (age 80, $P < 0.01$). In contrast, in Marion and Clark counties, members aged 10 and 39 (the mean for this sample) in NF areas were significantly more likely to have a restoration than were members with CWF (see Table 3A for P-values); at age 80, the NF and CWF areas did not differ.

The number of restorative procedures (Table 3B) in the same sample was significantly higher among older members living in the NF areas in all locales. In Clark County, the difference (NF > CWF) was significant at ages 10 and 39 also. The form of the association with age was linear (increasing steadily with age), and the three-way interaction was not significant, so only two-way interactions with age were included in the final model (locale × fluoridation status, $P < 0.01$; age × locale, $P < 0.05$; age × status, $P < 0.12$). The fit statistics indicated overdispersion of the data, and the standard errors were scaled using the deviance (generalized Poisson).

Cost of Restorative Procedures. We evaluated whether costs of restorative procedures were related to fluoridation status in members who had at least one restoration ($n = 37{,}801$). Figure 1 displays mean restorative costs [estimated on ln (restoration cost) and converted back to dollars] on age deciles calculated in the whole subsample. Decile points close together indicate a high density of members in that age range, whereas those far apart indicate that there are relatively few members in that age range. As the figure shows, the form of the association with age appears to be cubic, with decrease from early years to teens, increase during the middle years, and decrease or flattening late in life. The three-way interactions of locale and status with the three age terms were all significant (age-cubed $P < 0.001$, age-squared $P < 0.001$, and age $P < 0.001$). As shown in Table 4, model-based means at ages 10, 41 (the mean for this subsample), and 80 indicate a complex pattern. In Portland metro, the pattern of differences between NF and CWF areas is significant but inconsistent at ages 10 (CWF > NF) and 41 (CWF < NF). In Clark County, only at age 41 was there a significant difference (CWF > NF). In Marion County, significance was seen only at age 10 (CWF < NF). The oldest members had the highest restorative costs and the largest NF–CWF differences; however, with small *n*s and larger standard errors, fluoridation status did not contribute a significant effect in any locale. We observed the same pattern of results when we excluded S/PRR from restorative costs.

S/PRR. Table 5 shows the association between age and proportion receiving S/PRR in the age range 6 to 17. The association of age with S/PRR is quadratic. Use of S/PRR peaked at about ages 12-14 and then declined among older teens. No two-way or three-way interactions involving age-squared significant, although age-squared by itself was significant ($P < 0.0001$). The three-way interaction involving age was significant ($P < 0.03$). In Portland metro, significantly more children in the CWF area received S/PRR than in the NF area (age 8 $P < 0.01$, age 12 $P < 0.001$, age 16 $P < 0.001$). The opposite pattern

Table 6
Supplemental Fluoride Dispensing among Child Members with One or More Dental Visits

	NF			CWF		
Locale/age group	*n*	Proportion with 1+ dispensings	Mean (SD) number of dispensings*	*n*	Proportion with 1+ dispensings	Mean (SD) number of dispensings*
Portland metro						
6-11	2,734	0.52	3.8 (4.2)	322	0.22	2.8 (3.4)
12-17	3,972	0.14	2.8 (3.7)	425	0.04	2.9 (3.5)
Marion County						
6-11	120	0.36	3.1 (2.8)	338	0.07	1.8 (1.3)
12-17	178	0.12	1.3 (0.9)	484	0.03	1.3 (0.6)
Clark County						
6-11	387	0.27	2.6 (2.8)	394	0.12	2.8 (3.2)
12-17	616	0.07	2.9 (3.5)	592	0.02	2.6 (3.4)

* Among members with one or more dispensings.
CWF, community water fluoridated; NF, nonfluoridated; SD, standard deviation.

was found in Clark County (significant at ages 12, $P < 0.001$, and 16, $P < 0.01$), which also had a markedly high prevalence of S/PRR use overall. In Marion County, the NF–CWF difference was not significant at any age.

Supplemental Fluoride Dispensing. Among members who had one or more dental visits ($n = 47{,}807$), about 7 percent in the NF areas and 2 percent in the CWF areas had at least one supplemental fluoride dispensing. Table 6 shows the percentage of members in the 6 to 11 and 12 to 17 age groups who received supplemental dispensings, and the mean number of dispensings. Less than 2 percent of members over 18 years of age received any dispensings. In the NF group, 48.5 percent of 6- to 11-year-olds and 12.8 percent of 12- to 17-year-olds received one or more supplemental dispensings. In the CWF group, 13.6 percent of 6- to 11-year-olds and 2.9 percent of 12- to 17-year-olds received one or more supplemental dispensings. Among members with NF water who received one or more dispensings, means ranged from 3.82 dispensings for 6- to 11-year-olds in Portland metro to 1.29 for 12- to 17-year-olds in Marion County. The cost of supplemental dispensing was small – less than 0.1 percent of total costs.

