Water fluoridation: Suggested issues for consideration

Kathleen M. Thiessen, Ph.D.
December 13, 2006

This document provides several comments intended for readers who are considering or conducting a review of the data on the hazards and benefits of community water fluoridation. Some of the items discussed below pertain to the recent National Research Council report (NRC 2006) on the toxicology of fluoride in drinking water, of which I was one of the authors. Others represent my personal and professional experience in reviewing a substantial amount of the literature on fluoride.

(1) Importance of a review of water fluoridation. According to the Centers for Disease Control[1], approximately two-thirds of people on public water supplies in the US receive fluoridated water, or more than 160 million people. In some states, more than 90% of those served by public water supplies receive fluoridated water.

(2) Scope of the NRC report. The NRC committee was asked to review the adequacy of EPA's Maximum Contaminant Level Goal (MCLG[2]) of 4 mg/L fluoride in drinking water and the corresponding Secondary Maximum Contaminant Level (SMCL) of 2 mg/L. The committee concluded that those regulatory limits are not protective of public health. The committee was not asked to review the safety of so-called "optimal" concentrations of fluoride in drinking water (0.7-1.2 mg/L, as used in deliberate fluoridation of public drinking water supplies), although much of the report is relevant to such a review (discussed further below). In addition, the committee was not asked to review the efficacy or reported benefits of fluoridation, on the basis of which community water fluoridation was instituted. The committee also did not review in any detail either the history or the politics of water fluoridation.

(3) Relevance of the NRC report to water fluoridation. Although the NRC report did not examine the safety, efficacy, or benefits of water fluoridation, or specifically evaluate the toxic effects of "optimal" levels of water fluoride on humans, the committee did examine a number of issues that are relevant to such evaluations. In particular, the committee did an extremely thorough review of fluoride intake in the US, by age group, considering all sources of fluoride intake (water, dentifrices, food, air, soil, pesticides, pharmaceuticals), including fluoridated drinking water. In addition, the committee looked specifically at population subgroups of special concern, for example, due to very high water consumption or to impaired fluoride excretion. A number of the toxicity studies that the committee reviewed involved fluoridated water or exposures equivalent to those expected with fluoridated water.

---

[1] http://apps.nccd.cdc.gov/nohss/FluoridationV.asp; http://www.cdc.gov/OralHealth/factsheets/fl-stats-us2000.htm.

[2] The MCLG is defined as "A non-enforceable health goal which is set at a level at which no known or anticipated adverse effect on the health of persons occurs and which allows an adequate margin of safety" (EPA 2004).

(4) History and politics of water fluoridation. Suggested reading includes *The Fluoride Deception* by Christopher Bryson (Seven Stories Press, 2004) and papers by Nesin (1956), Wollan (1968), Marier (1977), Hileman (1988), Colquhoun (1997), Cross and Carton (2003), and Ananian et al. (2006). In addition, there have been recent statements by the Centers for Disease Control and Prevention[3], the American Dental Association[4], and the American Water Works Association[5], to the effect that the NRC report did not question the established safety and benefits of water fluoridation, and that the levels found not to be protective of human health are substantially higher than those encountered with water fluoridation and therefore are not of concern. In another context, the American Dental Association has acknowledged the relevance of the NRC report to the issue of fluoridation[6] (see below).

(5) Recent statement from the American Dental Association. The ADA has recently posted a position statement to the effect that infant formula should not be prepared with fluoridated water (due to the risk of dental fluorosis), although, according to the same statement, fluoridated water is still a very valuable and beneficial "strategy." In other words, drinking water should be fluoridated, but part of the population should not consume it, an attitude not entirely in keeping with the idea of protecting all members of the population, especially the most vulnerable. It is also worth noting that adherence to the ADA's position statement would require parents to spend money on alternative water for their children. A recent paper (Hong et al. 2006) reports that fluoride intakes during the second, third, and fourth years of life are also important with respect to development of dental fluorosis, not just the first year. The mean fluoride intakes associated with dental fluorosis in that study are in the range expected with fluoridated water.

