Lecture #9-12 Fluoride and Caries

Fluoride Lecture Objectives

Be Able To:

1. Explain how fluoride affects the critical pH of enamel.
2. Explain how fluoride protects teeth against caries. Explain this at a molecular level.
3. Briefly outline the foundation water fluoridation experiment, performed between 1945-1959 in Grand Rapids, Michigan. Describe the controls, and what the experiment showed. Also, outline the earlier foundation studies on 'mottled teeth' (fluorosis) carried out by Drs. McKay & Dean.
4. Graph the fluoride concentration [F^-]in a typical tooth cross-section. Explain why the graph looks the way it does.
5. Explain how the [F^-] in the local drinking water, and in the diet, affects the graph above. List foods and drinks that are naturally high in F^-.
6. Explain while fluoride is important during tooth development, the major anti-caries effect of fluoride is thought to occur after tooth eruption.
7. Outline the relative [F^-] in various structures (including plaque) found in the mouth, and why fluoride accumulates in this manner.
8. Explain by what mechanism(s) fluoride can cause acute poisoning.
9. Define Initial Toxic Dose (ITD). Explain treatment, if any.
10. Define Probable Toxic Does (PTD). Explain treatment, if any.
11. Define Certain Lethal Dose (CLD). Explain treatment, if any.
12. Know how to determine (i.e., calculate) how much fluoride an individual has consumed, and how this relates to the PTD and CLD.
13. Explain what causes fluorosis and what age groups are at risk and why.
14. Reproduce the recommended fluoride supplement dosage schedule for children. Besides age and [F] in water, what should be considered in determining fluoride supplementation dosage?
15. Discuss the validity of some of the more common arguments used against community water fluoridation and (less commonly) against fluoride-containing dental products.

Theme. Understanding how fluoride impacts the hydroxyapatite structure of teeth, both for good and bad is important in dentistry. Too little and the teeth are at higher risk of caries. Too much and you get cosmetically troublesome fluorosis of the teeth. Hit the sweat 'Goldilocks spot' and caries risk drops dramatically with no cosmetic problems!

Fluoride and Caries

Introduction

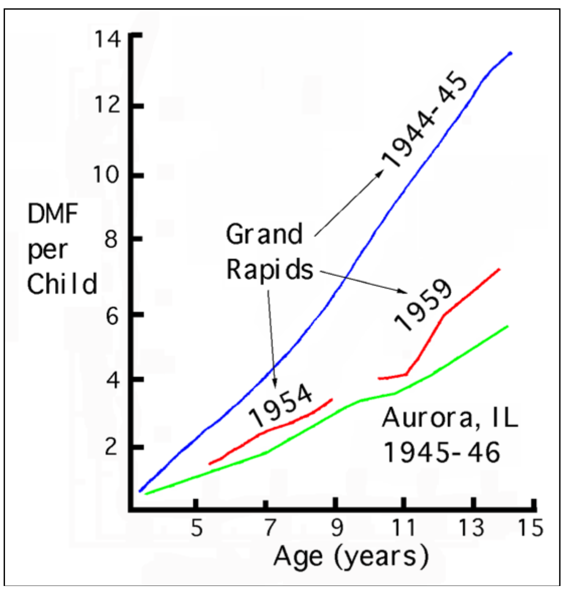
A. Observations on 'Colorado Stain - mottled enamel' (fluorosis) and caries prevalence in communities with drinking water naturally high in fluoride content (1901-39, Drs. Frederick McKay & H. Trendley Dean)

B. Epidemiological study of correlation between fluoride concentration in drinking water and caries incidence (1940-42, H. Trendley Dean)

C. Controlled experiments on fluoride added to drinking water and caries incidence (1944-present)

First Experiment: In 1945, children in Grand Rapids, MI, which had no natural fluoridation, were compared with children in Aurora, IL, which did. Then, in 1946, fluoride was added to the Grand Rapids drinking water and the children examined at subsequent intervals for their caries experiences.

Note: DMF = Decayed, Missing, & Filled)



Data from the 'famous' Grand Rapids fluoridation study. DMF teeth in children living in a naturally 'optimal' fluoridated community (Aurora, IL) were compared with the DMF experience of children in a naturally low-fluoridated community (Grand Rapids, MI). Initial data (1945) showed that children in naturally fluoridated Aurora (bottom, green line) enjoyed significantly fewer DMF teeth when compared to the children in low-fluoridated Grand Rapids (top, blue line). Fluoride was then added to the water supply of Grand Rapids (1946) to bring it up to 1ppm. The caries experience (DMF) of children in Grand Rapids was then recorded in 1954 and 1959. The data (middle, red lines) showed that the children who grew up drinking the *artificially* fluoridated water of Grand Rapids had a 50-60% reduction in caries!

D. Conclusions from decades of fluoride studies:

1. Excess fluoride consumption during tooth development causes fluorosis (McKay's so called 'mottled teeth').

2. Artificial, optimal fluoridation reduces the prevalence of caries by 40%-70%! (Note: This was prior to fluoridated dental products.)

3. Fluoride does *not* totally prevent caries.

4 The longer the exposure to fluoride, the more pronounced the caries reduction.

5. Fluoride is effective in reducing caries incidence even when exposure begins later in life.

Note: You've probably noticed that I use the word fluoride, which is the ionic form (F^-), even when I mean the element fluorine (F). While not 100% correct use of chemical terminology, fluoride has come to mean both fluorine and fluoride in most dental situations, so that's why I use the word fluoride most of the time!