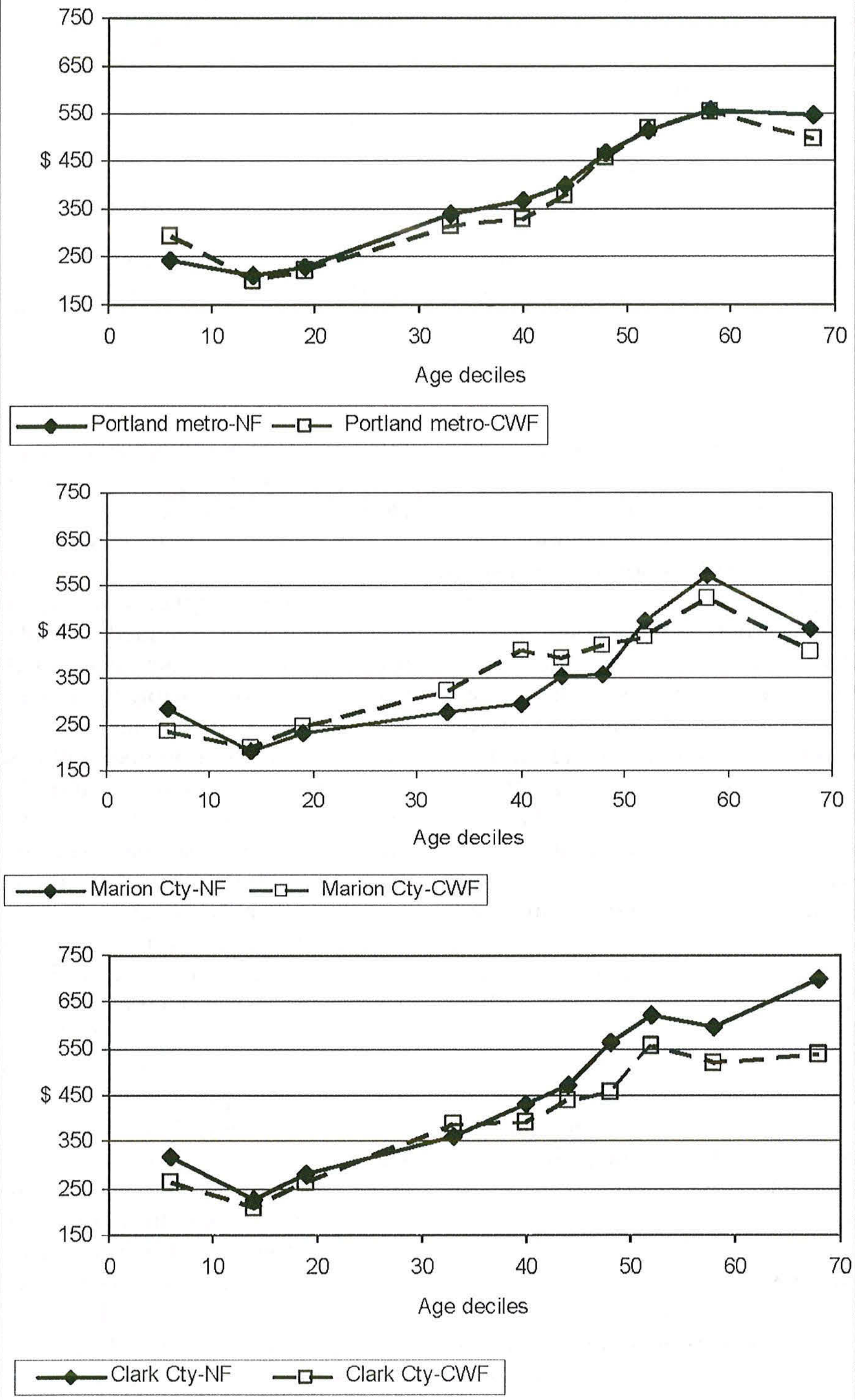
Preventive Procedures and Restorative Services. We evaluated whether a) the number of restorative procedures and b) restorative costs in children (ages 6 to 11 or 12 to 17) with one or more restorations could be predicted by fluoride dispensings or placement of S/PRR. These two models (not shown) controlled for fluoridation status and locale. We found that S/PRR was significantly associated with the number of restorations in both the 6- to 11- and 12- to 17-year-old groups ($P < 0.001$). However, the direction of the association was the opposite of what we would have expected – in every locale and fluoridation status, children with S/PRR had more restorations. Costs were not consistently higher in NF than CWF areas. There were significant two- and three-way interactions in all four models, making it difficult to generalize the specific contribution of these interactions beyond confirming the overall substantial association with S/PRR use.

