Fluoride is in the water! Can that be good?

ACTs Preceptor Conference

Clifton M. Carey, PhD

October 15, 2016
Objectives ...

1. About fluoride
2. Describe mechanisms for how fluoride works to prevent caries
3. Background and history of water fluoridation
4. Considerations for fluoride usage
   a. Criticisms – health concerns
   b. Fluorosis
5. Conversations with concerned people about fluoride in the water
Fluoride Occurs Naturally

ADA Fluoride Facts
Adapted from Dean, HT
Am J Pub Health 29(6)590-596(1939)
Where do we find fluoride?

0.7 ppm F
(USPHS recommendation)

0 ppm F
Sources of Fluoride

- Toothpaste
- Mouth wash
- Gels and Foams
- Varnish
- Prophy paste
- Creams, pastes and Mousse
- Glass Ionomer Cements
- Sealants
- Smart composites
- Toothpicks
- Floss
- Supplements (drops)
- Food and Drinks
- Air
- Water
How Discovery Happens

Take this test

https://www.youtube.com/watch?v=vJG698U2Mvo

Now, take this test

https://www.youtube.com/watch?v=IGQmdoK_ZfY
Fluoride in the Water
History

1901
F McKay observed Colorado Brown Stain

Three most probable causes

Air: Clean, dry

Water: Contains minerals Al, Fe, Cr, As, Pb, Zn, Cu, Ag, Au etc.

Environment: Sunny (high altitude), low O₂

1909
GV Black and F McKay observed teeth afflicted by Colorado Brown Stain were surprisingly and inexplicably resistant to decay
Fluoride is used because it reduces the rate of caries incidence. Evidence confirms reduction of caries from these sources:

1. Fluoride in the drinking water (1 mg/mL F)
2. Toothpastes with more than 1000 mg/mL F
3. Fluoride in the environment (halo effect)
4. Fluoride supplements
5. Topical F, F-releasing varnish (5 % NaF)

Critical Reviews of the Evidence supports these modes only. See ADA Center for Evidence-Based Dentistry at ebd.ada.org
Fluoride is ...

1. the only anticaries agent recognized by the FDA
2. publically available via
   a. community water
   b. toothpaste
   c. oral rinses
3. provided professionally
   a. varnishes
   b. gels/mousse
   c. sealants
   d. prophy pastes
   e. supplements – drops, food
4. can be augmented!
   a. calcium
   b. other adjuncts (protein, antibiotics, etc.)
Normal Conditions

Demineralization → Remineralization

Saliva
When things go wrong... increase in caries risk

**Cariogenic Factors**
- Poor oral hygiene
- High bacterial counts
- High sugar consumption
- Tooth Morphology
- Root exposure
- Xerostomia

**Diagram**
- Remineralization
- Demineralization
- Plaque
- Saliva
Minimize Caries Risk

**Protective Factors**
- Salivary flow
- Fluoride
- Ca & PO₄
- Patient education
- Oral hygiene
- Diet analysis and modification
- Antibacterial rinses
- Xylitol
- Sealants
Caries Development Diagnosis and Intervention

Sound → Remineralize ← Arrest → Restore ? ← Implant

Histological evidence → Overt enamel caries → Cavitation

Every white spot leads to an implant – it's just a matter of how long it takes.

Harold Loe

Photos: Dr. Domenick Zero, Indiana University
Fluoride Mechanisms

Current thinking about the anticaries effect of fluoride is that it works through five mechanisms:

1. Promotes remineralization in the tooth
2. Stabilizes the tooth surface (stops erosion)
3. Inhibits dental plaque bacteria metabolism thus reducing the amount of acid produced
4. Slows demineralization
5. Converts tooth apatite to fluoroapatite, a much less soluble mineral

