fluoride SCIENCE

CRITICAL REVIEW & ANALYSIS

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PUBLICATION

Cheng KK, Chalmers I, Sheldon TA. Adding fluoride to water supplies. *BMJ.* 2007;335(7622):699-702.

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ABSTRACT

The article written by Cheng, Chalmers and Sheldon outlines issues for discussion that are useful when communities are considering policy related to water fluoridation in the United Kingdom. However, it is not useful for discussion of water fluoridation in the United States as it does not consider the substantial body of research conducted on water fluoridation in the United States. The authors' review of the study cited to show potential harm appears erroneous and incomplete.

FRAMEWORK FOR CONSTRUCTIVE DISCOURSE

This paper is written for the United Kingdom (UK). Since the 2003 Water Act in the UK, water companies are required to add fluoride to supplies when requested – after public consultation – by a health authority in England or the Welsh Assembly in Wales. This paper outlines issues for discussion that are useful when communities are considering policy related to water fluoridation in the UK. The article by Cheng, Chalmers and Sheldon gives the public in the United States a superficial and incomplete perspective on the substantial body of research that has been conducted on water fluoridation.[1]

In this critique we present the framework that the authors developed and analyze the issues they raised from the context of the United States. The framework as laid out by Cheng, Chalmers and Sheldon is outlined below.[1]

A. Known benefits of adding fluoride to drinking water
B. Potential harms of fluoride
C. Alternatives to prevent caries (tooth decay)
D. Is fluoride a medicine?
E. Ethical implications
F. Trust in the dissemination of evidence

Within each of these headings the authors raise concerns about fluoridation – potential benefits of fluoridation, difficulty of identifying

> To impose a narrow research model from clinical medicine (RCT) as the basis of evidence in public health will never be accepted among public health researchers and public health professionals – and not in this journal. With this editorial we raise a tombstone over the RCT fanatics with the inscription: Give peace to the fanatics – but let them stay in their grave and not disturb a sound and broad evidence-based development in public health."
> - Kamper-Jørgensen[12]

harms, whether fluoride is a medicine, and the ethics of a mass intervention as controversies. Our purpose here is to examine the veracity of the evidence they cite to support their arguments. We limit our comments to the first three issues since questions raised regarding philosophical and ethical aspects are unique to the situation in the UK and US courts have repeatedly ruled that fluoride, in water, is not a medicine.

A. Known benefits of adding fluoride to drinking water

The authors express uncertainty about known benefits of adding fluoride to water. Figure 2 is used to illustrate that the average number of decayed, missing, and filled teeth in 12 year-old children, for several European countries, has fallen greatly in the past three decades and this trend has occurred regardless of the concentration of fluoride in water or the use of fluoridated salt, and it probably reflects use of fluoridated toothpastes and other factors, including perhaps aspects of nutrition.

This figure may be used to suggest a declining trend in dental caries but is insufficient to assess the role of fluoridation for the following reasons:

WHO Oral Health Database is not ideal for assessing the benefits of water fluoridation.

1. Many interventions and individual actions may explain the decline in dental caries. In determining the suitability of a public health program to a particular country, the question is not only whether a particular intervention worked or not, rather, it is the return on investment, reach and long term sustainability of a program that should be considered. Each country selects intervention(s) to control dental caries based on its unique needs and resources. European countries have different health care systems along with their own approach to controlling diseases (different ways of finance and services offered to the population, for example), thus making it harder to compare their performance.[2]
2. Unlike what is depicted in the figure, the decrease wasn't linear and uniform in all countries. Figure 1 below is the reproduction of the graph (Figure 2) using the information from the WHO database. While the WHO database is incomplete with gaps between data points, the published figure appears to have been given the impression of systematically collected data every 5 years showing a declining trend.