Fluoride and Hard Tissue

A. Fluorine is the most electronegative of all the elements, which makes it extremely reactive.

B. Incorporation into hard tissue

1. Fluoride ion, because of its similar size and charge, can substitute for the hydroxyl group in hydroxyapatite to form fluoridated hydroxyapatite

a. During hard tissue formation (incorporation):

$$10Ca^{2+} + 6(PO_4)^{3-} + (2\text{-}x)OH^- + xF^- \Rightarrow Ca_{10}(PO_4)_6(OH)_{2-x}F_x$$

b. Displacement of hydroxyl in already formed hydroxyapatite (ionic exchange, heteroionic exchange):

$$Ca_{10}(PO_4)_6(OH)_2 + xF^- \Rightarrow Ca_{10}(PO_4)_6(OH)_{2-x}F_x + OH^-$$

c. Very high concentrations of fluoride can lead to disorientation of the crystals; extremely high [F] can even lead to hard tissue breakdown:

$$Ca_{10}(PO_4)_6(OH)_2 + 20F^- \Rightarrow 10CaF_2 + 6(PO_4)^{3-} + 2OH^-$$

C. Factors affecting concentration of fluoride in apatite

1. Stage of tooth development

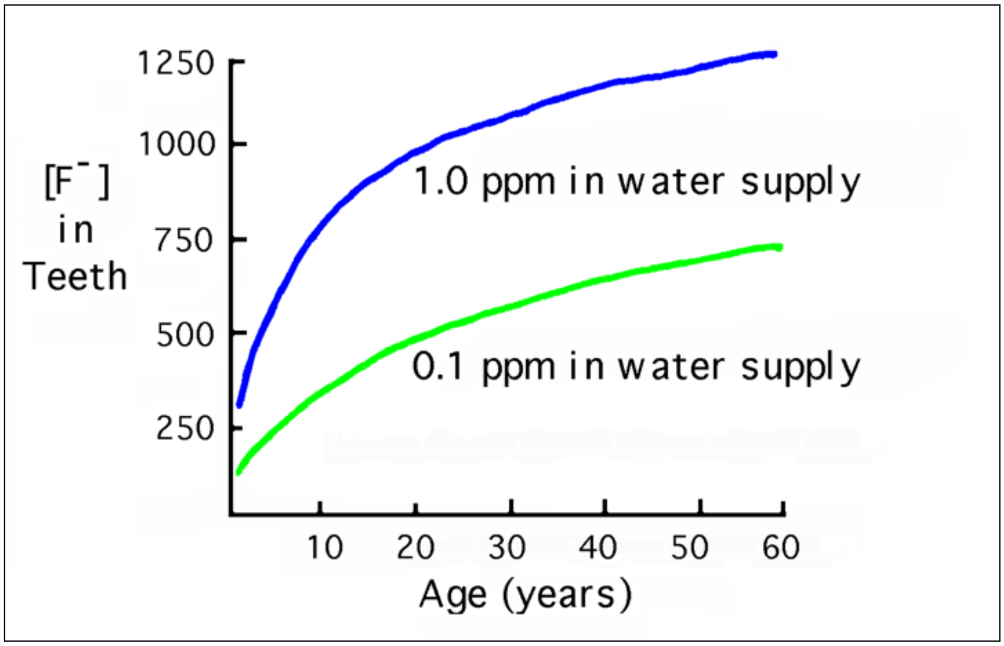
a. During tooth formation = Systemic F effects

b. After eruption = Topical F effects

c. Changes with maturation (e.g., reduced surface permeability as enamel ‘matures’)

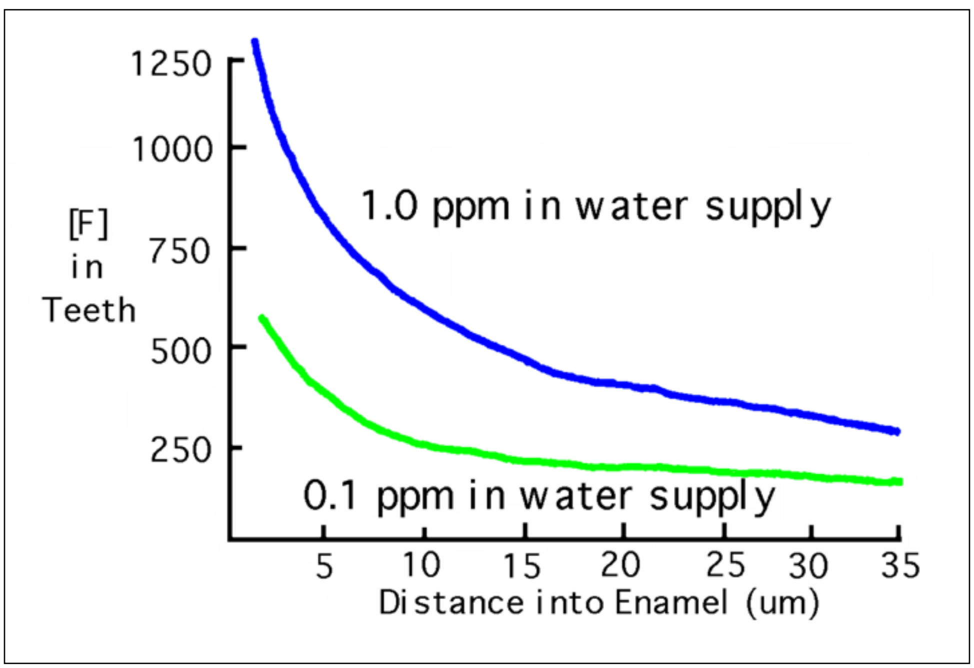
2. Concentration of fluoride consumed

3. Duration of exposure to fluoride, or more importantly, frequency of exposure



As a person ages, the amount of fluoride in their teeth typically increases. Because of ion exchange during remineralization in enamel and remodeling in dentin, teeth tend to accumulate fluoride. The fluoride incorporated is typically related to the concentration of fluoride in the local water supply.

4. Distance from tooth surface



Because of ion exchange during remineralization in enamel, enamel characteristically accumulate fluoride in highest amounts close to the enamel surface. The fluoride incorporated is related to the concentration of fluoride during remineralization, which is related to the local water supply.

5. Chemical form and pH of the fluoride solution

   a. NaF (sodium fluoride), Na_2PO_3F (sodium monofluorophosphate [MFP]), and SnF_2 (stannous fluoride):

      - Slow exchange at normal pH, rapid at lower pH

   b. Acidulated Fluoride (fluoride with added acid):

      - More rapid and deeper incorporation of F^- for OH^-, because acid solution tends to dissolve hard tissue

   c. Acidulated Phosphate Fluoride (fluoride with acid pH but controlled with phosphate buffer):

      - As with acidulated fluoride, but with less dissolution of hard tissue; also furnishes required phosphate for remineralization

Fluoride Anti-Caries Mechanisms

A. During Tooth Formation (**Systemic**)

1. Increases regularity of hydroxyapatite crystal formation (reduces crystal defects)

2. Reduces carbonate (CO_3^{2-}) incorporation into apatite

3. These both increase resistance of hydroxyapatite tissue to attack by acid (reduce acid solubility); reducing enamel critical pH in the oral environment to ~4.9 at optimal fluoride concentration in hydroxyapatite.