Discussion

This project evaluated the impact of CWF on treatment and associated costs for a group of HMO members in the US Northwest between 1990 and 1995. In terms of total costs of dental treatment (Table 2A), Portland metro had lower treatment costs for the NF area, while the other two areas showed costs marginally higher for the NF status. For the intermittently fluoridated Marion County and the consistently fluoridated Clark County, CWF was generally associated with lower costs.

The ordering of treatment cost and utilization in CWF areas was not consistent with their ordering on compliance with intended fluoridation levels. The fact that Clark County, the most reliably fluoridated locale, often had the highest costs overall, the highest number and cost of restorative procedures, and the highest number of S/PRR (Tables 2A, 3B, 4, and 5) suggests that characteristics of members in these communities rather than fluoridation of water may be the primary driver of dental utilization. This is consistent with the overdispersion observed in counts of visits and of procedures, which can result when unobserved variables (i.e., important predictors of utilization) are missing from a model. Theoretically, the variance should equal the mean of a Poisson-distributed variable. In these data, however, the variance was much larger. One possible way to improve model fit is to add covariates that might account for more of the variance. It was beyond the scope of the present study to identify these, and so this remains a potentially fruitful area of inquiry. Candidates for inclusion as covariates include socioeconomic status (SES), chronic health conditions, and long-term use of medications leading to salivary gland hypofunction.

Figure 1
Age group breakout of restorative costs by locale and fluoridation status (exponentiated average natural logarithm of restorative costs). CWF, community water fluoridated; NF, nonfluoridated



Dentists' decisions on treatments and preventive services may also be affected by knowledge of the member's home fluoridation status. The extent of this effect was beyond the scope of this data-only study. The fact that dentists were all members of one group-model practice seems likely to ameliorate differences in practice decisions and thus minimize such impact.

Differences in caries experience between NF and CWF locales may have been diluted by variations between NF and CWF groups with respect to two preventive therapies. First, far more children in NF areas received one or more supplemental fluoride dispensings than did those in CWF areas (Table 6). The fluoride treatments received by children in NF areas could thus reduce the experience of caries and lessen the differences between NF and CWF. Such treatments also could signal better knowledge and behaviors related to dental and general health in their recipients or their families. Also, the application of S/PRR among members 6 to 17 years of age was dramatically greater than that reported in national surveys (19) – 60.6 percent in the NF regions and 70.5 percent in the CWF regions had at least one S/PRR. Differences between NF and CWF areas for S/PRR were inconsistent between locales, however. This situation may be partly attributable to some pediatric dentists who were particularly aggressive in their use of S/PRR during this time period. As indicated earlier, children with S/PRR had more restorations than those without S/PRR for each combination of locale and fluoridation status; hence, the use of S/PRR may depend to a large extent on observed caries risk regardless of fluoridation status, as previously reported (20).

In the CWF area of Clark County, where fluoridation compliance was good, overall costs were lower than in the NF area of Clark County. The same relationship held within Marion County, although the effect of fluoridation here was only marginally significant when not controlling for number of visits. Marion County differs from Clark County in the age at which the impact of water fluoridation is strongest: in Marion County it is in the oldest members, whereas in Clark County it is in the youngest members. In Portland metro, there was no evidence of a beneficial effect of fluoridation on total costs; in fact, costs were generally higher among members living in the CWF than in the NF districts of the metropolitan area. (However, as noted, the Portland metro area's CWF compliance with guideline levels was not optimal.)

Across the three locales, the overall differences in total costs with one or more dental visits between the CWF and NF areas (NF – CWF) ranged from *negative* $152.31 (Portland, age 80) to $196.02 (Marion County, age 80). (Note that *negative* in this context connotes the direction of the relationship between CWF and NF – see table legends). The cost of the supplemental fluoride dispensing was not included in the comparisons of total dental cost. If included, the difference in mean total cost per person with one or more dental visits would increase by $0.94 over the 6-year period. Restorative cost differences (NF – CWF) per member with at least one dental visit over the study period ranged from *negative* $55.94 (Marion County, age 41) to $107.26 (Marion County, age 80). Taking into consideration the varying impact of age and locale, it seems reasonable to conclude that, as a general rule, costs were lower in the fluoridated areas.

