

## What we know and don't know about fluoride\*

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Symposium:  
New Frontiers on Fluoride and Enamel  
Fluorosis Surveillance

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## Herschel Horowitz 1932-2003



"because I have seen first-hand the beneficial effects...I have not changed my mind about safety and effectiveness of water fluoridation." Horowitz, JPHD 2000

## Herschel Horowitz 1932-2003



Introduced a new method for assessing the prevalence of fluorosis, the Tooth Surface Index of Fluorosis (TSIF), that was more sensitive with regard to both prevalence and severity of dental fluorosis Horowitz *et al.* 1984

## Herschel Horowitz 1932-2003



Advocated the introduction in the U.S.A. of dentifrices with 400-500 ppm fluoride for preschool-aged children Horowitz, JPHD 1992

## What we know

1. Optimal level of fluoride in water supplies for caries reduction with minimal fluorosis for children **before** the widespread use of topical fluoride agents, especially dentifrices.
2. The difference in caries rates between fluoridated and non-fluoridated communities is less, yet optimally fluoridated communities consistently have lower caries rates.
3. Excessive amount of fluoride intake causes fluorosis, the degree of fluorosis is directly related to fluoride level in water.
4. Unintentional swallowing of fluoride dentifrices by youngsters is a significant contributor to prevalence of fluorosis in USA.
5. Amount of fluoride supplement for children at various ages residing in non-fluoridated areas for caries reduction with minimal fluorosis.

## What we know

6. When a fluoride supplement is ingested as a single bolus, blood fluoride levels peak, more likely resulting in fluorosis.
7. Fluoride acts to prevent caries both pre- and post-eruptively, although the relative proportion of benefit has been disputed.
8. Fluoride should be ingested systemically (water, salt or as a supplement) and used topically on a daily basis, for maximum caries prevention.
9. With regard to health, at optimum fluoride level in the public water supplies, fluoride is safe from a medical perspective.
10. In spite of massive evidence with respect to safety and efficacy, water fluoridation continues to engender opposition from a small but vociferous and determined minority.

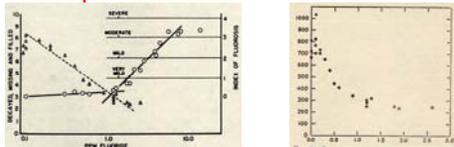
## What we don't know

1. If the level of fluoride in water supplies is reduced from currently accepted levels, how effective is the caries reduction and is the prevalence of fluorosis reduced?
2. When water fluoridation is stopped, what would have been the caries rates if water fluoridation had continued? Could the stable caries rates be explained by improved oral health behavior and increased application of preventive measures?
3. Has the prevalence of dental fluorosis really increased in the U.S.A. and is it of esthetic/cosmetic concern?
4. Exact amount of fluoride ingested from all sources by an individual, although we have a good idea of average intake; we need to know the amount that will trigger enamel fluorosis.
5. In countries that market low level fluoride dentifrices and have extensive communal water fluoridation, whether fluorosis is less than in U.S.A.

## What we don't know

6. Have socio-economic factors played an increasing role in determining the efficacy of communal water fluoridation?
7. Has the rise in consumption of bottled water in lieu of tap water resulted in an increase in caries prevalence or a decrease in fluorosis?

If fluoride in water supplies is reduced from currently accepted levels, how effective is the caries reduction and is the prevalence of fluorosis reduced?



Relationship between **logarithm F** in water & caries prevalence & dental fluorosis Hodge JADA 1950

Relationship between **F** in water & caries prevalence/ 100 children Dean et al. 1942

1. These relationships are based on data **before** widespread use of self-applied topical fluorides, especially dentifrices
2. Even then the differences between caries prevalence at 0.8 and 1.0 ppm F are small

If fluoride in water supplies is reduced from currently accepted levels, how effective is the caries reduction and is the prevalence of fluorosis reduced?