Promote Remineralization
Prevents Erosion

4-hour challenge

**Enamel**

- **Fluoride Concentration (ppm):**
  - 0.3% Cit
  - 1% Cit

- **Dentin**

- **Fluoride Concentration (ppm):**
  - 0.0% Cit
  - 0.25% Cit
  - 1.0% Cit

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Inhibits Dental Plaque

1. At low pH (cariogenic) free F\(^-\) ions become neutral HF (acid).
2. HF diffuses across bacterial membranes
3. HF disassociates into H\(^+\) and F\(^-\) ions inside bacteria.
4. Free F\(^-\) ions are non competitive inhibitors of enolase.
5. Retards metabolism (glycolysis) – bacterial stasis or death.
6. Effective at salivary concentrations (~0.3 ppm)

\[
\begin{align*}
H^+ + F^- & \rightleftharpoons HF \\
\text{Low pH} & \\
HF & \rightleftharpoons H^+ + F^- \\
\text{High pH}
\end{align*}
\]
Slows Demineralization
Slows Demineralization
Convert HAp to FAp

\[ \text{Ca}_5(\text{PO}_4)_3\text{OH} + \text{F}^- \rightarrow \text{Ca}_5(\text{PO}_4)_3\text{F} + \text{OH}^- \]

VERY SLOW

(Hydroxyapatite) \rightarrow (Fluoroapatite)

Solubility = 10^{-58.6} \quad \text{Solubility} = 10^{-60.5}

High [F] Concentrations
Mechanisms: H₂O Fluoridation (1 ppm)

Pre-eruption (systemic)
1. Induces fluoroapatite production within developing enamel. F-apatite protects kink-sites.

Post-eruption (topical)
1. Inhibits dental plaque bacteria thus reducing the amount of acid produced by the organisms
2. Stabilizes the tooth surface (stops erosion)
3. Promotes remineralization of the tooth
5 Fluoride Mechanisms

- Stabilizes surface
- Promotes remineralization
- Inhibits acid

- Community H$_2$O-F
- Dentifrice-F
- Oral Rinse-F
- Fluoride Varnish

- Slows demineralization

F-apatite

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American Dental Association and the U.S. Public Health Service recommend lowering the water fluoridation to 0.7 mg/L (Jan 7, 2011).

How Much Fluoride is Enough?

% of 12 yr olds with DMFT in community F - H₂O systems

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean DMFT</th>
<th>% Fluorosis</th>
<th>% drinking 0.7 &lt;&gt; 1.2 ppm F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1967</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1977</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2007</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Community Fluoridation Data

DMFT Data
1999 – 2004: CDC NHANES
Fluoride Benefits

71 years of Community H₂O Fluoridation (0.7 ppm F)
- Currently reduces caries in children by 18 to 40 % (compared to non-fluoridated cities)
- Reduces caries in non-fluoridated cities (at lower rates)
- Reduces caries by 11-15 % for high risk children
- Reduces adult caries by 31 % (coronal and root)

CDC: Community water fluoridation is one of the ten great public health achievements of the 20th century!
History

1901 – KcKay observed Colorado Brown Stain
1909 – Black/KcKay observed teeth afflicted by Colorado Brown Stain were surprisingly and inexplicably resistant to decay.
1930’s – H. Trendley Dean observed fluoride levels of up to 1.0 ppm in drinking water did not cause enamel fluorosis in most people and only mild enamel fluorosis in a small percentage of people.
1944 - Dean convinced the City of Grand Rapids, Michigan to add fluoride to its public water supply in Jan 1945. During the 15-year project, researchers monitored the rate of tooth decay among Grand Rapids' almost 30,000 schoolchildren. After just 11 years, Dean announced that the caries rate among Grand Rapids children born after fluoride was added to the water supply dropped more than 60 percent.

H. Trendley Dean
## H$_2$O Fluoridation Benefits

### 4 City Study, 1939

<table>
<thead>
<tr>
<th>City</th>
<th>ppm F in H$_2$O</th>
<th>Number Children</th>
<th>Caries Free (%)</th>
<th>Mean DMFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quincy</td>
<td>0.2</td>
<td>291</td>
<td>4.1</td>
<td>6.28</td>
</tr>
<tr>
<td>Macomb</td>
<td>0.2</td>
<td>63</td>
<td>14.3</td>
<td>3.68</td>
</tr>
<tr>
<td>Monmouth</td>
<td>1.7</td>
<td>99</td>
<td>36.4</td>
<td>2.08</td>
</tr>
<tr>
<td>Galesburg</td>
<td>1.8</td>
<td>243</td>
<td>36.2</td>
<td>1.94</td>
</tr>
</tbody>
</table>
Discontinuance of Fluoridation