Figure 1: Data from WHO Database

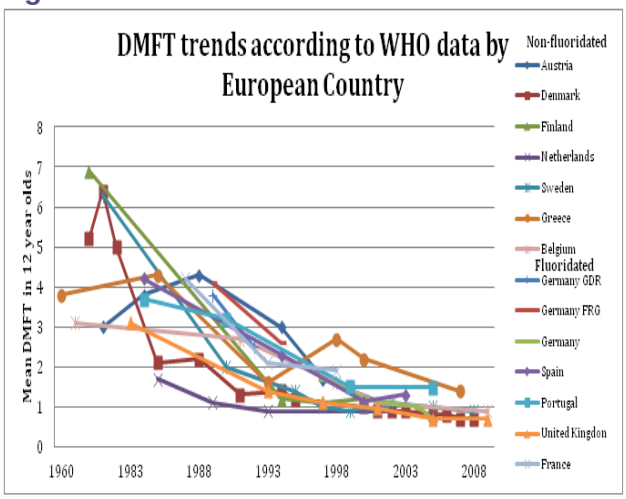
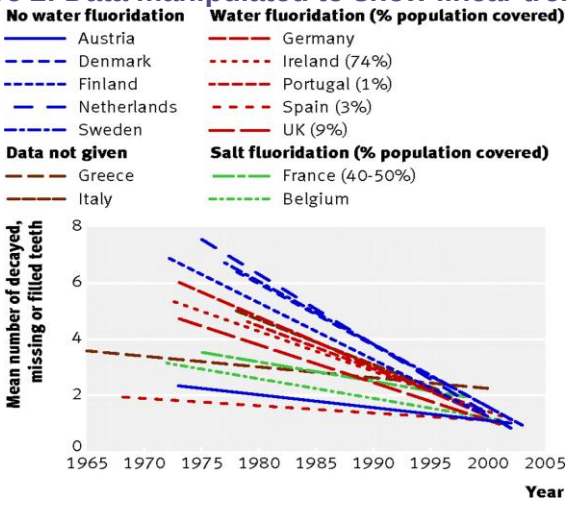


Figure 2: Data manipulated to show linear trend



Graphs created to depict declining trends in tooth decay

Figure 1. Source: Data from the World Health Organization database. Available at http://www.mah.se/CAPP/Country-Oral-Health-Profiles/ ;
Figure 2: Source: Cheng, KK, Chalmers, I, Sheldon, TA. Adding Fluoride to water supplies. *BMJ*; 2007;335(7622):699-702.

3. More importantly, Cheng et al. fail to note that although dental caries has declined in several countries, data confirms that the degree of this decline differs between fluoridated and non fluoridated areas in countries where such a comparison has been made. For example, Figure 3 below shows the mean DMFT trends in Ireland by water fluoridation status. Although both fluoridated and non-fluoridated areas experienced a decline in the mean DMFT from 1984 to 2002, the mean number of decayed, missing or filled teeth was lower in fluoridated areas (2.6 to 1.1) than in non-fluoridated areas (3.3 to 1.8). [3]

In Denmark, where community water fluoridation is not practiced, dental caries prevalence has declined. However, it is worth noting the relationship between the risk of dental caries in this nation and the fluoride

concentration in drinking water— in spite of the extensive use of fluoridated toothpaste and caries-preventive programs that are implemented by Denmark's municipal dental services. Fluoride concentration in drinking water varies considerably within the country from very low (<0.10 mg⁄l) to more than 1.5 mg⁄L. Thus, it was possible to assess the risk of dental caries at different levels of fluoride. Caries risk was reduced by approximately 50% where fluoride exposure was 1mg/L or higher.