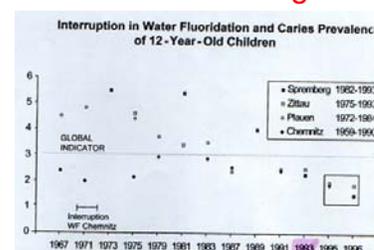
In 2007 Ireland set F between 0.6–0.8ppm (down from 1.00ppm), so that it is too soon to determine if this lower level has changed either the prevalence of caries or fluorosis.

In Hong Kong fluorosis has decreased since the level of fluoride its drinking water was lowered from 1.0 to 0.7 ppm (Evans & Stamm, 1991).

## Effect of discontinuing water fluoridation

1. Antigo, Wisconsin study showed 112% increase in caries prevalence (2.5 def to 5.3 def) from 1960 to 1966 Lemke et al. JADA 1970). Similar adverse trends resulting from ending water fluoridation have been reported in Anglesey, Wales (Thomas et al. 1995), Wick, Scotland (Stephen et al. 1987), Wigtownshire, Scotland (Attwood & Blinkhorn, 1991). In Prague, Czech Republic in 1995, 7 years after fluoridation had stopped, caries in 6 year olds had risen markedly by 40% (Lekešová et al. 1996).
2. Studies in Finland (Seppä et al. 1998), Cuba (Künzel & Fischer, 2000) and former East Germany (Künzel et al. 2000) found caries prevalence remained stable or continued to fall after cessation of water fluoridation.
3. These were all cross-sectional, observational studies lacking concurrent control communities that continued water fluoridation.

## Effect of discontinuing water fluoridation



Künzel et al. Commun.Dent. Oral Epidem.28:382-9 2000

Several preventive measures were instituted in these countries after the cessation of water fluoridation, primarily involving the use of **topical fluorides** but also use of fissure sealants and introduction of fluoridated salt, which account for the stability of the caries prevalence.

### When water fluoridation is stopped, what would have been the caries rates if water fluoridation had continued?

In Comox/Courtenay & Campbell River, B.C. Canada water fluoridation ceased in 1992, while Kamloops, B.C. continued to fluoridate (Maupomé et al. 2001). The fluoridation-ended and fluoridated sites were surveyed in 1993/4 and **only three years later** in 1996/7. The prevalence of caries decreased in the fluoridation-ended site while remaining unchanged in the fluoridated site. The authors concluded that multiple sources of fluoride, generally low caries experience and affluence with widely accessible dental services, make it difficult to detect changes. Detailed statistical analyses, including SES, could not explain their findings.

No mention was made of the fact that systemic fluoride during tooth formation has a prolonged benefit for the "fluoridation-ended" children in grades 5,6, 11 and 12 (ages 11,12,17 &18).

### Effect of stopping communal water fluoridation bottom line

A systematic review of the effect of stopping water fluoridation found a median increase of 18% in dental caries during 6 to 10 years of follow-up (Truman et al., 2002).

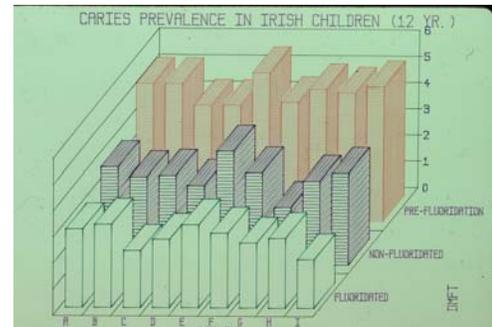
### Danish, Dutch & German dentists' attitude towards communal water fluoridation



Aesop: The Fox and the grapes

- For political or legal reasons, they have not succeeded in achieving or maintaining communal water fluoridation
- They have a surplus of dentists, many are kept employed delivering preventive treatments such as topical fluoride applications
- By a combination of intensive fluoride therapies (supervised rinses, F dentifrice, etc) caries prevalence has been lowered