<table>
<thead>
<tr>
<th>City or Town</th>
<th>Initiated Fluoridation</th>
<th>Discontinued Fluoridation</th>
<th>Number of years without Fluoridation</th>
<th>Percent increase in caries rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antigo, WI</td>
<td>1949</td>
<td>1960</td>
<td>5.5</td>
<td>70 - 200</td>
</tr>
<tr>
<td>Wick, Scotland</td>
<td>1971</td>
<td>1979</td>
<td>5.0</td>
<td>Primary 40 Permanent 27</td>
</tr>
<tr>
<td>Galesburg, IL</td>
<td>Naturally fluoridated</td>
<td>1959 (switched to non-fluoridated source)</td>
<td>2</td>
<td>38</td>
</tr>
</tbody>
</table>
Summary

1. Community water fluoridation …
   a. reduces caries by 60 % compared to non fluoridated communities
   b. when discontinued, resulted in significant increases in caries prevalence
   c. currently reduces additional caries for children at very high risk by 10-15 %

2. Dentifrice …
   a. is effective for reducing children's caries up to 23 %
   b. containing low fluoride concentrations is not effective
### Current Status

**Currently:**

<table>
<thead>
<tr>
<th></th>
<th>1960</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extractions of 1\textsuperscript{st} molars in children</td>
<td>Common</td>
<td>Rare</td>
</tr>
<tr>
<td>Average new decayed, filled surfaces per year in school aged children</td>
<td>3.5</td>
<td>0.36</td>
</tr>
<tr>
<td>Percent edentulous population (all ages)</td>
<td>20.6</td>
<td>10</td>
</tr>
<tr>
<td>Percent edentulous aged ≥ 65</td>
<td>75</td>
<td>20</td>
</tr>
<tr>
<td>Dentures as Bride dowries</td>
<td>common</td>
<td>Inconceivable</td>
</tr>
<tr>
<td>Dentures as HS Graduation present</td>
<td>common</td>
<td>Inconceivable</td>
</tr>
</tbody>
</table>
## Historical Context

<table>
<thead>
<tr>
<th></th>
<th>1960</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average lifespan</strong></td>
<td>73.1 ♀ / 66.6 ♂</td>
<td>78.9 ♀ / 76.5 ♂</td>
</tr>
<tr>
<td>(~50 yr tooth life)</td>
<td>(~65 yr tooth life)</td>
<td></td>
</tr>
<tr>
<td><strong>US Pop</strong></td>
<td>186.4 M</td>
<td>325.1 M</td>
</tr>
<tr>
<td><strong>Cariogenic Environment</strong></td>
<td>Low</td>
<td>Very high</td>
</tr>
<tr>
<td><strong>Childhood Beverage Examples</strong></td>
<td>Common beverages: water (typically fluoride free or not fluoride controlled)</td>
<td>Common beverages: fruit drinks, carbonated beverages, sugar-sweetened beverages, and fluoride-free water</td>
</tr>
<tr>
<td><strong>Childhood Food Examples</strong></td>
<td>Some candies, mostly low carbohydrate foods (meats, vegetables) at meals</td>
<td>processed foods that contain high amounts of fermentable carbohydrates, greater amounts of breads (in the form of sandwiches etc.)</td>
</tr>
<tr>
<td><strong>Adult and Children Medications</strong></td>
<td>Aspirin (non-xerostomic)</td>
<td>New drugs (prescription and non-prescription) developed in the 1980’s tend to cause xerostomia (reduced salivary flow). These include (but are not limited to) antihistamines, decongestants, asthma, cold formulas, blood pressure medications, analgesics, to name a few.</td>
</tr>
</tbody>
</table>
Since that time:

• Community water fluoridation programs have been declared to be in the top 10 most effective public health programs in the U.S.
• Fluoridated toothpastes are used by a large majority of the population
• The Cariogenic Environment is much greater:
  • In the past our diets were much (MUCH) friendlier for the teeth than they are now.
  • One can easily see that teeth would not last as long as they do without fluoride in the water (and topical fluoride) or something persistent to help them out.
• There are three factors that have led to the vast improvement of oral health in the U.S.
  1. Community water fluoridation and fluoridated toothpastes
  2. Public education on oral care and oral health
  3. Reduction of bad health habits such as cigarette smoking
1. The Halo Effect …
   a. is due to the availability of fluoride from other sources that were not previously available to the public
   b. has been identified as a major factor leading to increased fluorosis prevalence
   c. reduces the apparent efficacy of water fluoridation in comparison to non fluoridated communities

2. Water fluoridation and toothpaste prevent caries through different mechanisms; i.e., low verses high fluoride concentrations.
Dental Fluorosis ...

tooth hypomineralization resulting in a change in the appearance of teeth.