Note: If fluoridation is discontinued after tooth eruption, caries activity will, with time, return to normal; continued exposure to fluoride is necessary to maintain maximum anti-caries effect. Why?

B. After Tooth Eruption (**Topical**) - Principal Effect

1. Decrease solubility of hydroxyapatite in acid (as above)

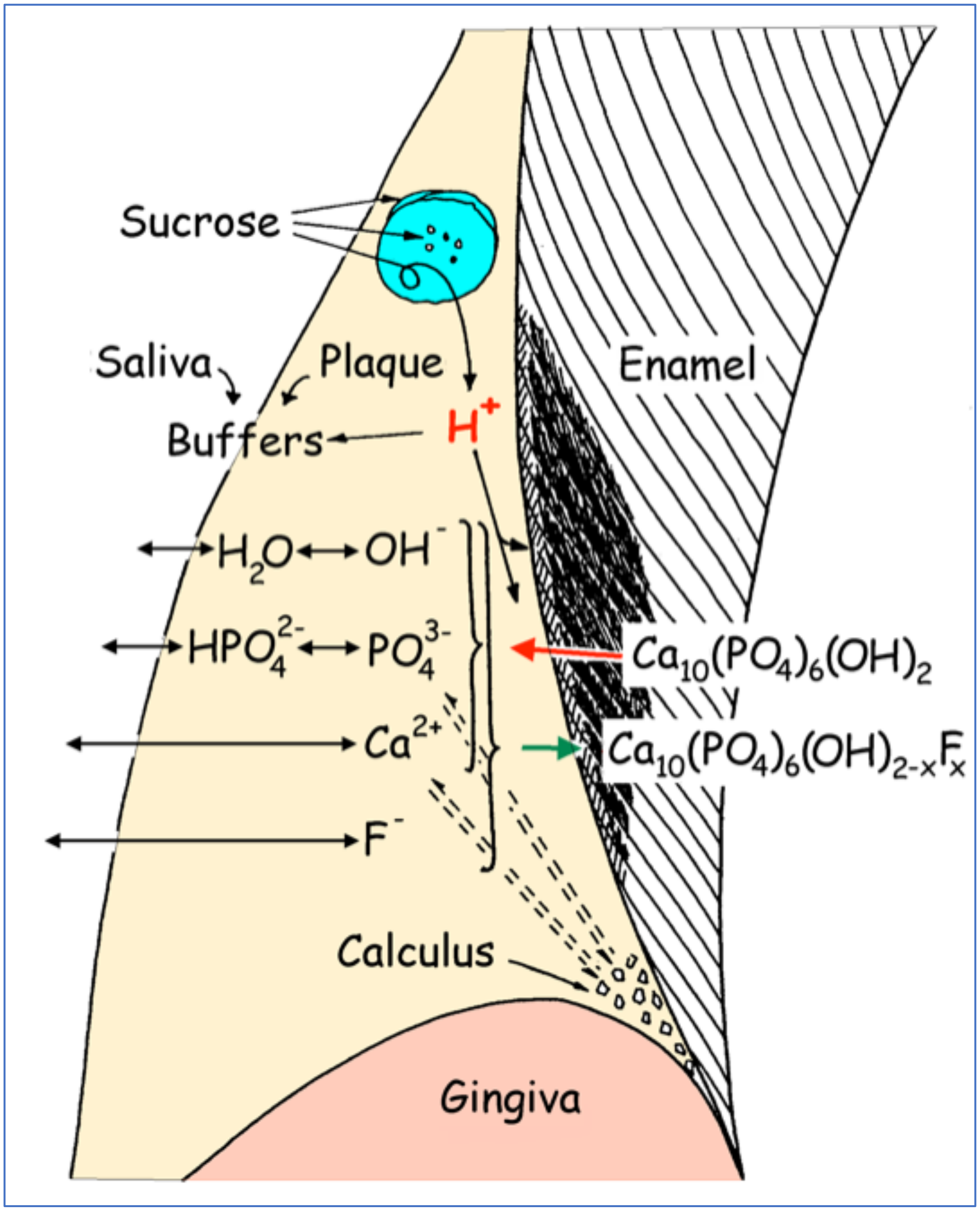
2. Enhances tooth remineralization (early in caries)

3. Bactericidal at high fluoride concentrations (*may* be a significant effect because of high fluoride concentration in plaque)

4. Inhibits bacterial metabolism at high fluoride concentrations, thus reducing rate of acid production

Note: 3 and 4 above were originally not thought to be a major effect in vivo because of the high concentration of fluoride required. However, recent experiments have shown that fluoride can concentrate at high levels in plaque!

Note: Current evidence strongly supports the major anti-caries effect of fluoride is the topical effects of fluoride more so than the systemic effects during tooth development. But together both systemic and topical fluoride result in a more caries-resistant tooth.



The figure illustrates the demineralization – remineralization process that occurs at a tooth surface. Certain plaque bacteria can metabolize simple sugars (especially sucrose) and release acid (H^+) end products. This acid production may drop the local pH below the **critical pH** (= <u>approximately 5.5</u>) of hydroxyapatite (enamel). Below the critical pH, the hydroxyapatite tooth structure can begin to demineralize into its individual ions. As the local pH rises back above the critical pH, the hydroxyapatite structure can remineralize using ions from saliva and plaque. <u>During the remineralization phase, fluoride (F^-) ions, if present, can incorporate into the crystal structure in place of some of the hydroxyl (OH^-) ions</u>. The resulting fluoridated hydroxyapatite is more resistant to demineralization caused by acid, <u>lowering the critical pH to approximately 4.9</u>.