As expected, total restorative costs increased with member age. The youngest and oldest members in the CWF areas had lower restorative costs and lower overall costs than same-age members in NF areas. Of note, in the older half of our sample (ages 43 to 98), mean difference in costs between the CWF and NF areas increased steadily and was highest in the 10th decile, centered at age 75 (NF > CWF, about $75, unweighted means across locales on deciles of age, Figure 1). The higher costs in older adults probably were associated with several factors, including use of anticholinergic medications, gingival recession and emergence of root caries, and impaired ability to practice self-care derived from frailty and illness in the oldest members (those over 90, for instance). We had no diagnostic codes available to investigate these possibilities, but against these risk factors, fluoridation appears to have some protective effect.

Various methodological considerations suggest that our findings may not be directly generalizable to the overall US population. The participants were primarily a relatively stable group in terms of employment. Having health insurance in the United States, in particular dental insurance, greatly depends on having employment. About 92 percent of members had one or more dental visits during the study period, with an average of more than two visits/year. Given what is known from national surveys, this population may be at relatively lower risk for dental disease and is likely to have higher-than-average dental utilization. (Generally speaking, the effect of CWF may be larger on persons with less stable employment and housing and lower SES.) Thus, if CWF were to have an effect on dental disease in an HMO population, one might expect the effect to be small.

This study was further limited by having available HMO pharmacy data restricted to what was already available for other purposes. While clinical records and diagnostic criteria were not standardized, quality audits and guidelines were in place. Because only disease recorded and/or treated can be ascertained, early or subclinical stages of disease may not have been recorded.

Another caveat is that our data do not capture actual time spent living in a particular water district (whether CWF or NF) because our administrative records included only members' current address. (Taking this discussion to the extreme, we could argue that water fluoridation status of school or place of work might differ from that of home, but the impact of this unknown factor is impossible to gauge in the current study design.) However, there may not have been much moving between water districts as this sample of HMO members with stable dental benefits over 5 years are also unlikely to have moved very far during this period. We are aware that fluoride levels fluctuated over time and varied between locales. However, the CWF areas in the three locales were not ordered consistently with the level of fluoridation compliance, indicating that such compliance accounts for little of the variation observed between locales. Examining the reasons for the fluoride-level fluctuation over time and across locales is beyond the scope of the present study.

A strength of our sample and our study is that data from a group-model HMO are likely to exhibit less variation in clinical decisions, patients' deferral of needed treatment because of out-of-pocket cost, and potential for overtreatment decisions than data from other systems of organizing and financing dental care – the opposite of limitations noted/assumed in previous studies (17,21). Furthermore, use of bottled water was much less popular in the 1990s, and thus the relative importance of this factor in overall exposure to CWF in the 1990s was probably less important then, compared with what it is today. Another strength is that although these data represent costs and utilization that occurred more than a decade ago, the practice of dentistry, such as the availability of effective preventive treatment, has varied relatively little since then. There has been sparse research addressing this question in a sample of comparable size in the United States.

In conclusion, we found evidence that CWF was associated with reduced total and restorative costs among members with one or more dental visits, particularly in older adults. The effect we observed was generally small, likely because of this insured population's access to care and the higher use of preventive procedures, in particular supplemental fluorides, in the NF areas. Differences in treatment costs (savings) associated with CWF should be estimated and included in future cost-effectiveness analyses of CWF. Direct cost of CWF, based on equipment replacement costs, was estimated to be ~$0.67 person/year in 1989 and ranged from $0.15 to $1.53 (converted to 1995 dollars) (22). Reductions in dental treatment costs in the CWF areas compare favorably with the estimated costs of CWF (15,23-25), suggesting that CWF may in fact have been cost saving at the time the study was carried out.

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September 6, 2012

Hearing on the Fluoridation of Portland's Water Supply: Public Input

185612

Hugo Schulz Hugo@cnufwaste.com
2224 SE Umatilla Street
Portland, OR 97202

Mayor Adams and Portland City Council members,

My testimony against the fluoridation of Portland's water supply focuses on its ineffectiveness as an ingested agent for the prevention of tooth decay in children and the corresponding direct and indirect costs. I don't dispute the efficacy of improved dental hygiene, diet, and topical application of fluoride.

