



Fluoridation of Public Drinking Water – One of the Top Ten Public Health Achievements of the 20th Century

Linda Ferraro, RDH, BS
Program Coordinator
Office of Oral Health
Connecticut Department of Public Health

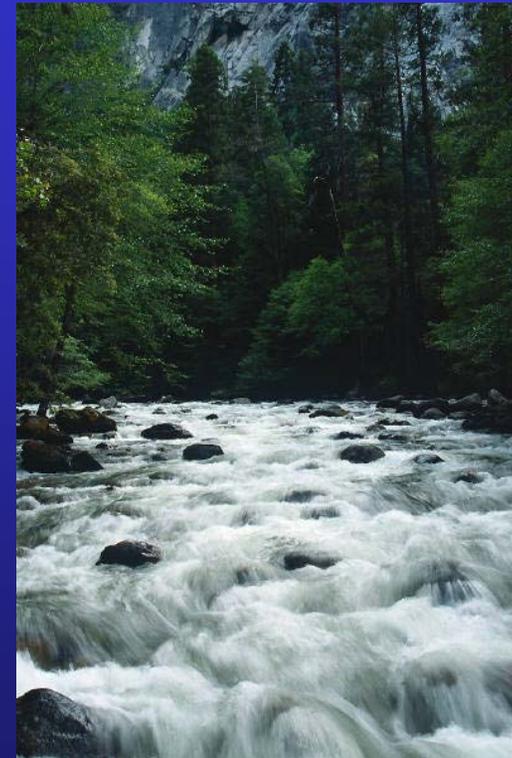
May 9, 2012



Presentation Courtesy of CDC Water Fluoridation Principles and Practices

Fluoride is Naturally Occurring

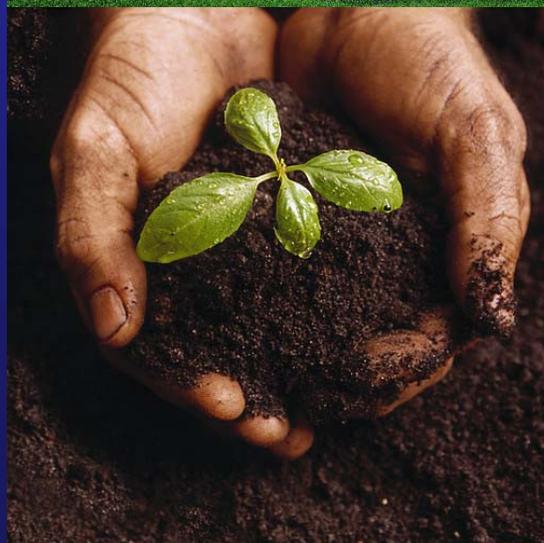
- Surface water (rivers) -- typically low concentrations, 0.2 mg/L (ppm) or less
- Groundwater (wells) -- higher concentrations, 0.1 mg/L to over 5.0 mg/L





Intake of fluoride from...

- Soil
- Plants
- Water
- Air





Definition of Fluoridation

- Fluoridation is the adjustment of the fluoride in drinking water to a level that is optimal for reduction of tooth decay



Natural
F
+
amount
in
water

Added
F
=

0.7 ppm
to 1.2
ppm

↑
Old Optimal
Range

0.7 ppm



NEW Proposed
HHS
Recommended
level





So How Much is 1 ppm?*

- One part per million (ppm) is equivalent to
 - 1 inch in 16 miles
 - 1 minute in two years
 - 1 cent in \$10,000
 - length of pickup truck on a road between New York and California



* 1 mg/L

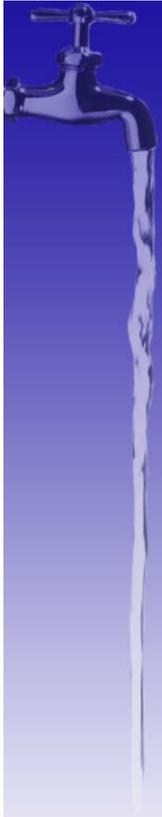




Adjusted Water Fluoridation

- Since 1962 optimal level varied in the U.S. from 0.7-1.2 parts per million
 - Exact level for a given location depends upon ambient air temperature
- 1 part per million (ppm) is the same as 1 milligram per liter (mg/L)
- At that time, drinking water and food and beverages prepared with fluoridated water were nearly the only sources for an individuals fluoride intake

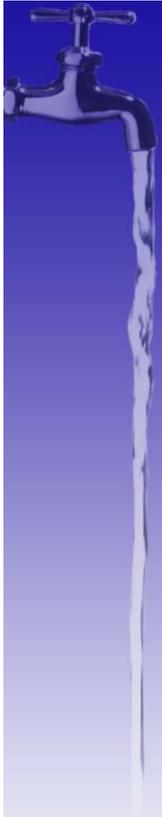




Adjusted Water Fluoridation

- In 2001 CDC recommended reevaluating the methodology used to determine optimal levels and has supported analyses of fluid intake, fluid consumption and ambient air temperatures
- Today, water is just one of several sources of fluoride
- Other sources for fluoride intake now are toothpastes, mouthrinses, prescription fluoride supplements and professionally applied fluorides





Adjusted Water Fluoridation

- In September 2010, the US Dept. of Health and Human Services convened a panel of scientists to review some of the new information related to fluoride intake.
- This new information led HHS to propose changing the recommended level for community water systems to 0.7 milligrams per liter, which will help in the prevention of dental fluorosis, but still provide the benefits of dental caries (cavities) prevention.





Adjusted Water Fluoridation

- This proposal was posted on the Federal Register and was open for comment until April 15, 2011.
- HHS is reviewing the comments and has not issued final guidance to date.



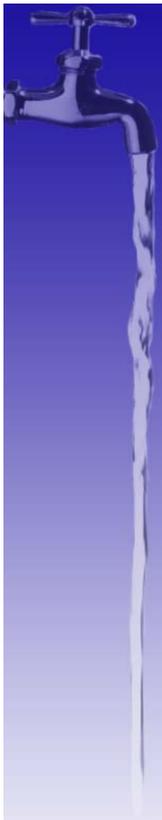


Enamel Fluorosis

- Occurs when children with developing teeth consume fluoride
- Teeth that have erupted are not at risk
- Dependent upon dose, duration, and timing of fluoride intake

Fluorosis is entirely
COSMETIC, not a health
issue





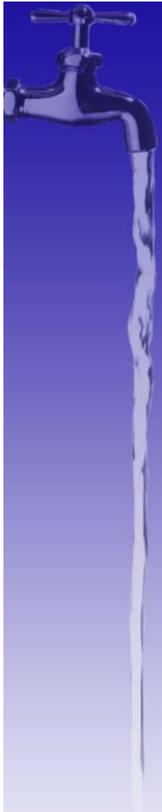
Risk Factors for Enamel Fluorosis

- Total Intake
- Fluoride supplements
 - 26% of kids in fluoridated area received inappropriate supplements
- Fluoride toothpaste
 - excess swallowing by young children



Pendrys & Morse. J Public Health Dent 1995;55:160-4.





