Editor's Note: The ten figures in the following guest editorial are available in full color on the Fluoride website: www.fluorideresearch.org.

WATER FLUORIDATION INTERVENTION: DENTISTRY'S CROWN JEWEL OR DARK HOUR?

SUMMARY: When applied to the community at large, water fluoridation does not show effectiveness. Dental fluorosis is both a health risk and a health care cost for initial treatment with restorations and replacement of restorations. Caries in pits and fissures of teeth can be especially problematic for diagnosis in fluoridated teeth, and delay in recognition of such decay can result in greater tooth loss and larger restorations. The possibility that fluoride exposure may increase the risk of tooth fracture must also be considered. From a dental standpoint, any need for fluoridation intervention is open to serious question.

Keywords: Dental fluorosis; Fluoridation; Fluoride dental "bomb"; Tooth cusp fracture; Tooth veneers.

Although the practice of water fluoridation is recognized as controversial,[1] both its proponents and opponents generally agree on two fundamental aspects: (1) reduction in tooth decay is the potential benefit from ingesting fluoride, and (2) dental fluorosis is caused by fluoride exposure during early years of life.

Dental benefits not evident: "Evidence for whether an intervention works when applied in the community at large is referred to as its effectiveness. . . . Effectiveness studies more accurately reflect results that may be expected from the implementation of interventions."[2] The implementation of fluoridation began over 60 years ago, and today proponents continue to claim fluoridation provides a 20–40% reduction in dental decay.[3] If their claim is correct, then substantial evidence for such effectiveness should be evident in the community at large.

As seen in their plots of dental caries rates for 12-year-old children collected by the World Health Organization for the years 1965–2000 and reported by Neurath[4] and by Cheng,[5] little difference in rates of tooth decay is found with or without fluoridation or fluoridated salt intervention in developed countries. Comparing the decay rate of any single developed country over time reveals a decrease in dental decay, regardless of fluoridation. Certainly the "halo" or "ubiquitous effect" theory, which suggests the anti-caries benefit of fluoridated water extends beyond the individual public fluoridated water user through shipping of processed foods and beverages and mixed water use from school, home, or work have a significant impact on individuals within a community or perhaps neighboring communities, but would have negligible worldwide effect.

Arranging the 50 USA states based on the percentage of their whole population fluoridated and the confounding factor of socioeconomic status (Figure 1),[6,7,8] one finds that about 82% of the wealthy and 55% of the poor are reporting very good to excellent teeth regardless of fluoridation. Thus, evidence for effectiveness of fluoridation is clearly lacking from this US national comparison.

In 1996, 46% of public water users in Washington State were fluoridated and a plot of percent fluoridation versus dental decay rates of third-grade children in the

39 counties indicates no evidence of reduction of dental decay with increased fluoridation (Figure 2).[9] Nevertheless, Washington State dental health officials disregarded such evidence and continued aggressively and successfully to promote fluoridation.