The largest survey ever conducted in this country was commissioned by the National Institute of Dental Research (NIDR) in 1987. In this study, Brunelle and Carlos[1] looked at 39,000 children in 84 communities. The average difference in tooth decay in children aged 5-17 years who had lived all their lives in fluoridated vs. non-fluoridated communities was not statistically significant! Using an index called DMFS, which means counting decayed, missing, and filled surfaces of teeth, the actual difference was less than one half of one percent. Similarly, a study done in Washington State in 1996[2] looked at caries prevalence in 3,000 third grade children in 39 counties throughout the state. Their statistics were almost identical to the Brunelle study, and the investigators reported, "This study did not find a statistically significant effect of water fluoridation." They did find a significant correlation between decay and economic status, which is a finding that should be pursued.*

The World Health Organization gathered data in 2001[3] on tooth decay trends over the last several decades in twenty different countries. They found that there has been a significant decline in decay in 12 year olds since about the early 1970's. What is more interesting is that this decline is *virtually the same* in countries that are fluoridated, partly fluoridated or totally non-fluoridated.* (Over 90% of European countries don't fluoridate their water supplies.)

In addition to the direct costs of fluoride delivery setup and ongoing purchase of expensive high-grade fluoride to avoid heavy metals associated with low-grade industrial fluoride, indirect costs include:

1. Purchases of non-fluoridated bottled water by new mothers for baby formula as recommended by the American Dental Association to prevent fluorosis - placing a particular burden on low-income parents.

2. Purchase of expensive, ($1,000+) multi-stage filters for those who don't want to be medicated.

3. Medical costs and suffering associated with brittle bones caused by the cumulative effects of fluoride build-up in them.

4. The tragic cost to the children whose problems will not be solved by an easy, but ineffective solution. Given caries prevalence correlation to low social-economic status, a better long-term solution might be to create a regulatory and tax environment more conducive to economic growth.

I can conclude with no better statement than that made by Dr. Paul Connet, a noted authority, who said, "Ingesting fluoride for cavity prevention makes as much sense as swallowing sun block to protect the skin from sunburn."

1. Brunelle and Carlos, NIDR Fluoridation Survey, 1987
2. "The estimation of caries prevalence in small areas," Journal of Dental Research, 75(12), 1996
3. World Health Organization Oral Health Country/Area Profile Programme, October 2000 and August 2001

* source website: http://www.dentalwellness4u.com/layperson/fluoridefacts.html

A Pediatrician's Literature Review of Potential Effects of Community Water Fluoridation (CWFl) on Intelligence by
Virginia Feldman, MD, FAAP, Adjunct Professor of Pediatrics OHSU
September, 2012

The recent publication of a meta-analysis referred to as 'the Harvard study' is no study at all, {33} has no recent data, and, contrary to its claims, contains studies actually well-known to the scientific community. This community has published other meta-analyses which come to opposite conclusions—i.e. Fluoride at levels of CWFl levels does not affect IQ. {Brazien, Hu, Connett, Departments of Health in Australia, San Fransisco etc:, 21,23, 30, 31,32}.

The deficits in the literature suggesting effects on IQ are:

1. ***Few (1, 3) controlled for many, no less all the main variables that influence intelligence: iron deficiency, lead, arsenic (As), and iodine. Few controlled for socioeconomics and parental education.***

None of the 16 Chinese studies in the meta-analyses sometimes referred to by anti-fluoridation proponents (6, 33) used this essential research design of controlling important variables. Choi 's meta-analysis claimed to control some of these, {33} but did so only for one at a time—not for all of the factors at the same time. No studies controlled for ALL the common Chinese environmental situations of iodine deficiency,' thyroid disease, high concentrations of air/ water toxicants, *and* food/airborne exposures to FL, AS nonexistent in our Oregon. (We don't have sky-high Fl in grains, brick tea, or thick coal burning). Since water with the very high levels of FL in these studies, often carries many truly toxic ingredients, such as Arsenic (As), lead, and bacteria/parasites, none of these studies can say what caused any of the purported chronic growth and/or development problems. In India, I measured different growth and school success after bacteria/parasite-free water was introduced in one village.

Only Wang in China (3) and Rocha in Mexico (1) looked at ***many*** of these common water contaminants. Only Rocha looked at most of the known, major influences on IQ: water arsenic, serum iron & lead, and maternal education and socioeconomic level. But Rocha did not control for iodine intake, nor for the bacteria and other substances typically found in the water of developing nations.