Moderate and Severe Fluorosis and 'Moderate/Severe' Caries



Moderate



Severe

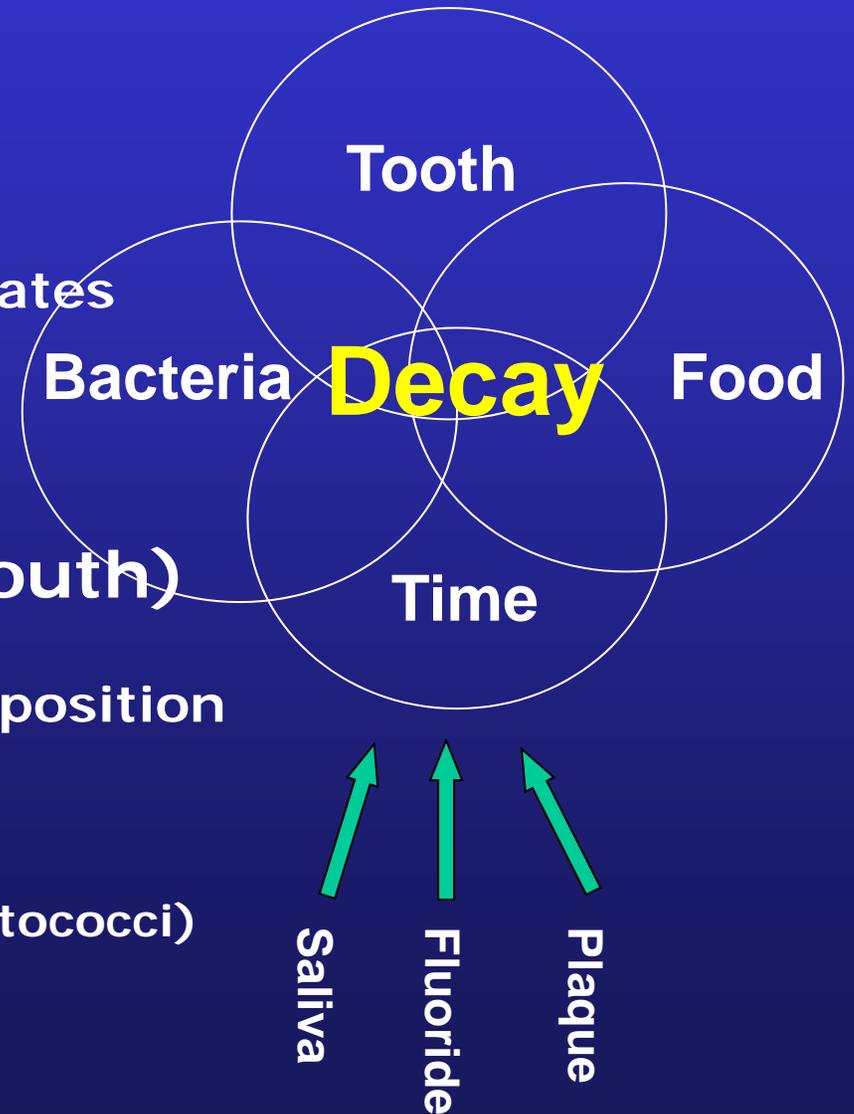


Photographs from Forum on Water Fluoridation in Ireland, 2002



Risk Factors for Caries

- **Diet**
 - sugars and carbohydrates
- **Oral hygiene**
- **Xerostomia (Dry Mouth)**
 - fluoride
 - salivary flow and composition
- **Bacteria Levels**
 - (especially mutans streptococci)