Figure 3: Mean DMFT 12 Year olds in Ireland by Water Fluoridation Status

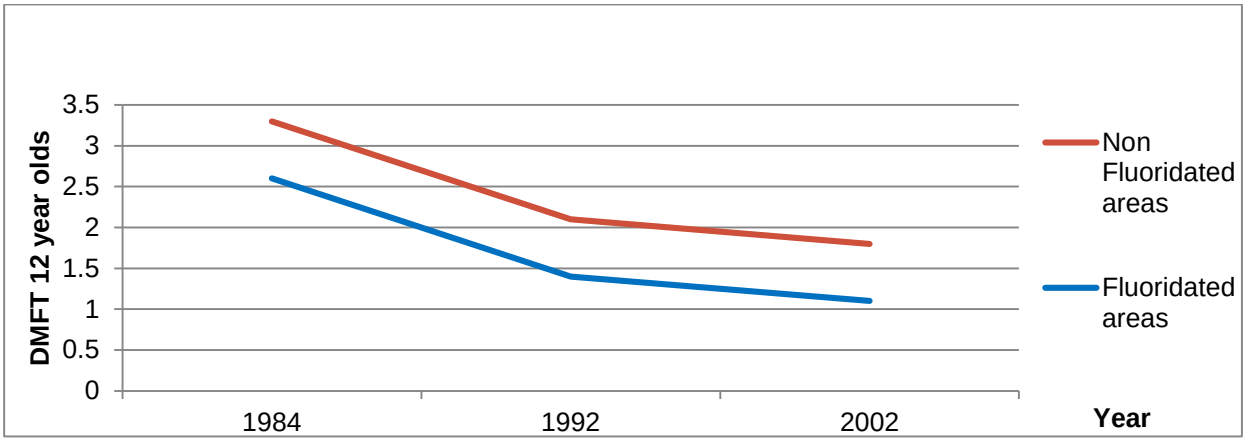


Figure 3: Data from the World Health Organization database. Available at http://www.mah.se/CAPP/Country-Oral-Health-Profiles/

Figure 4 shows how the natural fluoride concentration in drinking water may influence the reduction in the odds of having a tooth surface decayed, missing, or filled due to caries (DMFS) in 15-year-old Danish children. This caries reduction was also consistent in younger children (5 year-olds) even after adjusting for gender and family income.[6] The risk of caries was lowest for Danish children who lived in areas in which the natural fluoride level was similar to the concentrations used to fluoridate public water systems in the U.S.

Figure 4: Reduction in Caries Risk (OR) among 15-year-olds and drinking water fluoride concentration in Denmark