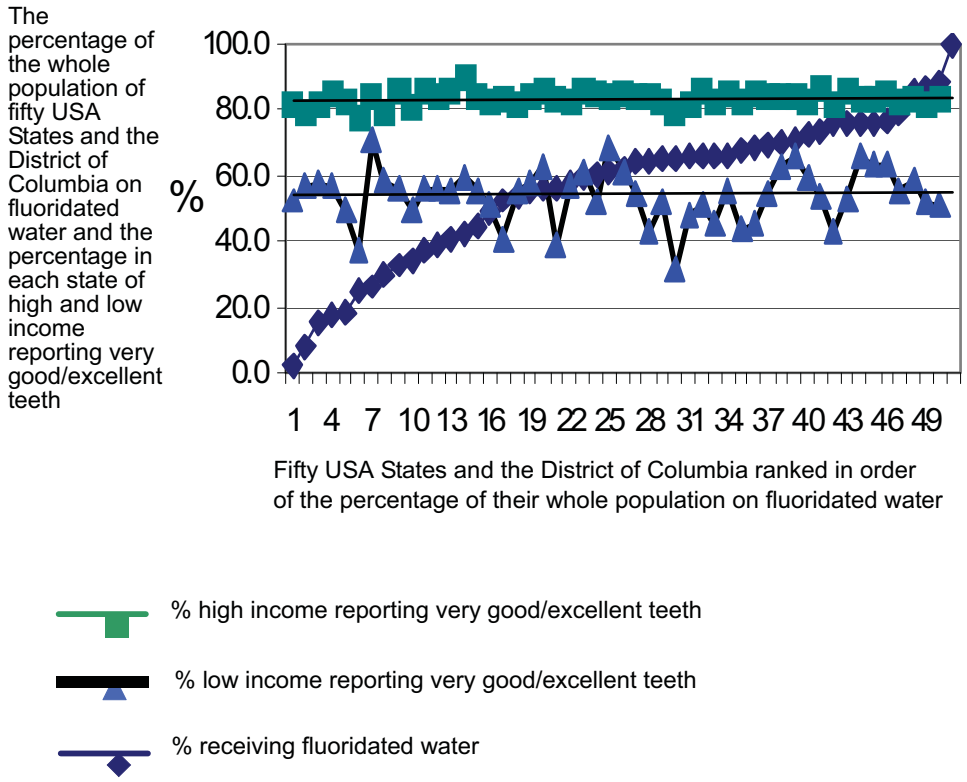

Figure 1. Fifty USA States and the District of Columbia ranked in order of the percentage of their whole population on fluoridated water and the percentage in each state of high and low income reporting very good/excellent teeth. To arrive at the percentage of whole population fluoridated, the USGS percent of those served by public water was multiplied by the percent on fluoridated public water.

Washington State currently has 59% of the population on public water systems receiving fluoridated water. By contrast, neighboring Oregon has only 19%.[7] Confounding factors of higher socioeconomics, [10] greater access to dental care are in Washington State's favor, yet Oregon with only a third as much fluoridation appears to generally have similar or better oral health overall.[11-13]

A comparison of Kaiser Health Maintenance Organization (HMO) patients in NW Oregon and SW Washington State reveals mixed results: higher dental costs in some community water fluoridated areas (CWF) and in some non-fluoridated (NF) areas. The authors state, "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 (sealants and preventive resin restorations)."[14] And NF Portland metro, with the largest number of subjects, showed lower dental expenses. If all subjects in the study had been fluoridated, the

data indicates Kaiser HMO would have experienced a true increase in net dental expenses of about 4%. Disregarding evidence of the whole, the conclusion cherry picks evidence, "suggesting that CWF may in fact have been cost saving at the time the study was carried out" with savings in dental treatments of perhaps $0.67 per person year (0.3%).[14] Costs for fluoridation equipment installation and maintenance, dental (not covered by Kaiser) and medical damage, and bottled water for infants and non-consenting adults were not considered.