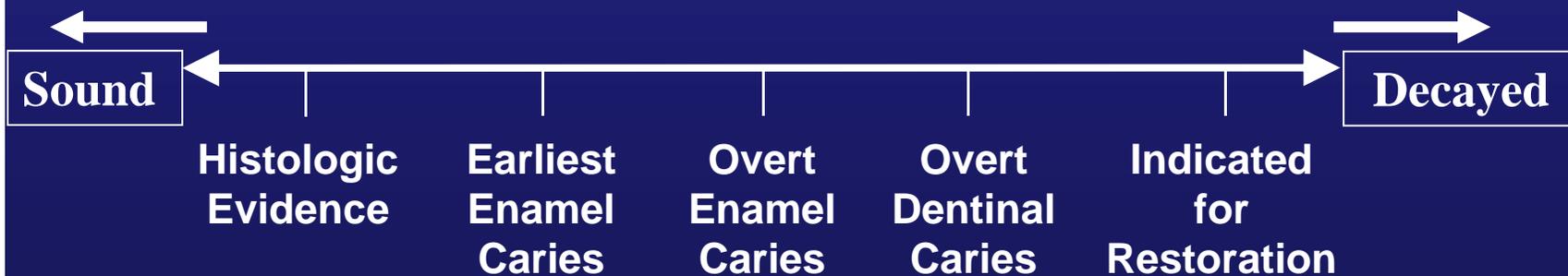




Progression of Caries

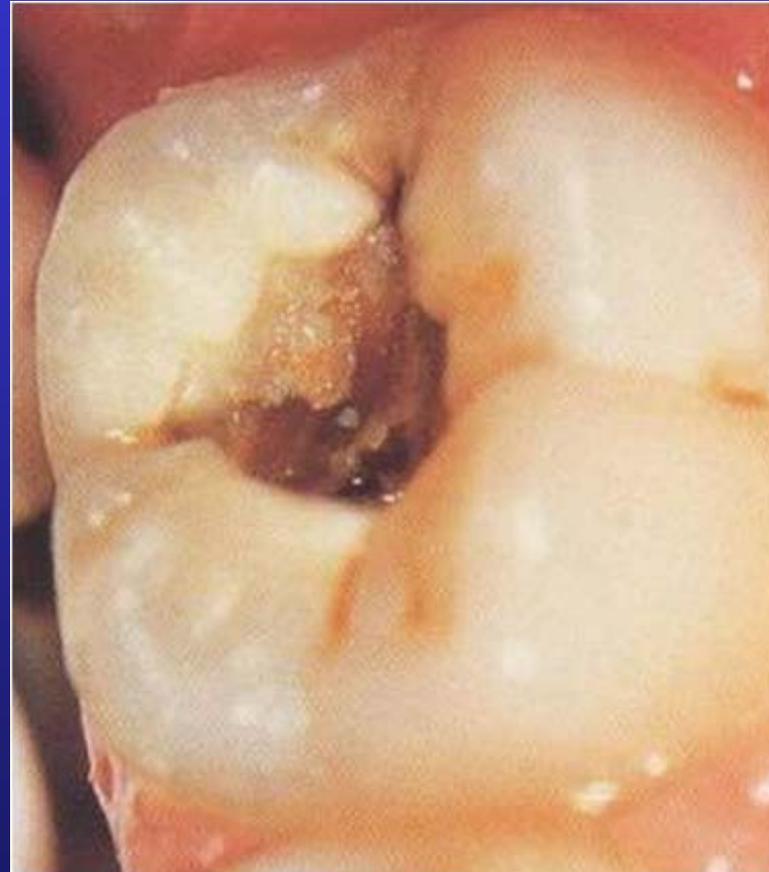
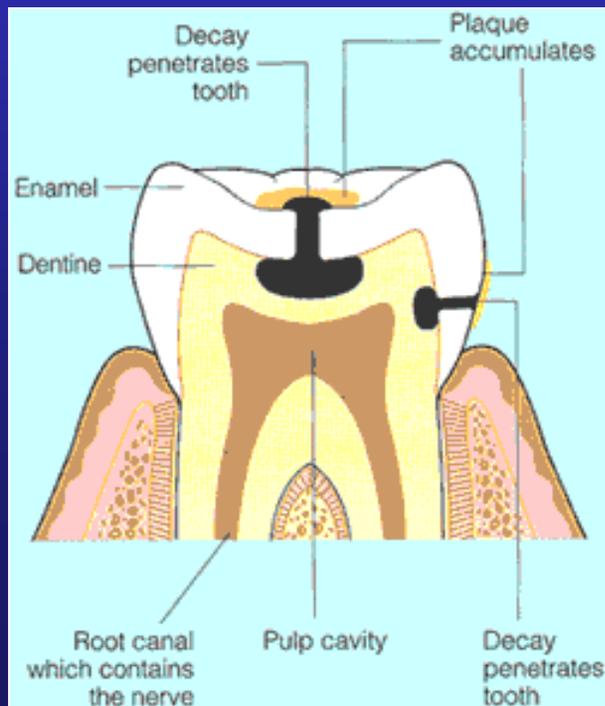
- First sign of a cavity is an increased microporosity of enamel
 - demineralization of apatite crystallites
 - A “chalky” appearance of the enamel
 - demineralization is reversible

Remineralization -- Demineralization





Demineralization to Cavity





Systemic Benefits – Pre-eruptive

- Earliest researchers - hypothesized that fluoride affects enamel and inhibits dental caries only when incorporated into developing dental enamel (pre-eruptively)
- Evidence supports hypothesis of systemic benefit





Topical Benefits - Posteruptive

- Predominant effect is post-eruptive and topical
- Effect depends on fluoride being in the right amount in the right place at the right time
- Best when small amounts maintained constantly in the mouth, specifically in dental plaque and saliva
- Adults also benefit from fluoride, rather than only children, as was previously assumed





How Fluoride Works Topically

- Fluoride inhibits demineralization
- Fluoride enhances remineralization of surface enamel
 - Fluoride concentrates in dental plaque releasing small amounts of fluoride when we eat
 - Fluoride concentrates in saliva continuously bathing the tooth in fluoride



Koulorides. J Dent Res 1990;69(Spec Issue):558.



Remineralization of Enamel

- Fluoride is released from plaque when pH is lowered
- Fluoride is taken up more readily by demineralized enamel than by sound enamel
- **TOPICAL ACTION -**
Posteruptive





Fluoride For Adults

- Many older adults experience dry mouth due to medications and health conditions
- Some have problems with dexterity and are unable to brush thoroughly
- Fluoride remineralizes demineralized tooth surfaces and helps protect exposed root surfaces





Frederick S. McKay

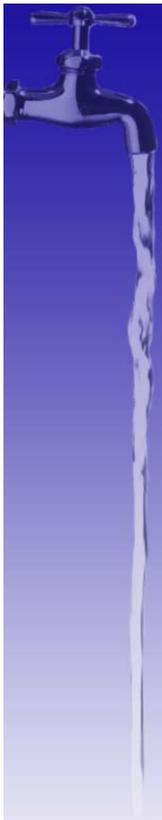
- 1901 – established practice in Colorado Springs, CO
- Curious mind and good observational skills
- “Colorado Brown Stain”
 - Stain was difficult to polish off – must be caused during the period of enamel formation – environmental agent
 - Only life-long residents (or those who had moved there as infants) had stain
- 1908 – began to investigate extent of condition in surrounding area





Colorado Brown Stain?





McKay's Investigations

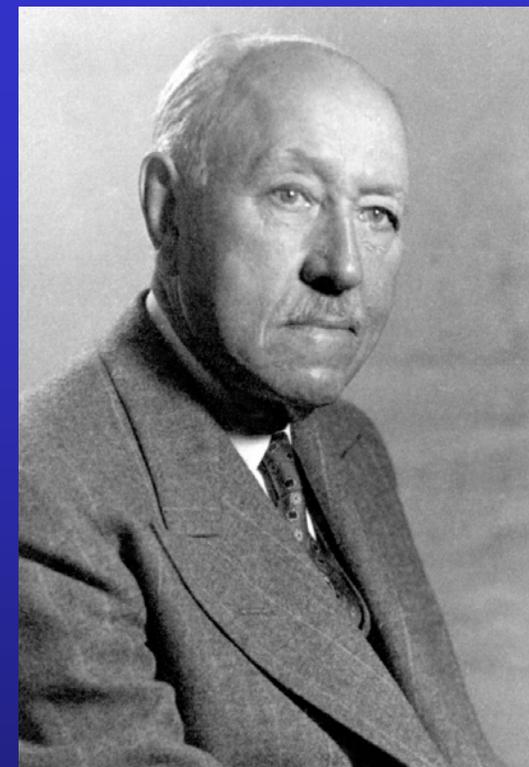
- Continued work over from 1900s through 1930s
 - Active investigation in Colorado, South Dakota and Idaho
- By 1920s had concluded that something in community water supply was the etiologic agent
 - Mostly occurred in places with deep wells
 - Advised residents of Oakley, Idaho to abandon water source and use new well -- fluorosis disappeared in children born from then on