(6) Benefits of water fluoridation. The ADA, CDC, and others promote the benefits of water fluoridation as being well established, substantial, and especially important for reducing socioeconomic disparities among populations (i.e., making up for differences in

---

[3] The NRC report deals only with "the safety of high levels of fluoride in water that occur naturally, and does not question the use of lower levels of fluoride to prevent tooth decay" and is "consistent with CDC's assessment that water is safe and healthy at the levels used for water fluoridation (0.7-1.2 mg/L)." [Available at http://www.cdc.gov/fluoridation/safety/nrc_report.htm]

[4] The NRC report "only addresses the levels of naturally occurring fluoride in drinking water that exceed the EPA's current recommendations. The report in no way examines or calls into question the safety of community water fluoridation, which is the process of adding fluoride to public water supplies to reach an optimal level of 0.7-1.2 ppm in order to protect people against tooth decay." [Available at http://www.ada.org/public/media/releases/0603_release02.asp] Also, the NRC report does not question the safety of community water fluoridation, deals only with naturally occurring fluoride in drinking water, and "is limited to a review of the level of naturally occurring fluoride currently recommended in drinking water – a level many (2 to 5) times higher than the level of fluoride used in optimally fluoridated community water systems. Nothing in this report calls into question the optimal levels of 0.7-1.2 parts per million in fluoridated community water systems."
[Available at http://www.ada.org/prof/resources/topics/fluoride_report_response.pdf]

[5] The NRC report addresses only "the increased health risks associated with high levels of fluoride in drinking water, typically from natural sources. The optimal level of fluoride that results from community water fluoridation is far below the level of concern identified in the NRC report." [Available at http://www.awwa.org/Advocacy/pressroom/pr/index.cfm?ArticleID=570]

[6] http://www.ada.org/prof/resources/positions/statements/fluoride_infants.asp

access to dental care, etc.). However, a growing body of information exists that calls these benefits into question. For example, the "York report" (McDonagh et al. 2000a; 2000b), which is widely cited as showing the safety and efficacy of water fluoridation, actually does neither. The report mentions a surprising lack of high quality studies demonstrating benefits, and also finds little evidence that water fluoridation reduces socioeconomic disparities. (See also the letter to the Yorkshire (UK) Post by Professor Trevor Sheldon, who chaired the Advisory Group for the University of York's review[7].) No studies comparing caries rates have accounted for the effects of delayed tooth eruption due to fluoride exposure. Several studies show differences in caries rates with socioeconomic status or dietary factors but not with fluoridation status (e.g., Adair et al. 1999; Hamasha et al. 2006). In addition, a growing body of information (referenced in the NRC report) indicates that any benefit of fluoride to the teeth is derived from topical rather than systemic exposure. In general, the role of diet and general nutrition in good dental health seems to be underappreciated. For example, Cote et al. (2004) have documented a much lower rate of caries experience in refugee children from Africa than in US children or refugee children from Eastern Europe, a situation that the authors attribute more to the amount of sugar in the diet than the presence of fluoride in the water.

(7) Hazards of fluoride exposure. The NRC report concluded that the existing MCLG of 4 mg/L is not protective of human health. This conclusion was based largely on health effects that have long been considered specific to fluoride and significant enough to warrant protection, namely dental fluorosis and skeletal fluorosis. The NRC's review differed from previous reviews of fluoride by saying that severe dental fluorosis is an adverse health effect (not merely a cosmetic effect), that stage II as well as stage III skeletal fluorosis is an adverse health effect, and that a fluoride concentration of 4 mg/L is likely not protective with respect to an increased risk of bone fracture. The NRC report indicated that at 2 or 4 mg/L, bone fluoride concentrations can reach the ranges historically associated with stage II and III skeletal fluorosis. The committee was not able to rule out a carcinogenic effect of fluoride or of "water fluoridation" (i.e., due to some substance added along with an impure fluoridating agent). Nor was the committee able to rule out the possibility that fluoridation is associated with an increased risk of Down syndrome in children of young mothers. The committee also reported that fluoride exposure is plausibly associated with a number of other health effects, including neurotoxicity, gastrointestinal problems, and endocrine problems, and that even though these effects are not necessarily specific to fluoride exposure, the associations cannot be ruled out and need further study.