Physiology of Fluoride

A. Sources of Fluoride

1. Fluoridated water (naturally or artificially fluoridated)
    a. Central water supply - 0.7 ppm
2. Fluoride in food
    a. Fluoride is widely distributed in soil (13th most common element), but concentration varies greatly in different regions; therefore, the concentration in plants is variable, but usually low
    b. Food additives containing fluoride (e.g., baking soda)
    c. Typical concentrations in some foods:

Food	RANGE PPM	MEAN PPM
Meat (beef, pork, poultry)	0.1 - 1.0	0.2
Fish (Salmon, sardines, crab)	0.2 - 4.5	2.0
Eggs	0.1 - 0.3	0.2
Potatoes	0.1 - 0.3	0.2
Wheat	0.1 - 0.4	0.2
Bread	0.1 - 0.3	0.3
Cereals	0.1 - 0.3	0.2
Fruit and vegetables	0.1 - 0.3	0.2
Cow milk	0.02 - 0.05	0.04
Human milk	0.01 - 0.02	0.01
Raisins	1.5 – 2.5	2.0
Wine	1.0 – 2.0	1.5
Tea	1.5 - 5.0	3.0

3. Dental products: dentifrice, rinse, varnish, etc. (some inadvertently swallowed)
4. Fluoride drops or vitamin tablets with added fluoride
5. Atmospheric sources: effluent from metal refinement (e.g. aluminum) and chemical manufacture (e.g., superphosphate production in the fertilizer industry)
6. Poisons: some insecticides, rodenticides, and fungicides contain fluoride as the major part of their active ingredient

Fluoride Supplement Dosage Schedule (mg/Day)

Ages (Years)	Drinking Water Fluoride Level (PPM) < 0.3	0.3 – 0.6	> 0.6
0 – 0.5	0	0	0
0.5 - 3	0.25	0	0
3 – 6	0.50	0.25	0
6 - 16	1.00	0.50	0

FYI: You can easily look up the fluoride level of most community water districts in the country by going to this CDC web site: https://nccd.cdc.gov/DOH_MWF/Default/Default.aspx

B. Absorption Routes

1. Alimentary tract (Stomach mostly)

   a. Absorption efficiency related to solubility: easily absorbed from soluble salts (e.g., NaF); poorly absorbed from insoluble compounds (e.g., fluorapatite, bone)

   b. Certain ions, particularly calcium, magnesium, aluminum, and iron, retard fluoride absorption by forming chemical complexes with fluoride

   c. Most common absorption route

Q? How do you think commonly used antacids might impact GI absorption of fluoride?

2. Lungs

   a. Absorbed from gases and dust particles deposited in airways

   b. Second most common absorption route

   c. Common route of absorption in industrial exposure (e.g., metal smelting)

3. Skin

   a. Possible absorption route, but uncommon

C. Distribution in Tissue

1. Majority of fluoride enters the blood stream within 30-60 minutes of ingestion

2. Fluoride concentration in saliva follows similar (with a slight time lag) kinetics of appearance and disappearance as in blood (Fluoride concentration in saliva is low and averages ~0.01 – 0.03 ppm)

3. Widely distributed in all tissue, but relatively low amounts in most soft tissues

4. Concentrated in mineralized tissues: i.e., bones and teeth

   a. Distribution within enamel - outside has highest [fluoride] = (500 – 5,000 ppm)

   b. Distribution within dentin – dependent on lifetime fluoride consumption - inside has highest [fluoride] = (500 – 5,000 ppm)

5. Plaque acts as a reservoir for fluoride in the mouth (5-50 ppm/wet weight). Mechanisms of how fluoride concentrates in plaque are not well understood, but probably involve binding to charged molecules and ions within the plaque biofilm.

   Note: This is a very important pH-dependent fluoride reservoir, important during remineralization: $\downarrow$ pH $\Rightarrow$ release of free F^-

D. Excretion

1. Urine

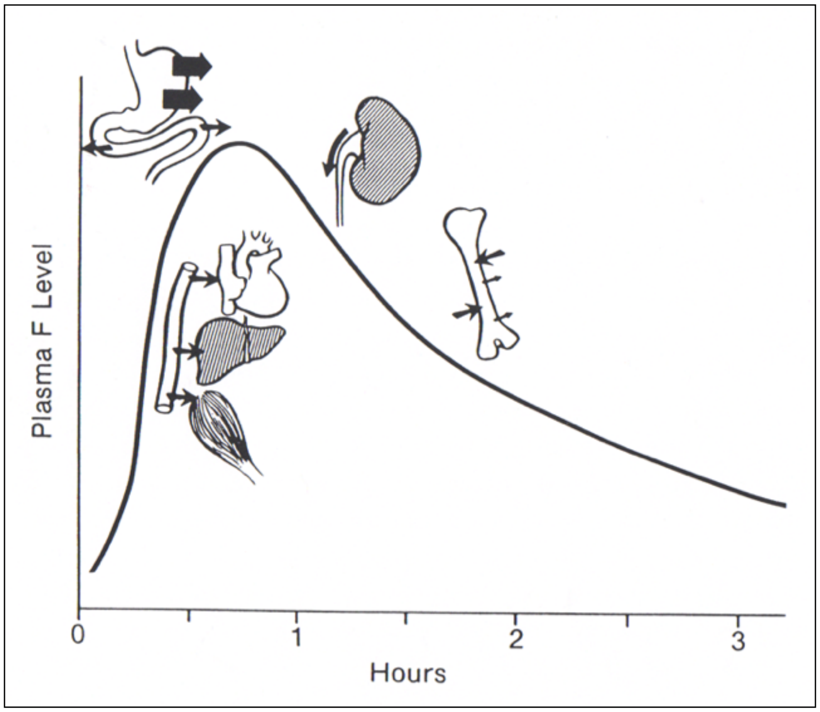
   a. Handled similar to chloride: filtered but only partially reabsorbed in the renal tubules

   b. Major route of excretion

2. Feces - usually <10% ingested F-, but higher if diet is high in Ca^{2+}, Mg^{2+}, Al^{3+}, which all retard fluoride absorption

3. Sweat - Usually minor, but can be a major route with heavy sweating

4. Lactation - little fluoride. A breast-fed baby will only get about 0.01 mg F/day.



Absorption, distribution, secretion, and plasma levels after consuming fluoride. Fluoride is rapidly absorbed from the acidic stomach into the blood plasma and rapidly distributed throughout the body, where ~50% is incorporated into bone, and ~50% is excreted mainly in the urine. Saliva levels are about 30% less than plasma, with slightly delayed kinetics ('recycled' F^-).