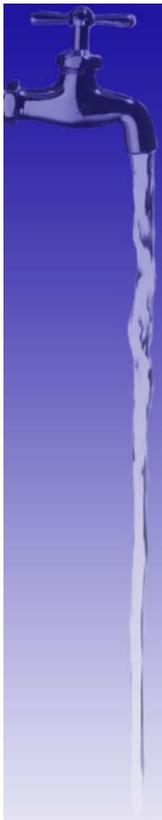
McKay's Investigations

- 1928 – a key observation
- McKay published his view that the same water that led to mottled teeth also decreased caries experience



McKay FS. The relation of mottled enamel to caries. J AM Dent Assoc 1928; 15:1429-37.





McKay's Investigations

- 1931 – McKay contacted Churchill and sent him water samples
- Fluoride was discovered in each sample that McKay sent for analysis (2.0 ppm to 12.0 ppm)
- Reaction of scientific community was concern

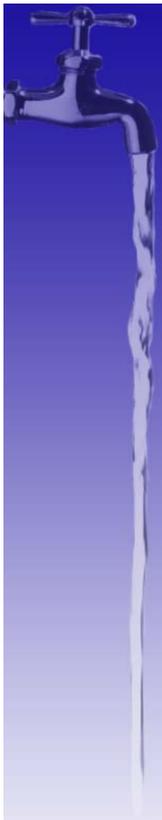




H. Trendley Dean

- 1931 - First dentist appointed to the National Institute of Health
- Primary responsibility - investigate the association between fluoride and mottled enamel
- Task was to map out the extent of mottled enamel in the U.S.
 - Wrote dental societies across the country for their input
 - Published first map in 1933





Dean's Investigations

- Mid 1930s – Dean began to use the term fluorosis in place of mottled enamel
- Continued studies on fluorosis and developed a tremendous store of information
- “Database” before computers





Dean's Investigations

- 1942 –mapping of fluorosis completed
- Focus shifted to caries
- Conducted landmark studies – natural fluoridation
 - 4 city study in Illinois
 - 21 city study





Natural Fluoridation Studies

4 cities Study

City	ppm F in Water	Number Children	Caries Free (%)	Mean DMFT
Quincy	0.2	291	4.1	6.28
Macomb	0.2	63	14.3	3.68
Monmouth	1.7	99	36.4	2.08
Galesburg	1.8	243	36.2	1.94

*Children 12-14 years of age

Dean et al., Pub Hlth Rep 54:862-888,1939





Dean's Investigations

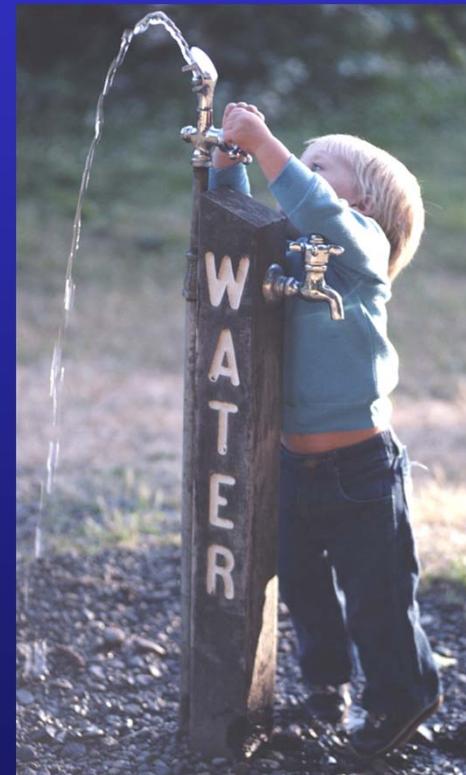
In 1930s, Dr. H. Trendley Dean conducted the "21 Cities Study"

- **Important conclusions:**
 - Optimum levels of fluoride for enhancing oral health
 - Increased incidence of objectionable dental fluorosis at 2 mg/L
 - 1.0 mg/L (ppm) provided best combination of reduction in tooth decay and low risk of fluorosis



Community Water Fluoridation Begins

- Grand Rapids, Michigan was the first city to adjust fluoride concentration in public drinking water (1945)
- 2005 marked the 60th anniversary of community water fluoridation





Fluoridation in Context

- **At the time when CWF was initiated:**
 - Extractions of first molars in young children were routine
 - The typical school child developed 3-4 new cavities each year
 - Full extractions and complete dentures were the norm for older adults
 - Recruits into WWII rejected because of poor oral health – 6 opposing teeth -10% rejection rate – 40% needed immediate treatment for relief of pain
 - Dowries of new brides included dentures
 - HS graduates sometimes received gift of complete dentures





Early CWF Trials

- Sequential cross-sectional surveys in these communities over 13-15 years, caries was reduced 50%-70% among children
- Some trials included periodic physical exams of participating children – no adverse health effects detected

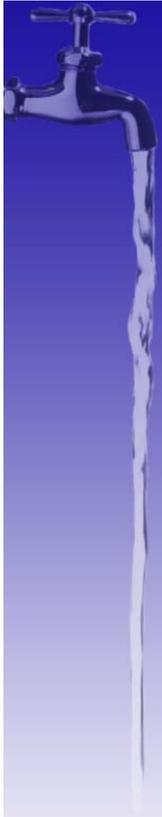




Discontinuation of Fluoridation

City or Town	Initiated Fluoridation	Discontinued Fluoridation	Number of Years without Fluoridation	Percent Increase in Caries Rates
Antigo, Wisconsin	1949	1960	5.5	70%-200%
Wick, Scotland	1971	1979	5.0	Primary 40% Permanent 27%
Galesburg, Illinois	Naturally fluoridated water source	1959 switched to non-fluoridated water source	2	38%





Impact of Water Fluoridation

- First evidence of an overall decline in the prevalence of dental caries in children was observed in 1970
- Decline in caries prevalence was observed in both fluoridated and non-fluoridated communities
- Decline continued at a rate of about 3% per year