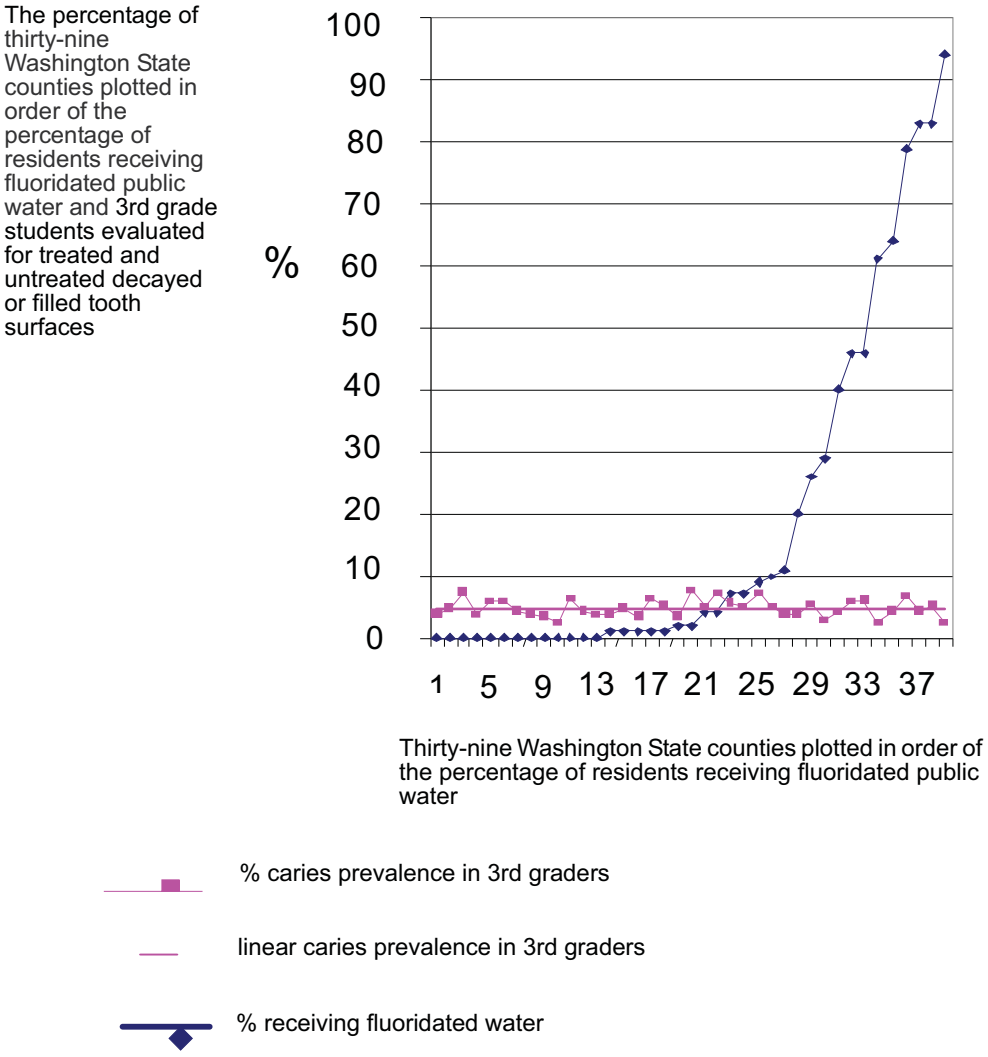

Figure 2. Thirty-nine Washington State counties plotted in order of the percentage of residents receiving fluoridated public water and 3rd grade students evaluated for treated and untreated decayed or filled tooth surfaces.

Recently, Pizzo has concluded, "several studies conducted in fluoridated and non-fluoridated communities suggested that this method of delivering fluoride may be unnecessary for caries prevention."[15] Likewise, a careful review of data by

Komarek found no convincing evidence for a beneficial effect of fluoride intake to deter caries development.[16]

Dental fluorosis: According to the American Dental Association, "The only known risk associated with the use of fluoride is mild enamel (dental) fluorosis which is a cosmetic effect with no known health consequences."[3] Proof that dental fluorosis indeed has a health consequence is the dental treatment provided to correct dental fluorosis. Cosmetic dentistry has risk of tooth loss, root canals, increased periodontal disease, complications of occlusion, and could certainly offset any theoretical cost savings from fluoridation. (Figures 3 and 4).

Photograph Dr Tony Soileau

Figure 3. Teeth with dental fluorosis.

Photograph Dr Tony Soileau

Figure 4. Restored teeth.

The disagreeable cosmetic appearance can sometimes be reduced with bleaching, but the effect is only temporary, and occasionally bleaching can make the appearance worse. Lower cost composite resin materials can provide a temporary cosmetic improvement, and recalcification of the hypocalcified dental fluorosis enamel is being tried.

Damage should NOT be measured by the amount of treatment provided but rather by the amount of damage experienced. When true costs for tooth pathology are considered, both treated and non-treated decay are generally combined (decayed, missing, filled). True costs for dental fluorosis should also include damage to teeth both treated and untreated. Cosmetic damage is indeed real damage to the teeth.

"*Fluoride bomb*"*:* Proponents of fluoridation allege ingested fluoride reduces dental decay on the smooth surfaces of the teeth, but they concede there appears to be little benefit to the pits and fissures of the teeth. Clinically, detecting decay in the pits and fissures of the teeth can be difficult (Figure 5) until the enamel breaks away or the tooth turns gray. Clinicians sometimes refer to a severely decayed tooth as "bombed out."

Photograph Dr Ray Voller

Figure 5. Decay in the grooves.