With respect to dental fluorosis, skeletal fluorosis, and risk of bone fracture, the NRC committee considered primarily studies in which populations were exposed to concentrations of fluoride in drinking water of around 4 mg/L; from those studies the committee concluded that 4 mg/L is not protective of those effects. The committee did not, for any endpoint, determine a "no-effect level," a individual intake level (mg per day of fluoride intake per kg body weight) below which no adverse health effects occur. However, the ranges of intake levels, or estimated average intake levels, associated with a

[7] http://www.yorkshiretoday.co.uk/ViewArticle2.aspx?SectionID=101&ArticleID=1651774

number of adverse effects, are in the range of intakes expected with fluoridated drinking water in the US. Fluoride exposures in the US are driven largely by consumption of drinking water and beverages made with tap water. Water intake for a given age group varies substantially—around a factor of 100 between the highest and lowest consumption rates (discussed in the NRC report). The result of this is that for water fluoride at 1 mg/L vs. water fluoride at 4 mg/L (the "large" difference referred to in the materials quoted earlier from the CDC, ADA, and AWWA), there will be a huge overlap between the respective populations, with apparent differences only at the very highest water intakes. In other words, any effect seen at 4 mg/L is probably going to occur in some people at 1 mg/L (e.g., in the people with highest water consumption or in people with impaired fluoride excretion), but this might easily be missed in the sample sizes typically used in studies.

(8) Difficulties in exposure characterization. Difficulties in exposure characterization affect most of the studies, whether of the benefits or the hazards of fluoride. Many studies are simply "ecological" studies—populations are grouped by their location or their water fluoride concentration, not by individual fluoride intakes. As discussed above, there will generally be large overlaps between the individual exposures of these populations. In addition, there is generally no information on whether the most affected individuals had the highest fluoride intakes or were the most susceptible for some other reason. Also, the exposure characterization should be appropriate for the endpoint examined, for example, current intake for endpoints such as hormone levels, but cumulative intake for endpoints such as skeletal fluorosis or bone fractures. Blood or plasma fluoride levels are generally an indicator of recent or current fluoride intake, not of cumulative fluoride intake or bone fluoride concentrations, but some authors have handled this incorrectly. There is some evidence that fluoride exposure during a critical time period is the determining factor for some endpoints (e.g., around the time of conception for induction of Down syndrome; in the years prior to menopause for bone fracture risk; during specific periods of childhood for pediatric osteosarcoma); for these situations, consideration only of cumulative fluoride exposure or current fluoride exposure (e.g., at the time of diagnosis or study) could miss the relevant information entirely.

(9) Basis for establishing fluoride concentrations in local drinking water supplies. Historically, the local temperature (the "annual average of maximum daily air temperatures" over a minimum of 5 years) has been used as the basis for recommending a given level of fluoride in the drinking water (e.g., CDC 1995). In practice (reviewed by the NRC), there seems to be little difference in water consumption for many people with temperature, season, or location. Obviously, for people with high levels of activity, water consumption can be very high. At present, basketball players or gymnasts, for example, will probably have similar rates of water consumption no matter which state they live in; however, under current guidelines, some of them will have water with 0.7 mg/L fluoride, while others will have water with 1.2 mg/L. Also, most states do not appear to account for temperature variations within a state, such that the water fluoridation levels are the same for the colder and hotter parts of the same state.

(10) Concerns about silicofluorides. A number of issues have been raised concerning the use of silicofluorides as the fluoridating agent in most public water supplies (discussed briefly in the NRC report). These include increased lead in children's blood, increased leaching of lead into water from plumbing fixtures, and the addition of other substances to the drinking water along with the silicofluorides. For instance, the MCLGs for arsenic and lead are 0, based on health risks; however, the actual level permitted (the Maximum Contaminant Level, or MCL) is above 0 (to account for difficulty in removing it or in measuring it). However, in the addition of the impure silicofluorides to drinking water, some arsenic and lead are generally added as well, although the resulting concentration must stay below the MCL. Given that the MCLGs are 0, the obvious question is whether knowingly adding any amount, however tiny, is appropriate.

(11) Bias or double standards in the literature or reviews of the literature. Much of the available literature (or interpretations of the literature) shows evidence of bias or double standards. For example, many reviews seem to require a much higher standard of evidence for any harmful effects of fluoride than for the benefits. In fact, as discussed in the York review, the studies of benefits are no better than many of the studies of harmful effects. Some animal studies report that the effects occurred only at levels of exposure vastly in excess of those that humans encounter from drinking water. However, in many cases, similar effects are also found in humans, at the lower levels of exposure. The real point is that rats and mice seem to need at least 5-10 times higher exposures to achieve a given effect or a given blood or bone fluoride concentration than do humans. In other words, humans appear to be at least 5-10 times more sensitive than rats. One important set of early studies, the Bartlett/Cameron studies, compared a high-fluoride town with a low-fluoride town. However, most of the papers make light of (or in some cases, fail to mention) the fact that the high-fluoride town was defluoridated approximately 1 1/2 years before the end of the study. (There are some other significant findings in those studies and in the Kingston/Newburgh studies that have been generally ignored or downplayed.)