Impact of Water Fluoridation

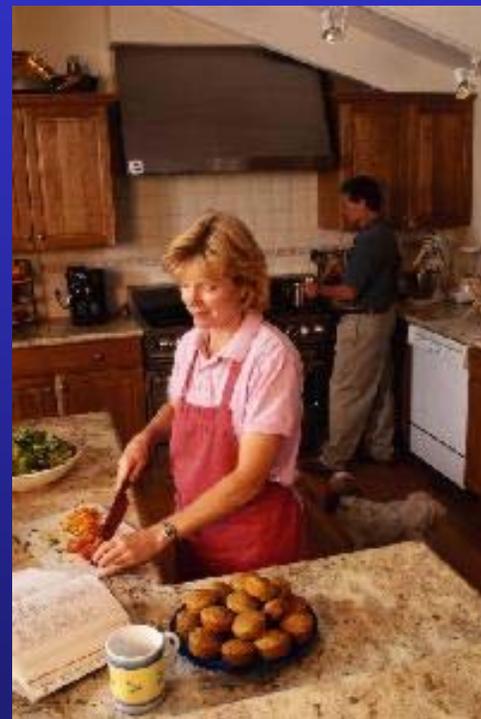
- Results of several dental caries prevalence surveys conducted during the 1980's suggested that the benefits of fluoridated water were much less than had been observed earlier





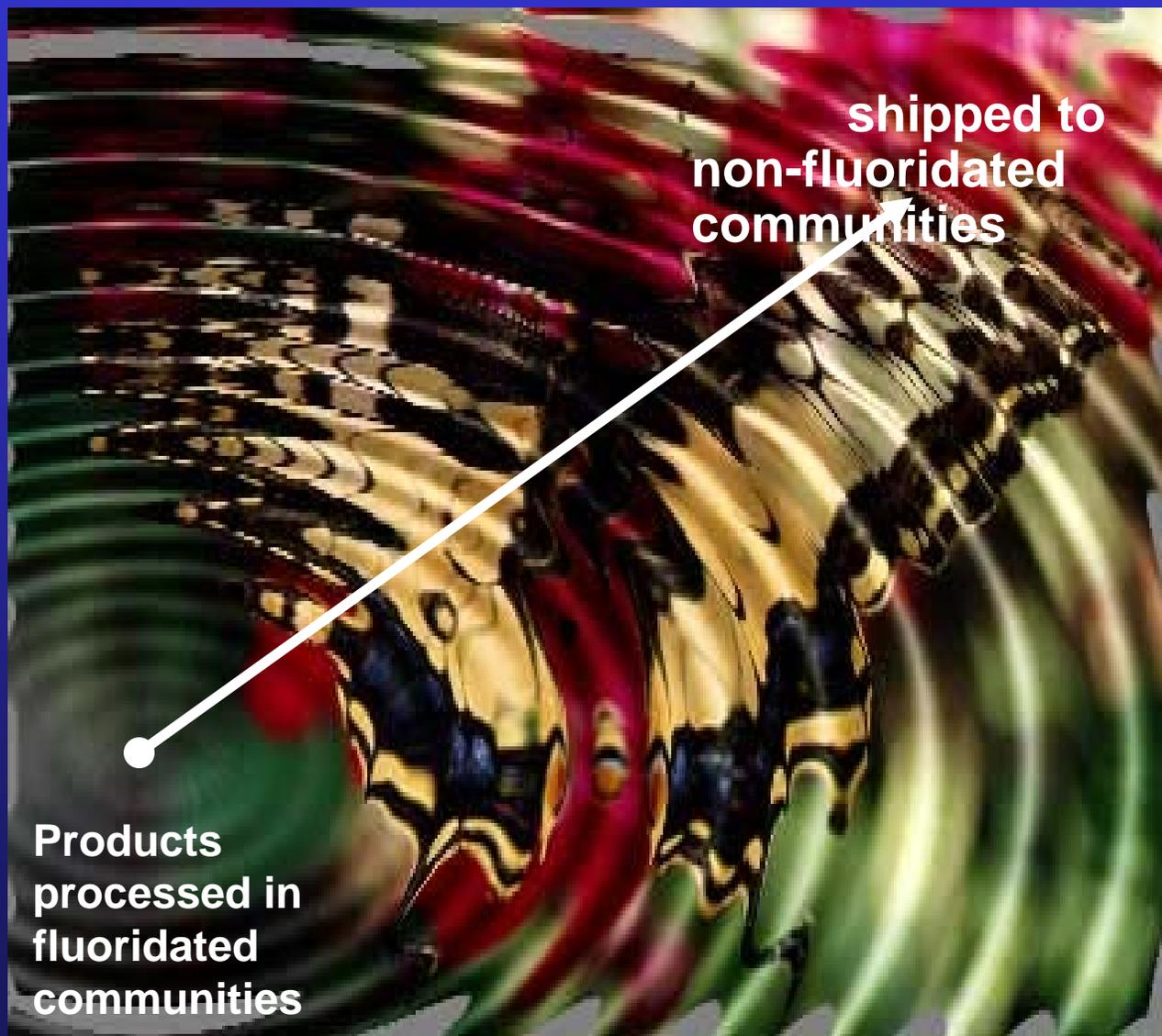
Halo (or Diffusion) Effect

- Initially reduced caries rates by 50%
- Due to the “halo” effect, community water fluoridation now reduces dental decay from 18% - 40%
- Fluoride exposure from multiple sources
 - Processed foods
 - Beverages