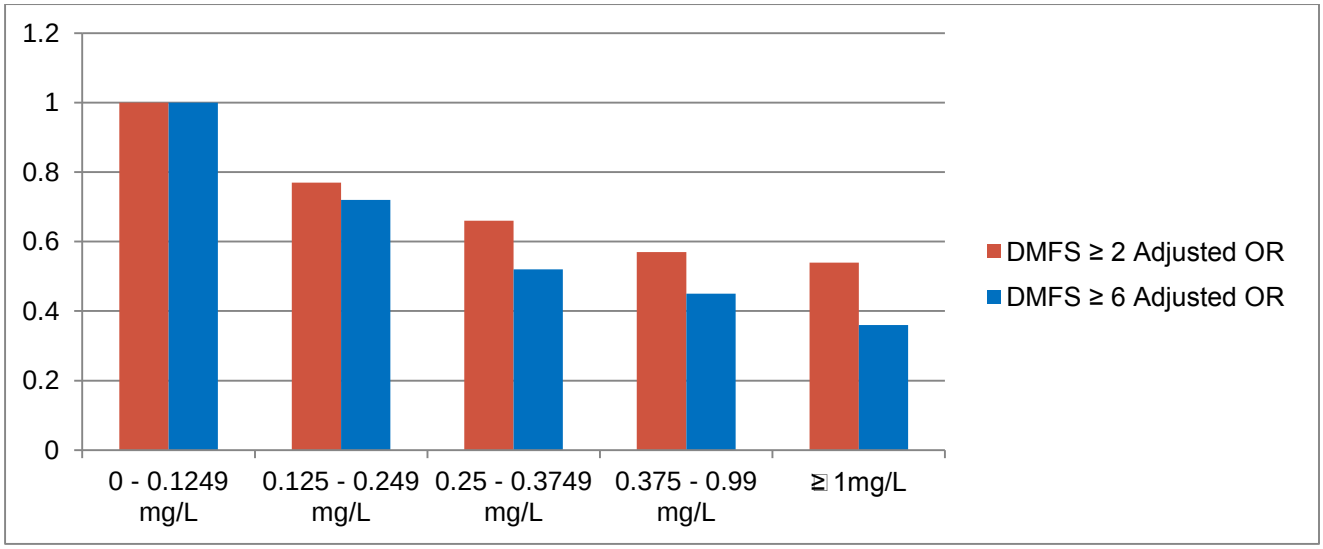


Figure 4. Odds ratio (OR) based on data from Kirkeskov L, Kristiansen E, Bøggild H, Platen-Hallermund F, Sckerl H, Carlsen A, Larsen MJ, Poulsen S. The association between fluoride in drinking water and dental caries in Danish children. Linking data from health registers, environmental registers and administrative registers. *Community Dent Oral Epidemiol*. 2010;38:206–12.[4]

Systematic Reviews of Fluoridation

Cheng et al. cite a systematic review conducted by the centre for reviews and dissemination at the University of York to express reviewers' surprise over the poor quality of the evidence and the uncertainty surrounding the beneficial and adverse effects of fluoridation. [5]

However, it's worth noting that the University of York systematic review was selective and didn't include all available studies. In fact, nearly 3,000 studies were excluded – only the studies that met the authors' inclusion criteria were included. The authors of the University of York review only included studies where two points in time were evaluated in a study where one of the groups had changed the water fluoridation status in the past one year, leaving out several studies done in communities already served by water fluoridation. [5]

For example, a large longitudinal study of 20,052 children conducted in the United States by Klein et al. (1985), showed that after implementing several classroom and school-based clinical interventions in fluoridated and non-fluoridated communities (education, brushing, flossing, professionally applied topical fluoride, fluoride rinses, sealants etc.), only dental sealants and community water fluoridation were found to significantly reduce tooth decay, with the latter being the most cost-effective approach.[6]

In the United States, The Community Preventive Services Task Force (Task Force), an independent, nonfederal body uses systematic reviews of interventions conducted by specialist teams in many topic areas to learn what works to promote public health. The Task Force uses the results of these reviews to issue evidence-based recommendations and findings to the public health community. The Task Force reviewed research and, based on the quality of the methodology and design, determined that 21 studies qualified for inclusion in its review. In turn, the Task Force's review revealed that community water fluoridation reduced tooth decay by a median of 29.1% among children ages 4 to 17 years.[7] Based on the rules of evidence established by the Task Force, it recommends community water fluoridation based on **strong evidence of effectiveness** in reducing tooth decay.

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B. Potential harms of fluoride

Cheng et al. argue that "small relative increases in risk are difficult to estimate reliably by epidemiological studies, even though lifetime exposure of the whole population may have large population effects". [1] In support of this, they cite an ecological study from Taiwan that purportedly found a higher incidence of bladder cancer in women in areas of naturally occurring fluoride. [8] Therefore, the authors contend that such a small increase in risk would mean about 2000 extra new cases of bladder cancer a year if the entire UK population was exposed to fluoridation. While small relative increases in risk associated with long-term exposure could have a large population effect, the authors fail to acknowledge that a weak association observed in an ecologic study needs further evidence to be identified as casual.

The article by Yang et al. found that the ratio of age-adjusted mortality rate (SRR) among females in naturally fluoridated water municipalities (fluoride concentration of 0.25 mg/L categorized as high) to those in unfluoridated municipalities (fluoride concentration of <0.1 mg/L categorized as low) was 2.79 [95% CI 1.41 to 5.55]. For males, however it was not statistically significant [1.27 (95% CI 0.75 to 2.15)]. [8] Yang et al. concluded that this seemed biologically implausible for fluoride to affect cancer rates for one sex only. Therefore, they concluded that the study did not provide any evidence that fluoridation of the water supplies was associated with an increase in cancer mortality in Taiwan.