Fluoride Toxicology

A. Acute Poisoning

1. Mechanisms

   a. Obstructs cellular metabolism, inhibits several enzyme systems: reduces glycolysis and metabolic rate

   b. Complexes with calcium and magnesium ions, reducing free ionic calcium and magnesium concentrations

2. Initial symptoms; result of alimentary tract irritation – rapid (starting in minutes usually)

   a. Nausea
   b. Vomiting
   c. Abdominal pain
   d. Diarrhea
   e. Salivation

3. Systemic symptoms, mainly depression of serum Ca^{++} and Mg^{++} concentrations - slower (hours)

   a. Nervous system hyperexcitability

      1) paresthesia
      2) hyperactive reflexes
      3) convulsions

   b. muscle pain and spasm

   c. hypotension

   d. respiratory depression

   e. coma

   f. cardiac failure

4. Certain Lethal Dose (CLD)

   a. Death will occur if treatment is not started ASAP, and even then, may still be fatal.

   b. Order of ≥ 25-50 mg F^-/kg (approximately 10-20 mg/lb.); but note wide range

Age (yr.)	Lethal Dose F^-
2-4	0.5 gm
6-8	0.8 gm
10-12	1.0 gm
14	1.5 gm
Adult	2.0 gm

5. Probable Toxic Dose (PTD)

   a. Approximate minimum dose for serious, potentially life-threatening symptoms – may require hospitalization, a visit to ER for sure.

   b. Approximately ≥ 5 mg F^-/kg

6. Initial Toxic Dose (ITD)

   a. Approximate minimum dose for non-life-threatening symptoms (e.g., mild abdominal pain, nausea, and diarrhea) – probably requires no hospitalization

   b. Approximately ≥ 1 mg F^-/kg

7. Treatment

   a. Calculate amount consumed (i.e., mg F^-/kg weight) to determine the risk

   b. Induce vomiting or gastric lavage

   c. Administer calcium (e.g., milk, Tums, etc.) to slow absorption

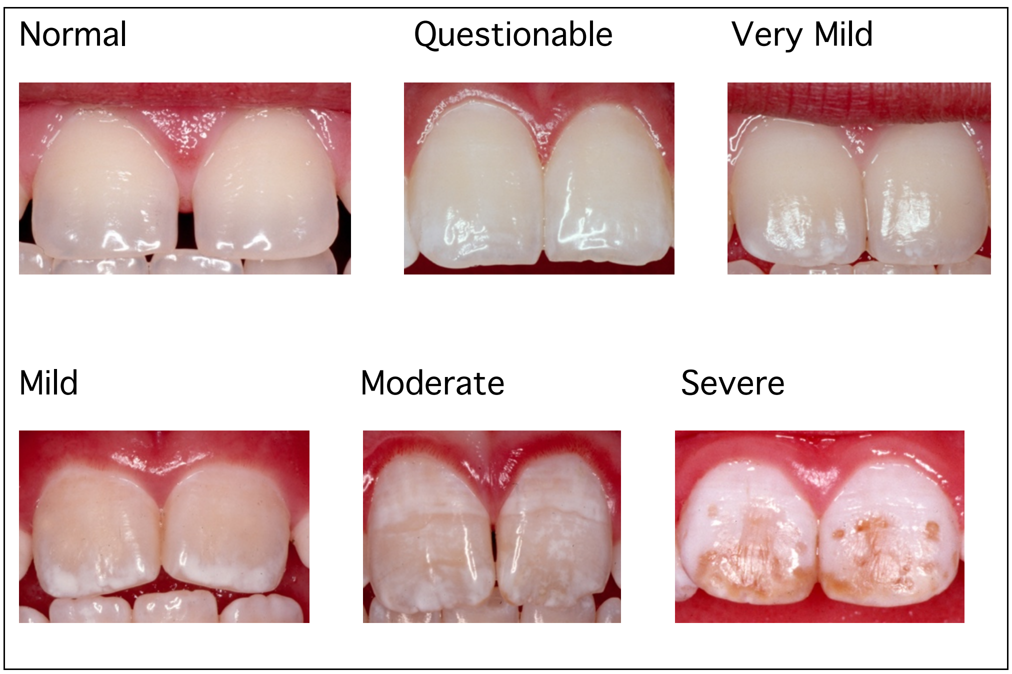
   d. Call 911 or transport to hospital if required

   e. Intravenous administration of saline, glucose, calcium

B. <u>Excess Chronic Exposure</u>

1. **Dental fluorosis:** <u>A change in the mineralization of the dental hard tissues (enamel, dentin, and cementum) caused by long-term ingestion (eating and drinking) of fluoride during the period of tooth development prior to eruption into the mouth</u> (first 8 years of life for most permanent teeth excluding third molars).

   Once the tooth erupts, dental fluorosis <u>refers to a range of visually detectable changes in enamel</u>. Change ranges from barely visible lacy white markings in milder cases to converged opaque areas and pitting of the teeth in severe forms. After eruption the pitted areas can become stained yellow to dark brown.