2. Only one study (1) used tests which are accepted as validated IQ tests.

Choi's review {33} claims the Ravens is an appropriate IQ test. And almost all of the 31 Chinese studies (3, 6-19), used a Chinese version of a subcomponent of Raven's, the Color Matrix. But this tests only nonverbal reasoning—not memory, language or attention. Raven originally designed this for younger children, the elderly, and people with moderate or severe learning difficulties. Its internal reliability, and validity vis-a-vis general intelligence can't been ascertained. Qin (2) used a Raven's Standard Progressive Matrix IQ, but it's validity coefficient with our Wechsler was only 0.70. One study used a Chinese Binet and one used the Wechsler, but neither were standardized for rural Chinese students. (3) The Iranian study used the subcomponent Raven. (4) The one Indian study used non-standardized IQ 'questionnaires' developed by a private educator. (5)

Since in any IQ testing, one Standard Deviation equals 15 points, one can't tell if the typical reports of 4-6 point differences in high FL vs. low FL villages have any clinical—no less statistical significance. It is true that across large populations, 6 points is a big issue; but statistically it has yet to be proved.

Few studies were blinded, few reported training of the testers,--and only 1 reported both.

3. ***The studies did not show uniformly lower IQs even at high FL levels—(i.e. 2--8 times higher than Community WFI).***

Even if one were to accept the above nonverbal reasoning tests as valid measures of intelligence, there was no consistent dose-response between Fl and purported IQ changes across these studies. Choi admits this. {33}

Xiang's (7) study shows no significant fall in {Raven-CM} IQ until **2.32** mg/L of Fl. Xiang concludes his paper by stating the Chinese standard of ***1 mg/L*** FL is thus safe.

Qin (2) *found a bimodal incidence of low {Raven-CM} IQs, occurring in the* very high (>2 mg/l) and the very low water FL (<0.2mg/l) groups. The highest number of very high IQs, and the largest group of normal IQs occurred in the children living in 1 mg/L Fl communities—i.e. at levels of CWFl..

Chen (8) found adolescents in high FL villages to have much higher Raven IQs. And only 0.06% of children in the high Fl were 'intellectually underdeveloped." CWFl, levels of 0.89 mg/L in his control village did no harm--- the average IQ was 104. (As was the average IQ of 105 in Zhao's control village of 0.9mg/l FL. (9)

Hong (10) found no significant differences in {Raven} IQ between high FL (2.9 mg/L) and low FL (0.48mg/l.

Li (11) found twice as many high {Raven} IQ children in the High Fl area, as well as the same average IQ as in the High Fl as in the Low Fl area.

4. ***Claims that 'the sheer number" of studies purporting an effect of FL on intelligence add up to 'proof'—belie a principle of meta-analysis: poorly-done studies, using different methods and variables, shouldn't be added together.***{22}

Choi's paper claims this principle of Egger {22} but concludes the opposite of Egger. Prior to 2010, other meta-analyses have come to different conclusions for this very reason—many poor studies can't add up to a reliable conclusion:

Connett's review of 18 articles (15 from China, 11 also covered in Tang) from high fluoride areas {1-9 mg/L} is available only on line from a poster session. The web site (12) stated that "the evidence was not conclusive in the 20 ecological studies showing an association between high fluoride exposure and decreased IQ."

Brazian, Ltd, (an independent investigative arm of the ***British Medical Journal***), reviewed 20 of the above studies, concluding: (23) "The lack of thorough consideration of confounding as a source of bias means that from these *studies, it is uncertain how fluoride could be responsible for any impairment in* any intellectual development seen."

And, since most of the articles on this topic have been selectively translated from China, it is hard to have peer-reviewed any literature in China showing opposite results. Hu {21} writing in English, does refer to "a collection of papers and abstracts on IQ and endemic fluorosis," (The 4th China Fluoride Research Association) which found *no* association of IQ and Fl.

Contrary to Choi's use of funnel plot to overcome this heterogeneity, Tang's own meta-analyses (of 16 observational studies), (6) using funnel plot analysis, admitted there was bias. As mentioned in #1. above, there was rare controlling for any, no less all the many factors influencing IQ. This, plus the marked heterogeneity of methods in Tang's 16 studies makes any pooling of the data only compound any original deficiencies, @ to meta-analysis experts like Egger.(22). And, while Tang concluded that high dose Fl is 5x as likely to give lower IQs, what he showed was a 5-point difference in Raven- CM IQ (between low Fl and very high Fl children). What other points are getting confused in translation?