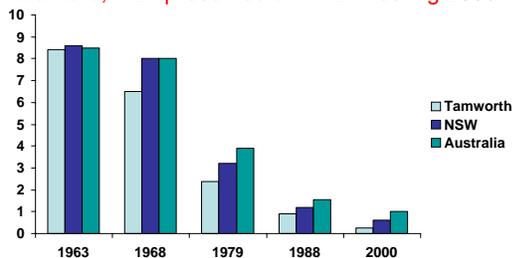
### Comparison of DMFT in Irish counties with topical only or systemic + topical fluoride



O'Mullane et al. Government publications, 1986

### Change in DMFT age 12 years

Barnard, P.D. presented at IAPD meeting 2005



Tamworth began water fluoridation in 1963, by 1975 12 yr-olds would have had lifelong systemic fluoride exposure, yet caries prevalence has continued to fall. Sugar consumption has remained stable >50kg/person/year. F dentifrice use ~95%

### Has the prevalence of dental fluorosis\* really increased in the U.S.A.?

Several reviewers (Pendrys and Stamm, 1990; Clark 1994; Rozier, 1999) have also concluded that the prevalence of fluorosis has risen in North America.

#### National Survey

NIDR 1986-7 survey 6-19 yr olds\* prevalence 22.3%

NHANES 1999-2002 survey 32%

**Increase** in prevalence in cohorts born since 1980 **9%**

(Beltran et al. JADA 2002; Beltran et al. MMWR 2005)

\* US school children

#### Illinois

Selwitz et al. (J Pub Hlth Dent 1995) found **no change** in the prevalence of fluorosis when comparing the same Illinois population from 1980 to 1990.

\*fluorosis = very mild, mild, moderate or severe

**What is the exact amount of fluoride ingested at optimal fluoride levels?**

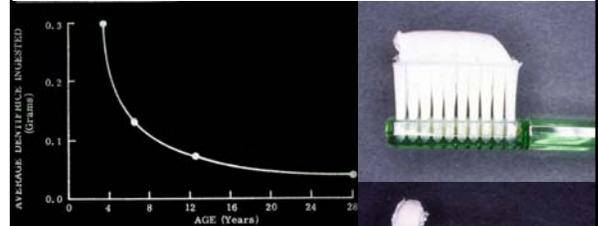
Market basket surveys analyzing fluoride content of different foods and beverages have been extrapolated to indicate average fluoride intake. Claims by anti-fluoridationists of high fluoride intake from breakfast cereals and milk are erroneous (Levy 2004) or of adequate fluoride intake in non-fluoridated communities are incorrect (Newbrun, WesternJMed 1975).  
 urinary F in optimal CWF 0.9ppm  
 urinary F in suboptimal community 0.3ppm

**Is the fluorosis of esthetic concern?**

Studies on the public perception of enamel fluorosis as an esthetic problem were conducted in various countries (Australia, Canada, U.K., U.S.A.) using different indices of enamel fluorosis. Generally, the findings from all these studies are that both parents and children are less concerned about low levels of fluorosis than dentists, that children with such low level fluorosis are less likely to have experienced decay and that everyone, lay and dental professionals considers high levels of fluorosis cosmetically objectionable. Esthetically objectionable fluorosis is a rare outcome, affecting only about 2% of children (Griffin et al. 2002). A clear population threshold exists for severe enamel fluorosis, which is close to zero in areas where the fluoride level in drinking water is below 2 mg/L (National Research Council, 2006).