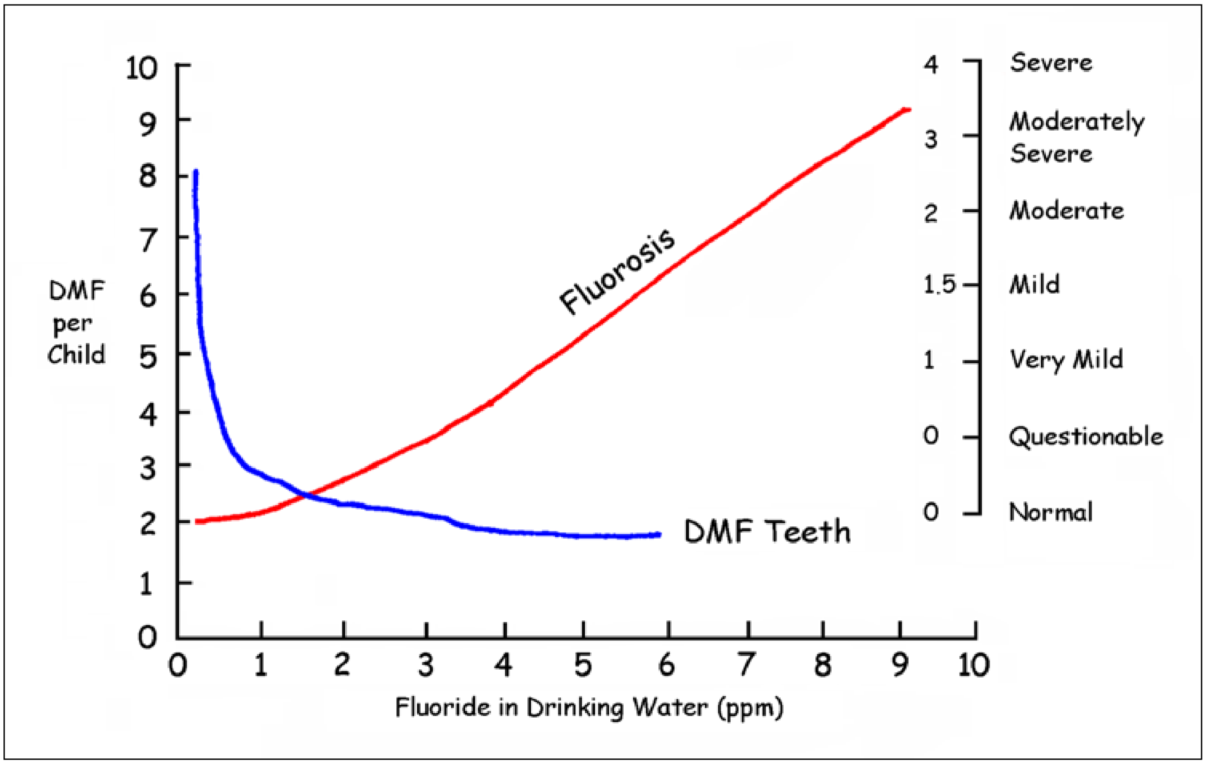
Source: https://www.cdc.gov/fluoridation/faqs/dental_fluorosis/index.htm

   a. Bilateral, opaque white regions on teeth at moderate fluoride consumption. Brown, pitted regions on teeth at high fluoride consumption.

   b. <u>Caused by extended moderate-high fluoride intake (i.e., too much) during tooth formation</u>

   c. Fluoride threshold - above ~0.7-1 ppm in water (<u>although other sources must also be considered!)</u>

d. Mechanism not really understood: Too high [F^-] 'impairs' ameloblasts, and the rate at which enamel matrix proteins are broken down and removed, resulting in crystal disorientation - causes light to reflect differently and look different to our eyes.



The figure shows the historical data comparing the anti-caries effect of fluoride with its ability to cause fluorosis. As the fluoride content of the local drinking water supply increases there is a rapid decrease in the number of DMF teeth. Correspondingly the community fluorosis index increases. Approximately where these lines intersect – about 1ppm – was the recommended level that local water supplies should maintain (recently lowered to 0.7ppm in the USA).

e. The incidence of fluorosis in the USA has been slowly increasing for years. This is thought to be the result of the increasing number of fluoride containing products, even in communities without water-fluoridation ('Halo Effect'). This was the major reason for lowering the recommended [F-] used in water fluoridation from 0.7-1.2ppm down to 0.7ppm in 2011.

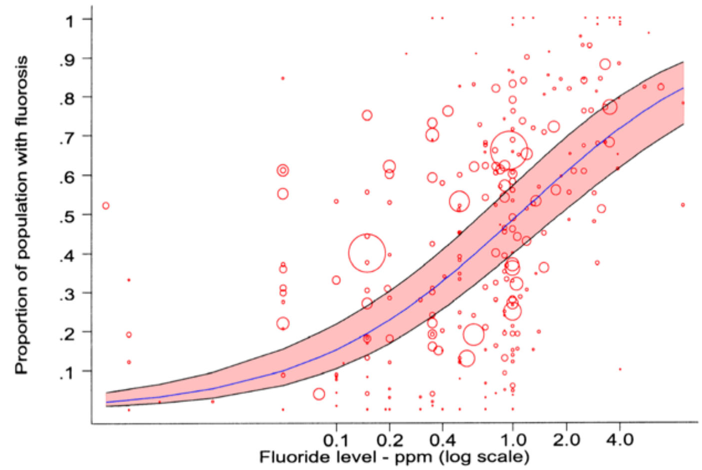


Figure 7.1 Proportion of the population with dental fluorosis by water fluoride level together with the 95% upper and lower confidence limits for the proportion

<u>Proportion of population with dental fluorosis by water fluoride concentration</u> with 95% confidence interval. Fluoride concentration is plotted on log scale because of linear association between this and log (odds) of fluorosis. Each circle represents a study area in which the proportion of people with fluorosis is estimated—the larger the circle, the higher the precision of the estimate.

f. It is important to keep in mind that <u>mildly fluorosed teeth are physiologically sounder (i.e., more acid resistant)</u>. Thus, <u>only the incidence of esthetic fluorosis should be of concern</u>.

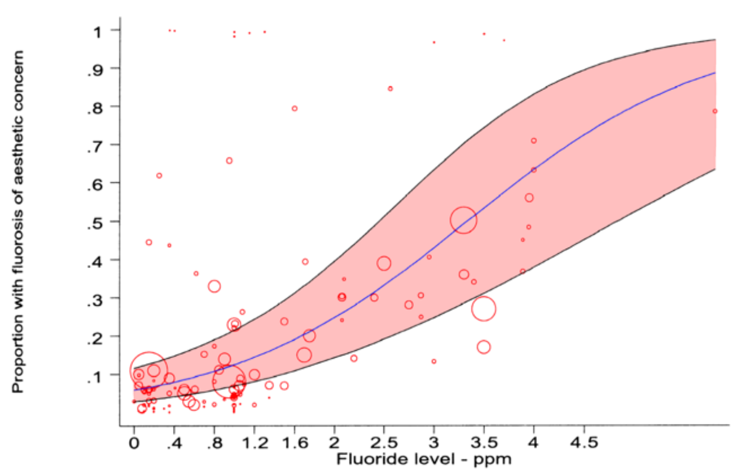


Figure 7.2 Proportion of the population with dental fluorosis of aesthetic concern by water fluoride level together with the 95% upper and lower confidence limits for the proportion

<u>Proportion of population with fluorosis of aesthetic concern by water fluoride concentration</u> (plotted on untransformed scale because of linear association between this and log (odds) of "aesthetic fluorosis"). Each circle represents a study area in which the proportion of people with fluorosis is estimated—the larger the circle, the higher the precision of the estimate.