5. ***The literature in animals shows very different results in different species (rats vs mice), and even within species of rats. And, these animals were exposed to massive doses FL***. (24,28).

Example: The Mullenix article quoted by Choi noted behavior changes in rats with blood FL levels claimed to be similar to those in children with CWFl. But these levels *(0.59--0.64 mg/l) were actually up to 10x higher than those reported in* CWFl (0.02-0.04) (26,27,28,), and were achieved only through either injecting pregnant mother rats with huge doses of FL, or exposing the offspring to 100 ppm Fl water. (vs. 1 ppm in CWFl).

Verner's 1994 study-- of giving 0.34 , 3.4 mg/L ,and then a huge dose (34 mg/l FL in water) to a different species of rats found no changes in behavior except for banana odor preference. {24a}. Many other rat/mice sacrificial data can be read in the NRC 2006 report. (25)

Even without such issues of methodology, generalizing to human behavior and intelligence may generate a hypothesis, but should it determine public policy?

Strengths of this Literature:

Strengths are hard to list, for the above reasons. But the best study was done by Rocha in Mexico, (1). It had enough controllers that I did not groan reading the methods section. But however valiant were Rocha's attempts to control for the many influences on intelligence, as with most studies in developing nations, she analyzed communities with:

1. Highly contaminated water:
   arsenic@ 169 and 196 ug/l (<10 ug/l = US standard); and FL 5.3 and 9.4 mg/l. You could almost walk on this water.
2. High rates of iron deficiency and lead excess, each differing between their 3 villages.
3. Rocha had to change her entire methodology when discovering that ~1/2 of the children in the high Fl village used quite varying amounts of bottled water. So she converted to a continuous variable design, which is highly questionable, given the small number of children with normal iron and lead and low water As and FL. Since ability to buy bottled water reflects socioeconomics, this variable could not be truly controlled in her study design, Nor did she control for iodine.

Interestingly, Rocha & Calderon did another study in Mexico, (water FL =1.5-- 3 mg/L), showing NO relation between fluoride in the urine and Wechsler IQ. (29)

The same problems for determining FL effect on intelligence also apply to the osteosarcoma. literature. Many meta-analyses of this literature show no consistent effect of Fluoride at CWFl levels on rates of cancer. (30,31, 32)

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Virginia Feldman MD

Ginny & George Feldman
11230 SW Collina Ave.
Portland, Or. 97219-7835

September 6, 2012

185612

Good afternoon Council members,

I am Dr Barry Taylor, an assistant professor at the OHSU School of Dentistry and the Editor for the Oregon Dental Association. For six years I worked full time in a clinic that treated patients of all ages on the Oregon Health Plan. I enthusiastically support the addition of fluoride to the City of Portland water system.

Much has been said of the benefit to children by fluoridating water and it is true. But what I would like to speak about today is the huge benefit to adults and the elderly as well. It is conclusive that adults are keeping their teeth longer, increasing the need for dental care for the elderly. Many elderly are unable to receive proper dental care due to the expense, and the Oregon Health Plan dental funding is becoming more stretched while the elderly population is increasing.

As people age, their gums begin to recede, exposing the roots of their teeth. These exposed roots are susceptible to cavities because the area does not have the protective layer of enamel. Cavities on the root surface are aggressive and destructive and lead to tooth loss.

Additionally, many adults experience reduction in their saliva output causing dry mouth, a condition referred to as Xerostomia. Over 400 medications, including 80% of the most commonly prescribed, list Xerostomia as a side effect. Without the anti-cavity benefits of saliva these individuals have an even higher susceptibility to cavities.

A combination of the elderly taking several medications, having gingival recession, and keeping their teeth longer put this demographic at great risk for dental problems.

Fluoridated water reduces the extent and the number of cavities in the elderly. The benefit of exposure to fluoridated water is greatest when the individual is a child, but even exposure at a later age will reduce the extent of the infectious disease of dental caries in the elderly.

Thank you very much for your time, and thank you for supporting water fluoridation.