**What amount of fluoride ingested will cause fluorosis, is it just the total amount, the rapidity with which it is absorbed causing high peak blood plasma levels?**

**Fluoride ingestion from dentifrices**



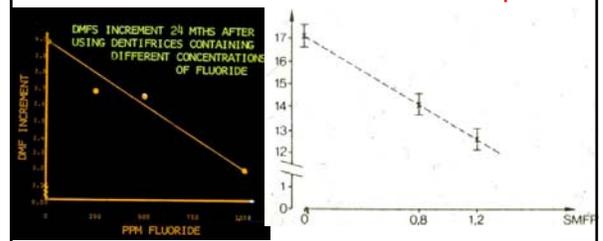
Dentifrice ingestion is greatest in infants, decreases with age. Estimated ingestion from dentifrice brushing 2X/day is ~0.3 mg F. In USA recommended that children under 6 years of age use only "pea size" amount of paste.



**Children's fluoride dentifrices**

Many countries (Australia, Austria, Czech Republic, Belgium,Finland,France, Germany, Israel, Luxembourg,Netherlands, New Zealand, Portugal, Sweden, Switzerland, U.K.) market children's dentifrices containing 250, 400, 500 or 550 ppm fluoride in order to reduce unintentional fluoride ingestion (Newbrun JDR 1992; Riordan, 2002).

**Caries rates and fluoride concentration in dentifrices show +ve dose-response**



NaF (0, 250, 500 & 1000 ppmF) Reed JADA 1973  
 MFP (0,1000, 1500 ppm F) Buhe et al. 1984  
 Several reviewers have concluded there is positive dose-response between fluoride concentrations in dentifrices and caries reductions (Newbrun, 1992; Beisbrock et al., 2001, Marinho et al. 2009).

### Do low fluoride dentifrices provide adequate caries protection? while reducing enamel fluorosis?

Some studies have shown low fluoride dentifrices (<1100ppm) are less efficacious in caries protection compared to standard fluoride toothpastes (Reed, 1973; Mitropoulos et al., 1984) while others have found no statistical difference (Koch et al., 1982; Winter et al., 1989; Beisbrock et al., 2003; Stookey et al., 2004).

### Do low fluoride dentifrices reduce prevalence of enamel fluorosis?

- One study has reported significantly less enamel opacities using TF index of fluorosis for children using low fluoride (550 ppm) as compared to standard fluoride (1050 ppm) dentifrices, however "the differences were numerically very small despite being statistically significant" (Holt et al., 1994).
- retrospective "recall" studies of use 400- to 550-ppm F dentifrices found significantly lowered fluorosis prevalence following their introduction (Riordan, 2002; Do & Spencer, 2007; Spencer & Do, 2007)

### Have socio-economic factors played an increasing role in determining the efficacy of communal water fluoridation?

- Social class is a potent discriminator of health inequalities and caries is no exception.
- Implementation of water fluoridation reduce decay and socio-economic dental inequalities are reduced (Pitts & Palmer, 1995; Jones & Worthington, 2000).
- In USA caries differences between fluoridated and non-fluoridated areas only holds when similar socio-economic groups are compared (Kumar et al., 1998 ). Because of socio-economic differences low SES children are less likely to have early diagnosis of caries, to have additional preventive care and more likely to have extractions, all of which would account for disparities in apparent benefits from communal water fluoridation.

### Has the rise in consumption of bottled water resulted in an increase in caries prevalence or a decrease in fluorosis?

- It is assumed that consumption of bottled water (most contain <0.3 ppmF) leads to decreased fluoride intake.
- Whether this is clinically significant is not known.
- ADA makes no conclusion, simply recommending, "consumers should seek the advice from their dentist about specific fluoride needs."
- The only scientifically acceptable way would be to conduct a double blind study with half the sample population using non-fluoridated bottled water and the other half using fluoride-containing bottled water.

## Conclusions

- The randomized, controlled, double blind, clinical trial is the gold standard for answering many of the questions that remain concerning fluoride therapy in relation to preventing dental caries and minimizing enamel fluorosis.
- Given the length, cost and difficulty of conducting such clinical trials, some of the issues raised in this symposium will never be properly investigated.
- Some clues can be derived from retrospective "recall" studies but they cannot substitute for long-term prospective investigations.