Halo Effect



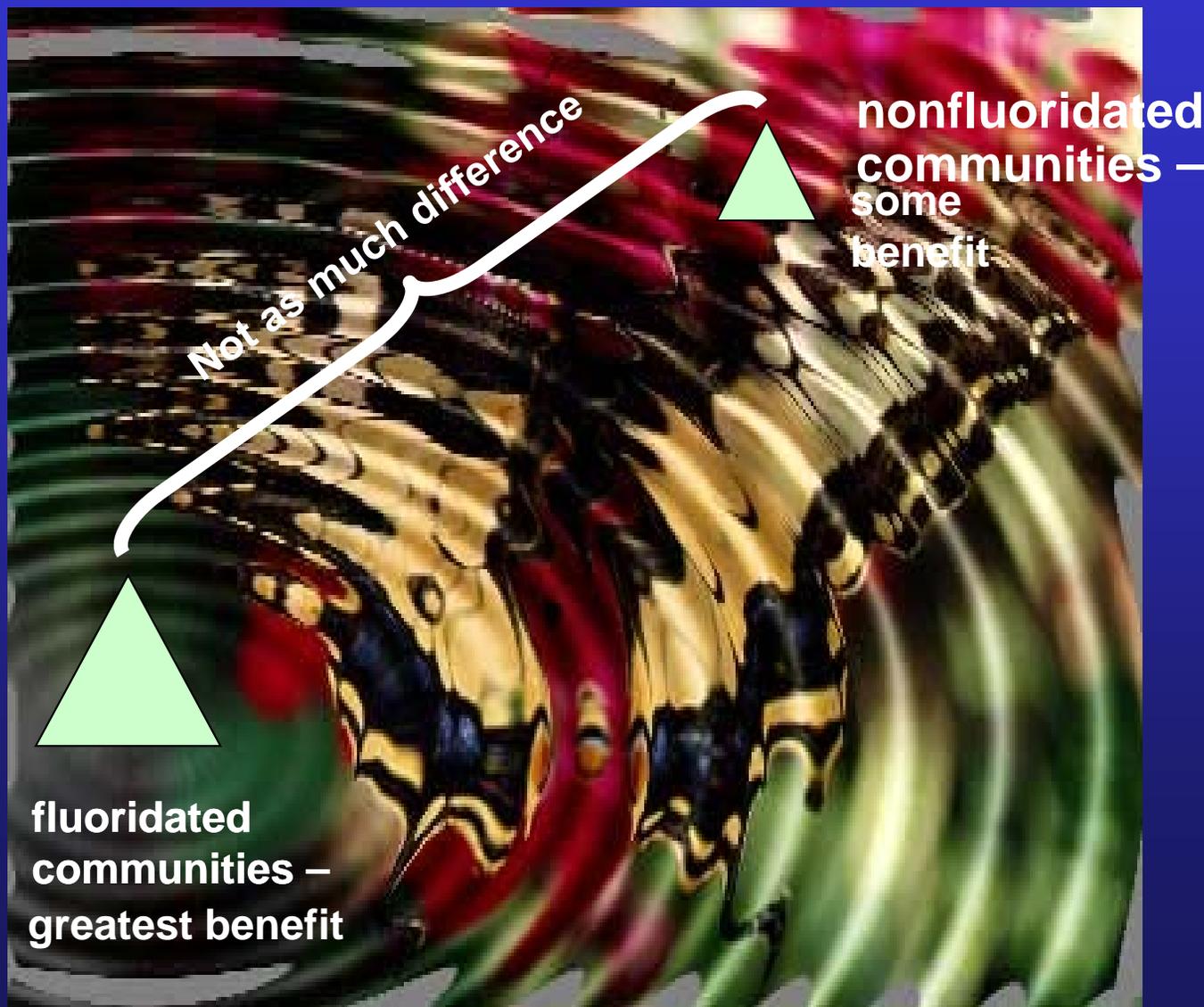
shipped to
non-fluoridated
communities

Products
processed in
fluoridated
communities





Halo Effect





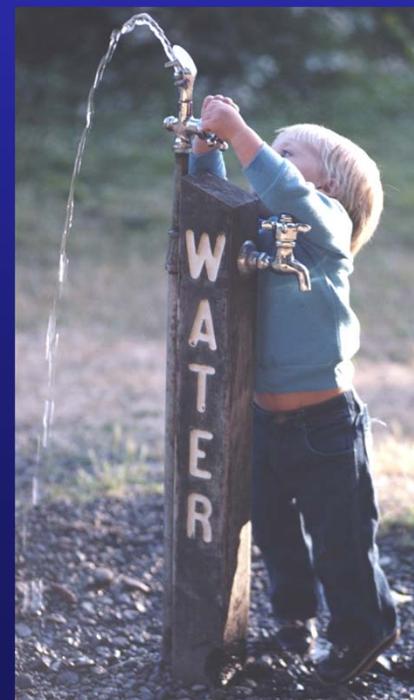
Fluoridation Public Health Issues



Fluoridation has resulted in a remarkable decline in the prevalence and severity of dental caries (tooth decay).

Despite this reduction, dental caries is still the most common preventable chronic disease in the U.S.

- 1 in 5 elementary school children
- 2 out of 3 adolescents
- 9 out of 10 adults





Fluoride Public Health Issues

- Decline in tooth decay has been uneven across the general population
- 80% of decay found in 25% of children aged 5-17 years old
- Populations with increased risk
 - Low socioeconomic status
 - Low level of parental education
 - Little, if any, access to dental care



Public Policy on Fluoridation

Endorsed by key scientific and professional organizations:

- American Dental Association
- U.S. Public Health Service
- American Medical Association
- World Health Organization
- American Water Works Association



And virtually every other scientific and professional organization in the health field





Ideal Public Health Measure

- No compliance required – do not have to DO anything – just drink and use the water
- Benefits everyone
- Safe
- Benefits spread beyond immediate area (halo effect)
- No access to care issues
- Inexpensive
- True cost savings



Credible Scientific Evidence

- **Studies and Research**
 - 60+ years
 - Extensive number of investigations with
 - Solid design
 - Reproducible results
 - Peer-reviewed findings
 - Demonstrated **safety and effectiveness**





Community Water Fluoridation

CDC named water fluoridation as one of 10 great public health achievements of the 20th Century



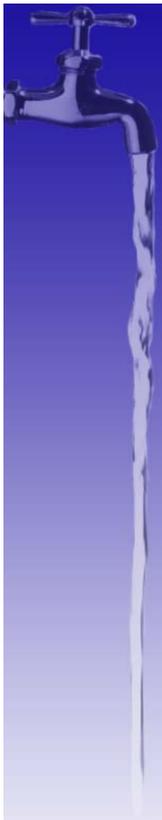


Total Intake

"All substances are poisons; there is none which is not a poison. The right dose differentiates a poison...."

Paracelsus (1493-1541)





Fluoridation Information Sources

- CDC web site at www.CDC.gov/OralHealth
- American Dental Association “Fluoridation Facts” available from www.ADA.org
- Connecticut Department of Public Health
 - Drinking Water Section
 - Office of Oral Health
 - www.ct.gov/dph





Fluoride Toxicology: Addressing the Public's Health Concerns

Gary Ginsberg, Ph.D.