The weaker the association between exposure and outcome, the less likely it is that the association is causal.

Cheng et al. however, used the mortality data from this study to calculate excess new cancer cases, ignoring the serious limitations of the Taiwan study—problems that even the authors of this study acknowledge.[8] First, it is scientifically unsound to use mortality statistics to derive incidence data of bladder cancers. This principle is firmly recognized by epidemiologists. Second, the concentration of 0.25 mg/L of fluoride is not high and the difference between 0.25

mg/L and <0.1 mg/L is within the detectable level for fluoride. Third, the study is ecological in nature and hence the study design is too weak to draw any conclusions about causality. Fourth, the association was found only in females and not in males in a study where multiple comparisons were made. Fifth, confounders for bladder cancer, such as smoking, were not assessed. Cheng et al., could have used another example like the development of severe dental fluorosis to illustrate their concern but their use of bladder cancer mortality data is both scientifically indefensible and misleading.

C. Alternative ways to prevent caries

Use of toothpastes containing fluoride has strong evidence to prevent caries in randomized clinical trials but compliance is required to have a population impact, and therefore the two interventions are not equivalent.

The evidence from systematic reviews of 70 randomized clinical trials (RCT) that included 42,300 children is often cited as strong evidence for alternative ways of preventing caries–mainly toothpastes containing fluorides. The preventive fraction for decayed, missing, or filled teeth of 24% (21% to 28%) observed in the clinical trials. These findings may not translate to effectiveness in the population as the conditions under which they are tested are different from more realistic "real world" conditions.[9] The authors acknowledge this by stating that the use of toothpaste depends on individual behavior, which has implications for reducing disparities in health outcomes that are generally worse in low SES and underprivileged groups.

This debate on the quality of evidence supporting water fluoridation and toothpastes has created the impression that an intervention based on randomized clinical trials is superior. However, the experience in Puerto Rico provides weak support for relying solely on results of randomized clinical trials to reduce the disease at the population level. The following table based on artificial data illustrates the ultimate impact of a highly efficacious magic pill that was hypothesized to reduce cavities by 90% in a group of 1000 children assuming that each child was developing one cavity per year.

Table 1: Assumption: Percent and Number of cavities prevented from a clinical trial are 90% and 900 cavities, respectively.

Factors affecting the impact of a magic pill	Compliance %	Cavities Prevented in 1000 children
Efficacy from a Randomized Clinical Trial	90%	900
Percent of physicians and dentists who are willing to prescribe the pill	90%	810
Percent of parents who are willing to fill the prescription every 3 months	80%	648
Percent of parents who give the pill on a daily basis	90%	583
Percent of children who are willing to follow the instructions for a long time	80%	467
A pill shown to be 90% efficacious in an RCT study will only be 46.7% effective (467 cavities prevented out of 1000) when implemented as a program.		

Table1: Source: Adapted from Lawrence W. Green. A CDC Workshop on PRECEDE-PROCEED & RE RE-AIM as Frameworks for Practice-Based Planning and Evaluation. Atlanta, October 24, 2007.

The experience from Puerto Rico, a territory in the United States is a case in point. Although fluoride containing toothpastes are available in Puerto Rico, it is one of the Western Nations with the highest caries prevalence (81%) with a mean 3.8 DMFT for 12 year olds, much higher than in the Continental United States.[10] Puerto Rico does not have water fluoridation and individual level interventions, i.e., brushing with fluoridated toothpaste has had minimal impact in reducing caries.[11] Furthermore, in Puerto Rico, even under the rigorous conditions of a trial with more than double the concentration fluoride, where frequency of brushing, amount of toothpaste used, and other factors were controlled, a study found only marginal effect with children developing almost 2 new DMFS per year.[11] A lesson from studies like this is that while RCTs provide strong evidence of efficacy, they do not necessarily translate to public health impact.

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