2. Tissue fluorosis
   a. Calcification of tendons and ligaments:
   b. Possible kidney stones
   c. Threshold: extended consumption greater than 20 mg/day(?)

3. Osteofluorosis
   a. Brittle bones
   b. Threshold: extended consumption greater than 20 mg/day(?)

4. Gastric ulcer

5. Neuritis
   a. Excess nervous system excitability
   b. Threshold: extended consumption 40-60 mg/day

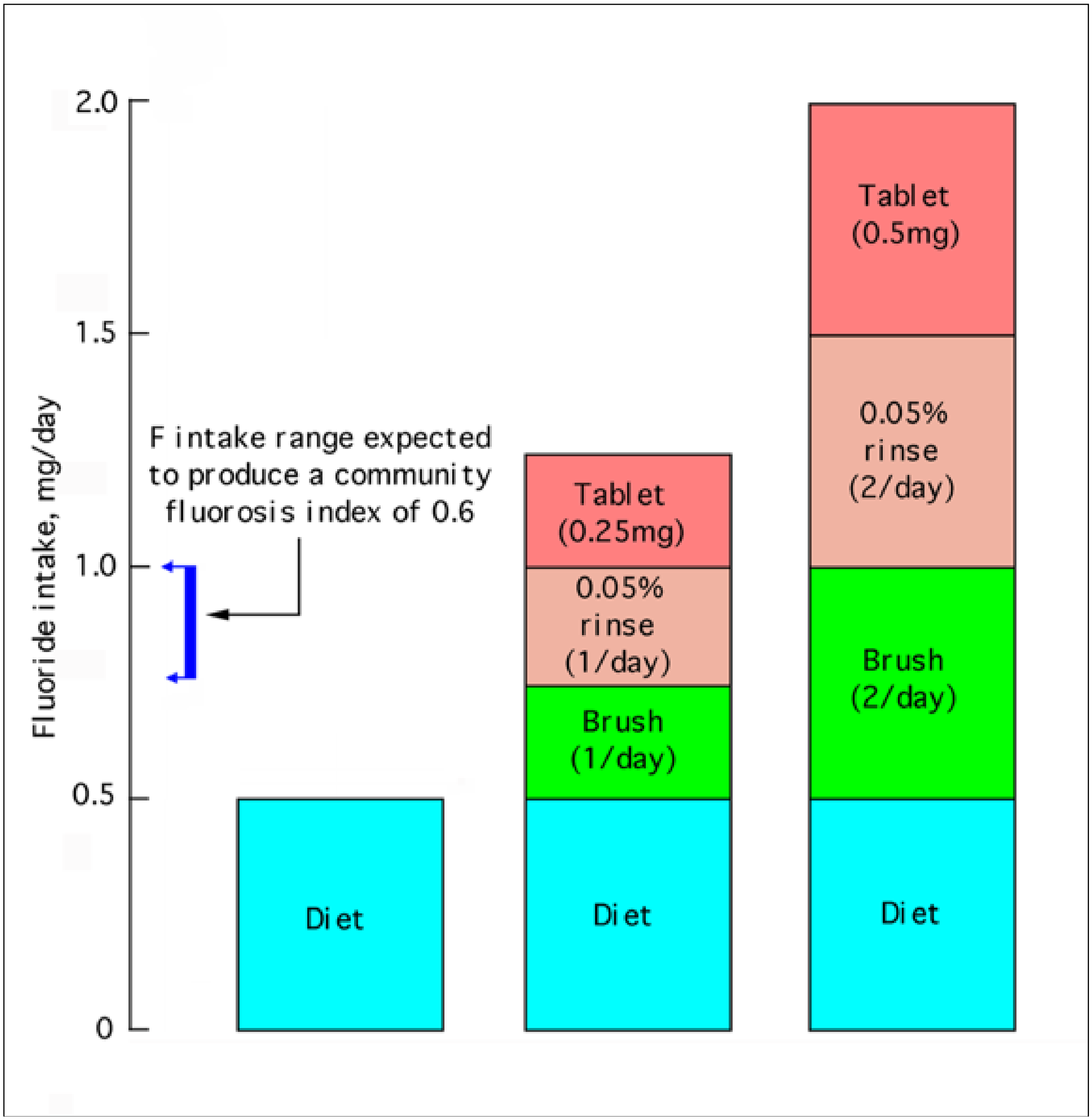
6. Treatment
   a. Calculate the amount consumed to determine risk
   b. Decrease fluoride consumption

C. Surprisingly there is no specific recommended dietary allowance for fluoride. Here are the estimated safe and adequate intake guidelines indorsed by the Institute of Medicine (similar to the American Dental Association recommendations):

Dietary Reference Intakes for fluoride

Age group	Dietary Reference Intakes for Fluoride		
	Reference weights kg (lb.)	Adequate intake (mg/day)	Tolerable upper limit (mg/day)
Infants 0-6 mo	7 (16)	0.01	0.7
Infants 6-12 mo	9 (20)	0.5	0.9
Children 1-3 y	13 (29)	0.7	1.3
Children 4-8 y	22 (48)	1.0	2.2
Children 9-13y	40 (88)	2.0	10
Boys 14-18 y	64 (142)	3.0	10
Girls 14-18 y	57 (125)	3.0	10
Males 19 y and older	76 (166)	4.0	10
Females 19 y and older	61 (133)	3.0	10

The Dietary Reference Intakes (DRI) guidelines set by the Institute of Medicine of **Adequate Intakes (AI)** of fluoride: 0.01 mg/day for infants through 6 months, 0.05 mg/kg/day beyond 6 months of age, and 3 mg/day and 4 mg/day for adult women and men (respectively), to reduce the risk of dental caries. **Upper Limits (UL)** of 0.10 mg/kg/day in children less than 8 years and 10 mg/day for those older than 8 years are recommended for prevention of dental fluorosis.