Connecticut Department of Public Health

May 9, 2012

Challenges

- **Opponents of community water fluoridation have made claims that optimally fluoridated water can cause an array of health problems including:**
 - Cancer
 - Increased bone fractures
 - Effects on the renal, gastrointestinal, and immune systems
 - Lower IQ in children
 - Down's syndrome
 - Allergies
 - AIDS
 - Alzheimer's disease
 - Reproductive problems



National Academy Sciences 2006

- Is the USEPA MCL of 4 mg/L health protective?
 - Also reviewed SMCL of 2 mg/L
 - precaution for moderate dental fluorosis
- NAS didn't evaluate the 0.7-1.2 mg/L range
 - Approx 162 million Americans have fluoridated water at 0.7-1.2 mg/L

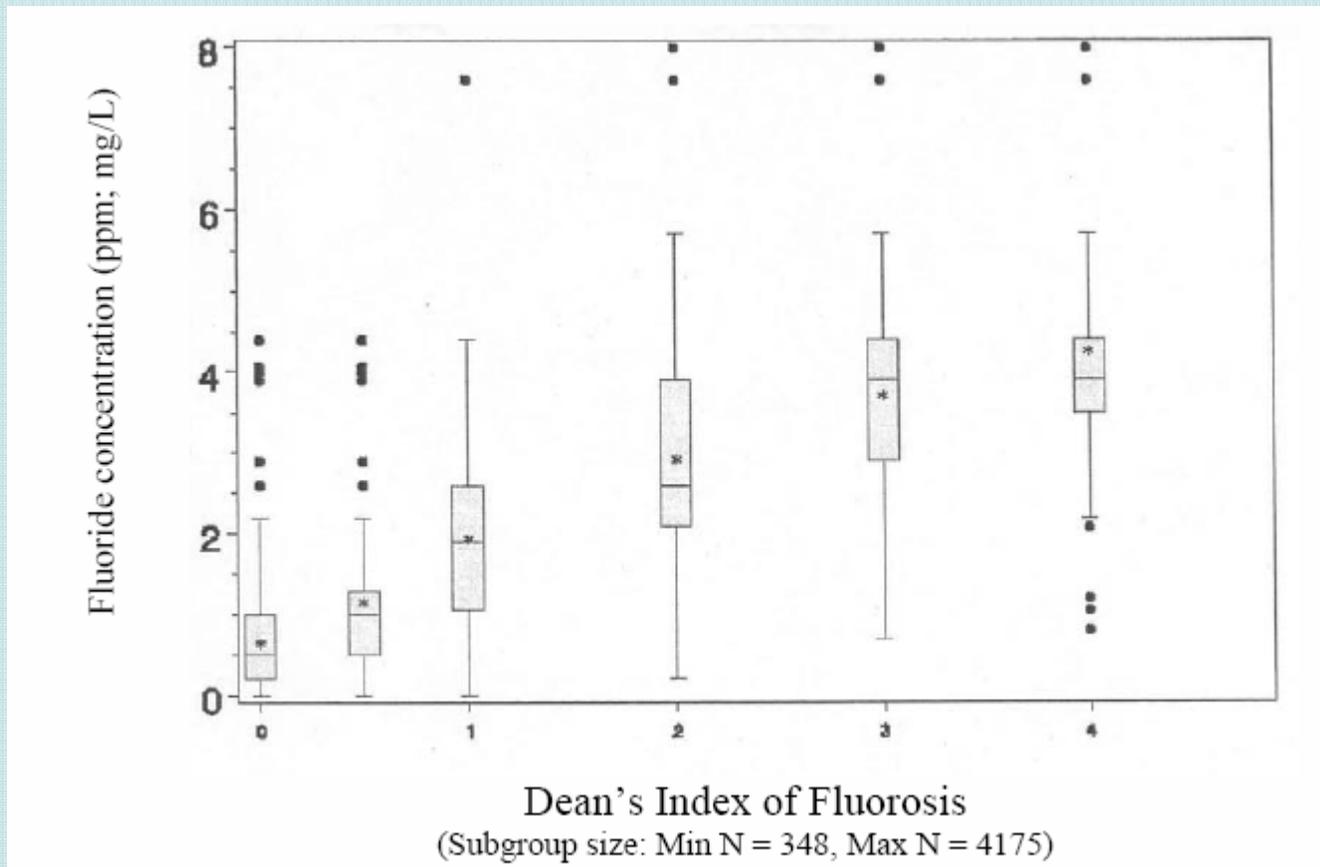
NAS 2006 Findings

- 10% of those drinking water at 4 mg/L have severe fluorosis – staining and pitting
- 15% have moderate fluorosis at 2 mg/L
- Unanimous – 4 mg/L too high
 - “Exposure at the MCL clearly puts children at risk of developing severe enamel fluorosis,”
 - MCL also not protective of bone fractures

Effects on Bone and Reproduction

- Excess fluoride enlarge bone → joint pain, tender (skeletal fluorosis)
 - Theoretically possible at 2 or 4 mg/L but its rare
 - More research needed
- Bone Fractures
 - Bones weakened by 4 mg/L or higher, but no evidence that it does so at 1 or 2 mg/L

USEPA Fluoride Risk Assessment, 2011



Fluorosis scores: 0.5 = questionable; 1 = very mild; 2= mild;
3= moderate; 4 = severe