A fluoridated "bombed out" tooth clinically can have unique characteristics of good smooth surface enamel yet have extensive dentin decay in the pits and fissures. In contrast, the non-fluoridated bombed out tooth may chip next to the pits and fissures before as much dentin damage occurs and provide earlier detection of the decay by patient or clinician, explaining in part the lack of effectiveness with fluoridation. Cautious removal of the dark groove reveals a deep "bomb" of decay (Figure 6).

Photographs Dr Ray Voller

Figure 6. Access for decay.

As the soft rotten dentin is removed, the clinician's concern rises as this "tiny dark spot" often belies significant hidden dentin damage and may require extensive restoration or treatment with a crown and/or root canal (Figures 7 and 8). Thus the potential benefit of fluoridation on the smooth surface enamel may have complicated or delayed the diagnosis of dentin decay in the pits and fissures. Early reports suggesting fluoridation reduces tooth decay could have been flawed in part by the difficulty in diagnosing pit and fissure decay.

Incomplete and complete tooth fracture: After dental decay and periodontal disease, fractured teeth are the third most common cause of tooth loss,[17] but to date no identifiable cause has been found for 30 to 50% of fractured teeth.[18] In a survey of North Carolina dentists, 5% of all non-hygiene visits to their practices were complete cusp fractures.[19] When the costs for treatment of complete dental fractures, which often include crowns, endodontics, extractions, bridges, and implants, and the treatment for prevention of incomplete tooth fractures, is added to the costs for retreatments, the true lifetime cost for fractured teeth could represent the single greatest dental expense for adults (Figures 9 and 10).

Photograph Dr Ray Voller

Figure 7. Most decay removed.

Photograph Dr Ray Voller

Figure 8. Restorations placed.

Figures 9 and 10 represent a classic case of complete cusp fracture. Preventive treatment was declined and complete cusp fracture a year later was not a surprise.

In view of a reported correlation between dental fluorosis and the frequency of bone fractures in adults and children,[20] consideration of a possible relationship between fluoridation and tooth fracture is prudent. Fluoride alters the chemical composition and the physical and mechanical characteristics of teeth. Evaluating dentin with ultrasound, Vieira concluded that dentin fluoride is an indicator of dentin structural properties.[21] Ultrasound is an assessment tool for determining bone and tooth fragility and consequence of fracture.

In the dental literature, cusp fracture rates of 2.0%, 4.4%, and 7% per year have been reported for posterior teeth. In the Netherlands, not fluoridated for about 35 years, a recent study found 2.0% per year (20.5 per 1,000 person-years) posterior

cusp fracture rate.[22] A preliminary report of complete cusp fractures in non-fluoridated Portland, Oregon (19% CWF state wide) found a posterior cusp fracture rate of 4.4%.[23] A third study in highly fluoridated North Carolina (85% CWF state wide) found a 7% posterior cusp fracture rate.[24]

Photograph Dr Ray Voller

Figure 9. Fractured mesial lingual cusp.

Photograph Dr Ray Voller

Figure 10. Loose fractured cusp removed.

Although the North Carolina and Netherlands studies should not be directly compared, they merit comparative examination. The North Carolina study was a relatively closed private paid HMO panel, while the Netherlands's nationally funded dental payment is similar but more inclusive. It is possible that the fluoridated North Carolina subjects with more tooth fractures had larger dental restorations, lower socioeconomics, poorer diet and hygiene. However, larger restorations in fluoridated North Carolina would not support the effectiveness of fluoridation. Obviously, further studies are needed to clarify what effect fluoride might have on the incidence and etiology of decay and fractured teeth.

In conclusion, after decades of public health intervention with water fluoridation, the lack of evidence showing community effectiveness for reducing dental caries, along with the known and reasonably suspected fluoride damage to teeth, is reason enough to reconsider fluoridation. The lack of lower dental costs in fluoridated areas could be explained, in part, by such difficulties as diagnosing the "fluoride bomb", increased tooth fractures, dental fluorosis repairs, or simply attributing a decline in tooth decay to fluoride rather than the effects of socioeconomics. For these as well as other reasons, support for fluoridation has

waned, and today many professional dental organizations no longer recommend the ingestion of fluoride supplements.[25]

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