The estimated average total fluoride intake with diet and dental products by young children (1-3 years old) who live in a community with drinking water fluoride concentration of 0.7 ppm. Note: A community fluorosis index (CFI) of ≤ 0.6 is desirable. A community fluorosis index is determined by doing a 'door to door' survey of people in an area. They are classified into various categories based on the classification scheme on page 52. The number of people in each category is multiplied by the corresponding numerical weight, the products thus obtained for the various categories are added up and the sum total divided by the total number of people surveyed, gives the community fluorosis index. Only when the CFI value is greater than 0.6, is fluorosis considered to be a public health problem in that area. The ADA recommends only a 'smear sized' amount of fluoride toothpaste for children under 3 years of age, and a 'pea-sized' amount from 3-6 years of age.

Fluoride content of dental products and their relationship to the 'probable toxic dose' (PTD).

Product	Concentration of			Amount of product and F usually used		Amount containing the PTD for:	
	salt	Fluoride				10 Kg child	20 Kg child
	%	%	PPM	Product	Fluoride		
Rinse:							
NaF	0.05	0.023	230	10 ml	2.3 mg	217 ml	434 ml
NaF (APF)	0.044	0.020	200	10	2.0	250	500
NaF	0.20	0.091	910	10	9.1	55	110
SnF_2	0.40	0.097	970	10	9.7	52	104
Dentifrice:							
NaF	0.23	0.11	1100	1 g	1.1	45 g	90 g
MFP	0.76	0.10	1000	1	1.0	50	100
SnF_2	0.45	0.11	1100	1	1.1	45	90
NaF	1.08	0.50	5000	1	5.0	10	20
Topical gel or solution:							
NaF (APF)	2.72	1.23	12,300	5 ml	61.5	4 ml	8 ml
NaF	2.0	0.90	9,000	5	45	5.5	11
SnF_2	8.0	1.94	19,400	1	19.4	2.5	5
Prophylaxis Paste:							
NaF	2.7	1.23	12,300	1 ml	12.3	4 ml	8 ml
Varnish:							
NaF (50mg NaF/ml)			-	0.05mL	11.3	2.2ml	4.4ml
Tablet/Drops:							
0.25 mg	-	-	-	1/day	0.25	200 Tab	400 Tab
0.50 mg	-	-	-	1/day	0.50	100 "	200 "
1.00 mg	-	-	-	1/day	1.00	50 "	100 "
Water (1 ppm):							
	-	-	1	250 ml	0.25	50 L	100 L
Salt (250mg/kg):							
	-	-	250	4 g	1.00	50 g	100 g

The PTD is the threshold for the 'probable toxic dose:' ≥ 5mg F/kg. If this amount is ingested, the individual should receive emergency treatment and perhaps be hospitalized. (Note: 10 kg is used as the approximate average body weight of a 1-year-old child. 20 kg is used as the approximate average body weight of a 4 to 6-year-old child. (This also makes the math easier!)

Fluoride Concentrations and Conversion

A. Concentration of fluoride containing compounds

1. Mass/volume: e.g., mg/ml
2. Percent solution: gm/100 ml solution
3. ppm (part-per-million): gm/1,000,000 ml = mg/liter

B. Fluoride concentration in solution:

1. Based on ratio of fluorine atomic weight to total molecular weight

FYI: Atomic weight of elements common in fluoride containing compounds:

Fluorine	F	19.0
Oxygen	O	16.0
Phosphorus	P	31.0
Potassium	K	39.1
Sodium	Na	23.0
Tin	Sn	118.7

C. Sample problems

1. What is the concentration of a 2.0% NaF solution expressed in ppm?

Answer: 2.0% = 2 gm/100 ml = 20 gm/Liter (1,000 ml)
= 20,000 mg/Liter = 20,000 ppm

2. What is the concentration of fluoride in a 2.0% NaF solution, expressed in mg/ml?

Answer: 2.0% solution = 2 gm/100 ml = 0.02 gm/ml
= 20 mg/ml
NaF, fraction fluoride = 19 / (23+19) = 0.452
= 45.2%
20 mg/ml NaF = 0.452 x 20 mg/ml F = 9 mg/ml F

3. A child swallows the contents of a 100 ml bottle of 2.0% NaF solution. How many milligrams of fluoride did the child swallow?

Answer: 2.0% NaF solution = 9 mg/ml F
100 ml x 9 mg/ml = 900 mg

D. More Sample Problems.

1. What is the concentration of stannous fluoride in an 8.0% SnF_2 solution expressed as ppm SnF_2?

   Answer?

2. What is the concentration of <u>fluoride</u> in an 8.0% SnF_2 solution, expressed in mg/ml? In ppm?

   Answer?

3. A child swallows the contents of a 100 ml bottle of 8.0% SnF_2 solution. How many milligrams of fluoride does the child get?

   Answer?

E. Even More Sample Fluoride Problem!

1. What is the concentration of an 8.0% SnF_2 solution expressed as ppm?

   Answer: 8.0% = 8 gm/100 ml = 80 gm/Liter = 80,000 mg/Liter
   <u>= 80,000 ppm</u>

2. What is the concentration of fluoride in an 8.0% SnF_2 solution expressed in mg/ml?

   Answer: 8.0% solution = 8 gm/100 ml = 0.08 gm/ml = 80 mg/ml
   SnF_2 fluoride fraction = (2 x 19)/(118.7 +2 x 19) = 0.243
   = 24.3% fluoride
   80 mg/ml SnF_2 = 0.243 x 80 mg/ml F = <u>19.4 mg/ml F</u>

   Similarly: 80,000 ppm SnF_2 = 80,000 x 24.3% ppm F_2
   = 19,400 ppm F

   Note: The "x2" in the above is due to the fact that, when a SnF_2 molecule is dissolved in water, 2 F-ions are created.

3. A 20 Kg child swallows the contents of 100 ml bottle of 8.0% SnF_2 solution. How many milligrams of fluoride does the child get? How does this relate to the PTD?

Answer: 8.0% SnF_2 solution = 19.4 mg/ml F
100 ml x 19.4 mg/ml = <u>1940 mg</u> = 1.94 gm
The PTD = 5 mg F/kg
20 x 5 = <u>100 mg F = PTD for this child</u>

In fact, this child is in a very, very serious situation:
10 x 25 = <u>250 mg F = CLD for this child</u>