Evidence of U-Shaped Fluoride D-R Curve for Bone Fractures

USEPA Risk Assessment, 2011

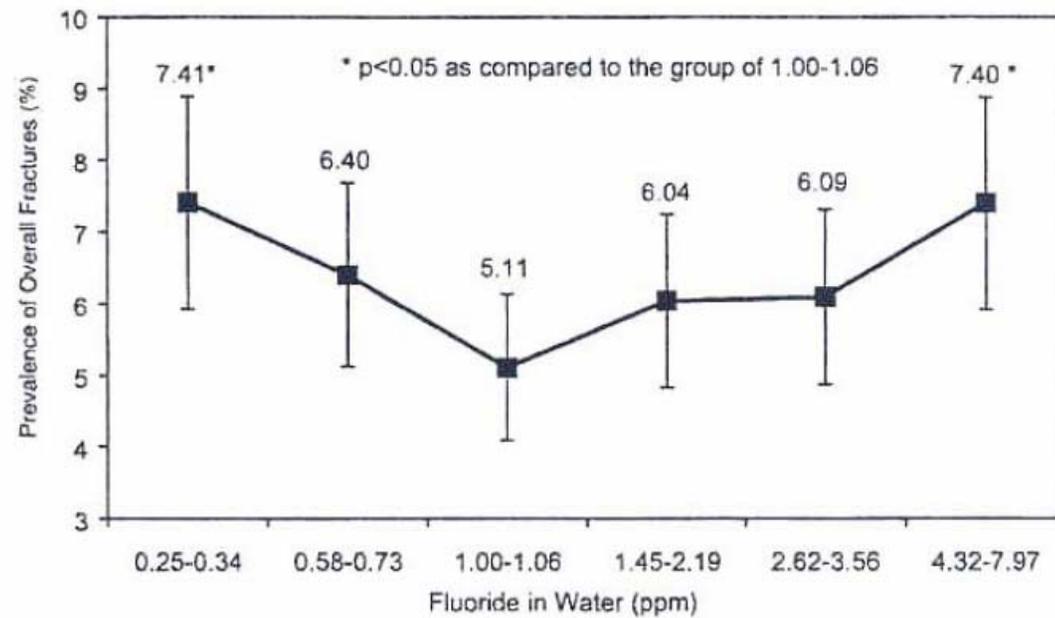


Figure 3-9. Prevalence of overall fractures and fluoride concentration in drinking water in six Chinese populations since the age of 20 yr (Li et al., 2001).

Brain and Hormone Development

- Limited Evidence suggests fluoride may affect IQ
 - Chinese studies - 2.5 mg/L – impaired IQ
 - Controversial findings
 - More recent Mexico study (Calderon 2000) – no IQ effect
- Endocrine disruption
 - Primarily targets thyroid/parathyroid
 - Impaired glucose tolerance
 - Mild imbalances at 4 mg/L
 - Questionable that any concern at 2 mg/L
- Impaired reproduction and fetal development
 - Requires high fluoride loading >> 4 mg/L

DNA Damage and Cancer

- Many screening tests done, mixed results
- Bone cancer concern since NTP osteosarc in rats (1990)
 - 3 of 80 male rats in high dose (70 mg/L) had bone cancer
 - Equivocal results, marginal statistical significance
- Human studies of bone cancer since 1993 mixed
 - Summary view: “the evidence on the potential of fluoride to initiate or promote cancers, particularly of the bone, is tentative and mixed”
 - Harvard 2006 bone cancer study – mostly negative
 - Boys exposed at age 7 slightly elevated risk
 - Harvard 2011 (Kim et al.) – no excess bone cancer BUT
 - No consideration when exposure occurred
 - Poor matching of controls (25 yrs older than cases)

Bassin et al. 2006 Cancer Causes and Control

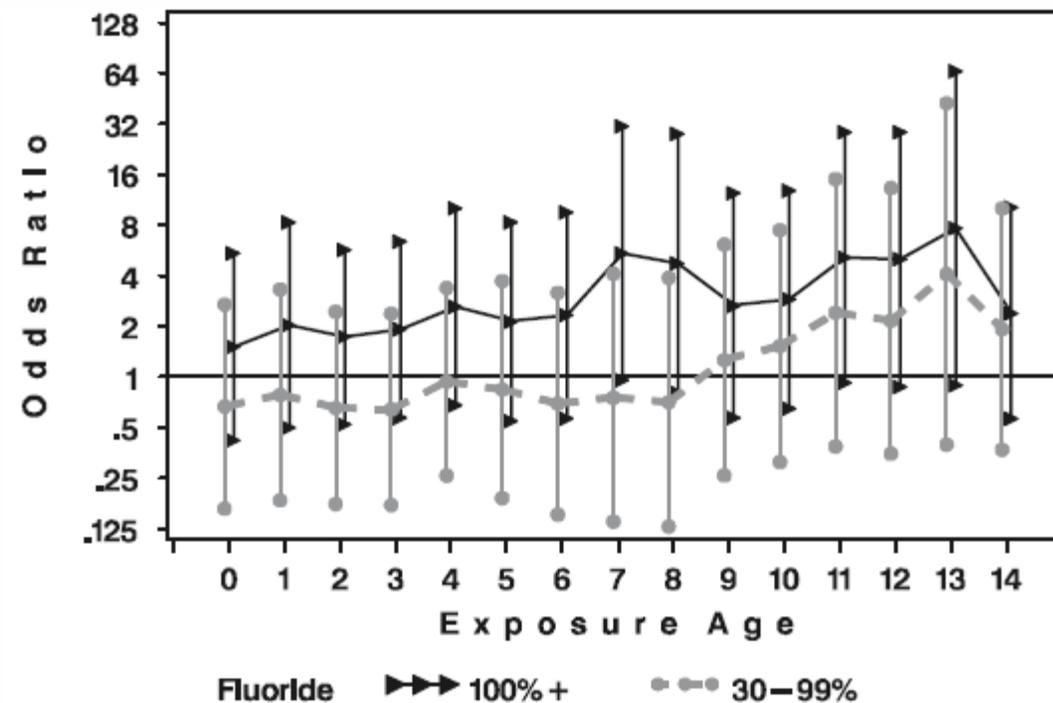


Fig. 3 Odds ratios and 95% confidence intervals relative to fluoride levels less than 30% of target are shown for the subset of male participants who never used fluoride supplements or rinses. The dashed line shows the odds ratios for the intermediate exposure category (30–99% of target fluoride level) and the solid line shows the odds ratios for the high exposure category (100% of target or greater)

CDC 2011 Recommendations (USEPA Risk Assessment)

- Target range of 0.7 to 1.2 mg/L narrowed
 - Previously based upon climactic range
 - Water ingestion now less a function of climate
- Prudent to supplement water at lowest effective concentration (0.7 mg/L)
 - Other sources of fluoride – dental products
 - Evidence that optimal carie prevent at 0.7 mg/L
 - Evidence that dental fluorosis ↑'s above 0.7 mg/L
 - Goal – protect < 8 yr olds from dental fluorosis

Infants Harmed by Fluoridation

Claim:

Infants (< 1 yr) should not consume fluoridated water

Fact:

- **There is no known adverse health effect for infants.**
- **There may be increased chance for fluorosis if child predominantly consumes formula mixed with fluoridated water.**

CDC Advisory – exclusively formula-fed babies should have some water from non-fluoridated sources to minimize fluorosis chance

Summary

- The dose makes the poison
- U-shaped dose response common with trace elements
 - Benefit at low levels, some risk at higher levels
- Fluoride adverse effects mitigated by using least amount for the benefit
 - More defined target of 0.7 mg/L accomplishes this
- Important to avoid excess fluoride in children
 - Toothpaste
 - Ground water used for tap water
 - Naturally high fluoride an issue