Barry Taylor, DMD

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Michael D. Turner, DDS, MD and Jonathan A. Ship, DMD, FDS RCS (Edin)
The Journal of the American Dental Association September 2007 vol. 138 no. suppl 1 15S-20S

A Comparison of Dental Treatment Utilization and Costs by HMO Members Living in Fluoridated and Nonfluoridated Areas
Gerardo Maupomé BDS, MSc, PhD1,*, Christina M. Gullion PhD2, Dawn Peters PhD3, Sally Jo Little RDH, MS4
Article first published online: 6 NOV 2007
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Good Afternoon Mayor Adams and City Council Members,

185612

My name is Mitra Ebrahimi, Clinic Operations Manager of Virginia Garcia Memorial Health Center dental clinics. Our clinics predominantly serve low-income individuals, such as uninsured children and adults. And I believe that all these patients will benefit from fluoridated water being readily accessible.

Fluoridation is a community health procedure that provides all children and adults, regardless of income, education, or ethnicity, prevention from tooth decay. Fluoridation is a preventative measure that not only benefits those with dental insurance, but goes even further for those who do not. I think this is an important implication to consider when analyzing such a decision to add fluoride to our community's water.

At Virginia Garcia, we regularly treat children with rampant cases of tooth decay, causing painful reactions. Too often, we have patients under the age of 4 years with such severe cavities, that their teeth could not be extracted without a surgical procedure. These children do not have access to continuous dental care, nor do they have the necessary knowledge to prevent such problems from occurring in the first place. More importantly, these children live in areas that lack water fluoridation.

I personally have given fluoride supplements to my two children as they were growing up. I wish there was access to water with fluoride to ease my concern for their dental health. As a mother, non-profit dental manager and concerned constituent, I advocate the process of water fluoridation as an effective and efficient way of improving our community dental health.

Drinking Fluoridated tap water is the best protection against unnecessary pain and suffering caused by tooth decay. This is your opportunity to make the right decision for the people of Portland that will positively impact this city's health for years to come.

Thank you for your time, Mitra

Testimony to the City Council in favor of water fluoridation. September 6, 2012

Good afternoon, and thank you for the opportunity to submit testimony on this important issue. My name is Michael Heumann. I am an epidemiologist and from 1984 through 2011, I worked as an environmental and occupational epidemiologist with the Oregon Public Health Division.

During my time working at the Health Division, I was acutely aware of the dental crisis in Portland. Dental caries affect children of all socioeconomic strata; and even though families with means have greater access to medical and dental care and may be able to afford to buy daily fluoride supplements for their children, it can still be a problem getting children to consistently take the daily treatment.

When my children were little, we would find fluoride tablets that they had taken out of their mouth because they did not like the taste. That means that despite our spending the money to buy individual fluoride treatment and going to the effort of having our kids take them, they did not consistently get the intended benefits. And we are among the fortunate families who could afford to make that effort.

Tooth decay is a problem among families in the Boise Elliot neighborhood, where my children went to school, and among more affluent families in the Grant Park /Irvington area, where I live. Despite people's best efforts, the current system of individual treatment is inequitable and ineffective.

As a parent and a public health professional, I have seen that individual daily treatment option has not worked. 1 in 5 children in Oregon still suffer from rampant tooth decay. Untreated tooth decay can become a significant health problem for children and a disruption for their parents. Cavities can become painful and lead to the need for extracting teeth, and they contribute to abscesses and other oral diseases. Most importantly, tooth decay is preventable through providing fluoride in the drinking water!

As a public health scientist, it is disappointing to see how some people are distorting and misinterpreting scientific studies that have been published. For example, the studies looking at the potential impact of fluoride on IQ were done in other countries where levels of exposure many times higher than levels in treated drinking water here in the United States, and the small differences in IQ levels could not be causally attributed to fluoride alone. Their argument is not applicable to Portland.

I am strongly in favor of the proposal to fluoridate Portland's drinking water. It is an effective, safe, affordable, and equitable way to address this problem and finally put it behind us. While working as a public health official, dental caries would repeatedly come up as an issue. Sadly, Oregon has the highest percentage of children with untreated tooth decay. And the reason is that most other major population centers have fluoridated water.

Taking action to add fluoride to the drinking water provides for the common good of all people in our community—especially for our children. This is an example of our elected officials taking action to improve the health and wellbeing of all constituents across the spectrum of the City. The benefits of doing this has been demonstrated in almost all major cities across this country – fluoride in the drinking water helps improve the dental health of all members of the community. It is cost effective and it is good leadership.

I urge you to vote to improve dental health in Portland, by adding fluoride to the drinking water.

Thank you.

Respectfully submitted by

Michael Heumann, MPH, MA
2402 NE 26th Ave.
Portland, OR 97212