(12) Costs of fluoridating vs. not fluoridating. Various estimates exist for the actual costs of fluoridating vs. not fluoridating; many of these indicate that fluoridation will cost a small number of dollars per person per year, while saving many dollars per person in dental expenses. However, the true costs are probably not being fully considered. The costs of fluoridation should include not just the costs of equipment and chemicals (and protective gear for the workers), but also the costs of lobbying and promoting fluoridation, the costs of treating and repairing dental fluorosis, the costs of health effects (e.g., broken hips) on members of the population, and the cost of obtaining low-fluoride water for bottle-fed infants or for others who prefer to avoid fluoride.

References

Adair, S.M., C.M. Hanes, C.M. Russell, and G.M. Whitford. 1999. Dental caries and fluorosis among children in a rural Georgia area. Pediatr. Dent. 21(2):81-85.

Ananian, A., B.H. Solomowitz, and I.A. Dowrich. 2006. Fluoride: A controversy revisited. New York State Dental Journal April/May 2006: 14-18.

CDC (Centers for Disease Control and Prevention). 1995. Engineering and Administrative Recommendations for Water Fluoridation, 1995. Morbidity and Mortality Weekly Report, Recommendations and Reports 44(RR-13). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention.

Colquhoun, J. 1997. Why I changed my mind about water fluoridation. Perspect. Biol. Med. 41(1):29-44.

Cote, S., P. Geltman, M. Nunn, K. Lituri, M. Henshaw, and R.I. Garcia. 2004. Dental caries of refugee children compared with US children. Pediatrics 114:e733–e740. [Available at www.pediatrics.org/cgi/doi/10.1542/peds.2004-049]

Cross, D.W., and R.J. Carton. 2003. Fluoridation: A violation of medical ethics and human rights. Int. J. Occup. Environ. Health 9(1):24-29.

EPA (U.S. Environmental Protection Agency). 2004. 2004 Edition of the Drinking Water Standards and Health Advisories. Washington, DC: U.S. Environmental Protection Agency, Office of Water, EPA 822-R-04-005. [Available at http://www.epa.gov/waterscience/criteria/drinking/standards/dwstandards.pdf]

Hamasha, A.A., J.J. Warren, S.M. Levy, B. Broffitt, and M.J. Kanellis. 2006. Oral health behaviors of children in low and high socioeconomic status families. Pediatr. Dent. 28(4):310-315.

Hileman, B. 1988. Fluoridation of water: Questions about health risks and benefits remain after more than 40 years. Chem. Eng. News (August 1):26-42.

Hong, L., S.M. Levy, B. Broffitt, J.J. Warren, M.J. Kanellis, J.S. Wefel, and D.V. Dawson. 2006. Timing of fluoride intake in relation to development of fluorosis on maxillary central incisors. Community Dent. Oral Epidemiol. 34:299-309.

Marier, J.R. 1977. Some current aspects of environmental fluoride. Sci. Total Environ. 8(3):253-265.

McDonagh, M., P. Whiting, M. Bradley, J. Cooper, A. Sutton, I. Chestnutt, K. Misso, P. Wilson, E. Treasure, and J. Kleijnen. 2000a. A Systematic Review of Public Water Fluoridation. NHS Centre for Reviews and Dissemination, University of York, York,

UK.

McDonagh, M.S., P.F. Whiting, P.M. Wilson, A.J. Sutton, I. Chestnutt, J. Cooper, K. Misso, M. Bradley, E. Treasure, and J. Kleijnen. 2000b. Systematic review of water fluoridation. Br. Med. J. 321(7265):855-859.

Nesin, B.C. 1956. A water supply perspective of the fluoridation discussion. J. Maine Water Util. Assoc. 32:33-47.

NRC (National Research Council). 2006. Fluoride in Drinking Water: A Scientific Review of EPA's Standards. Washington, DC: The National Academies Press. [Available at http://www.nap.edu/catalog/11571.html]

Wollan, M. 1968. Controlling the potential hazards of government-sponsored technology. George Wash. Law Rev. 36(5):1105-1137.

Kathleen M. Thiessen, Ph.D.
SENES Oak Ridge, Inc., Center for Risk Analysis
102 Donner Drive, Oak Ridge, TN 37830 USA
Tel.: (865) 483-6111
Fax: (865) 481-0060
E-mail: kmt@senes.com

(revised December 22, 2006)