Causes:
- long-term ingestion of higher than optimal levels of fluoride during tooth mineralization (< 6 years)
- Use of antibiotics (amoxicillan) during childhood <6 years
- Genetic predisposition
Public Policy

This policy was met with general agreement in the earliest years.

The policy has been questioned from several different aspects:

- Social policy
- Personal choice
- Environmental safety
- Other health concerns, side effects
- Scientific basis
Using Dean’s Chart
to assess the impact of the Halo Effect

Caries Experience per Child
In DMF Teeth

Apparent Water [F] (ppm, mg/L)

Percent of Population Affected by Dental Fluorosis

Δ = -0.3 ppm F

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After Jan 2011, the U.S. Public Health Service and the American Dental Association recommend that the fluoride content of community water be adjusted to 0.7 mg/L (ppm F) for the whole country.

The reasons for the new recommended range is that most children do not drink much water. Also, the Halo effect provides sufficient fluoride to make up for any deficit in colder climates.
Evidence Based Recommendations

You're not going to poison my water with fluoride!
Say it with Teeth !!

You're not going to poison my water with fluoride!
What is the Problem?

Issues Raised by Opponents

- Potential or “proven” adverse effects
- “Industrial toxic waste”
- Safety not adequately studied
- Medicating without consent
- No difference in caries rates

"Mommy, please don't make my sister’s formula with fluoridated tap water“
Other Claims*

AIDS
Allergic Reactions
Alzheimer's disease
Arthritis
Asthma
Behavior Problems
  (ADD etc.)
Bone disease
  osteoporosis, etc.
Cancer
Colic
Down Syndrome
Enzyme effects
Flatulence
Gastrointestinal Problems

Harmful medication interactions
Heart disease
Increased infant mortality
Kidney disease
Lead poisoning
Lethargy
Lower IQ (retardation)
Malpositioned teeth
Pineal Gland (early puberty)
Reproductive Organs
  reduced fertility, damaged sperm
Skin conditions
Sudden Infant Death Syndrome
Thyroid problems

!! Tooth Decay

*List is not comprehensive: could also include social, political, and financial effects
The It's Time to Talk Programme focuses on the residents of Port Macquarie, Australia who are fighting to keep fluoride out of their water supply Mar 2010. [http://www.youtube.com/watch?v=U9ZlwQbx70I](http://www.youtube.com/watch?v=U9ZlwQbx70I)
The Most Convincing Anti-Fluoride Discussion Ever? (10 min)

Paul Connent: Released September 6th, 2012 at the City Hall in Portland, Oregon. [https://www.youtube.com/watch?v=sh-oeu2L8yM](https://www.youtube.com/watch?v=sh-oeu2L8yM)

The truth about fluoride! (The pineal gland, drinking water & how to protect yourself) [https://www.youtube.com/watch?v=1ACNmtdHjUc](https://www.youtube.com/watch?v=1ACNmtdHjUc) (9 min)

Melissa Melton
[http://www.youtube.com/watch?v=H3IjmufPTow](http://www.youtube.com/watch?v=H3IjmufPTow)
Fluoride Is Poison: A Quick Demo (7 min)

Trace
[https://www.youtube.com/watch?v=XuMxAB9q92E](https://www.youtube.com/watch?v=XuMxAB9q92E)
Why government puts fluoride in our water (3 min)
Fluoride is in the water! Can that be good?

NO!

IT IS GREAT!
A vision for tomorrow
Clifton Carey, PhD
School of Dental Medicine
University of Colorado Anschutz Medical Campus

Caries Research
Fluoride Research
Standards
Methods Development

Donations: www.cufund.org/CareyLab.