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COMMENTARY -- ADDING FLUORIDE TO DRINKING WATER: A GOOD IDEA?

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Seeking to prevent tooth decay, many U.S. communities add fluoride to public drinking water, usually in the form of hydrofluorosilicic acid, which is a waste product of the phosphate fertilizer industry.

From the beginning, the practice was controversial, but the Centers for Disease Control and Prevention (CDC) and American Dental Association (ADA) have vigorously supported it. The CDC claims that fluoridating public drinking water is one of the ten great public health achievements of the 20th century, giving it primary credit for the decline in tooth decay in the U.S. Despite their enthusiasm, abundant evidence raises serious concerns about the safety and efficacy of adding fluoride to drinking water today.

Since 1945, when the public health intervention began, much has changed with regard to dental health. Several trends are worth mentioning:

* Tooth decay has markedly declined in countries and communities that do not fluoridate drinking water as well as in those that do. Dramatic increases in the use of topically-applied fluoride-containing oral hygiene products are likely to have played a role, along with other changes.

* Today people are exposed to fluoride from bottled drinks, toothpaste, fluoride drops and treatments, pesticides, pharmaceuticals, and industrial discharges. As a result, dental fluorosis, a condition entirely attributable to excessive fluoride intake, is increasing in a substantial portion of the U.S. population.[1]

* A somewhat surprising trend that may increase risks associated with fluoride ingestion involves dietary iodine. In recent years, inadequate iodine intake has become common in the U.S. According to the CDC, the average urinary iodine level today is half what it was in 1971.[2] The agency estimates that 36% of U.S. women now have sub- optimal iodine intake. Adequate dietary iodine is essential for producing normal amounts of thyroid hormone. Excessive dietary fluoride can also lower thyroid hormone production. Excess fluoride and inadequate iodine intake combined increase risks of hypothyroidism.

Much research addresses the potential benefits and adverse impacts of fluoride ingestion. Yet, many data gaps remain. We know that:

* Tooth decay is an infectious process and its origins are multifactorial. General dietary

practices, nutrition, oral hygiene, socioeconomic status, and access to dental care play direct and indirect roles. The relative contribution of each depends on the context.

* To the extent that fluoride helps to prevent tooth decay or slow its progression, the predominant advantage is from topical application rather than through ingestion.[3] Topical application includes fluoride in toothpaste, drops, mouth rinses, and fluoride treatments in a dental office, as well as from drinking fluoride-containing beverages.

* There is little disagreement that ingested fluoride has adverse effects as exposures increase beyond some amount.[4] The question is, at what level of exposure do adverse effects begin and when do they begin to outweigh any potential benefits?

* Individuals drinking water with "optimal" fluoride[5] have, on average, less than one fewer missing, decayed, or filled tooth surface than individuals whose drinking water does not have added fluoride.[6] With respect to prevention of tooth decay, therefore, the benefits of fluoride in drinking water are relatively minor. That is not to say that tooth decay has not declined during the last 50 years (it has), or that fluoride has not contributed (it has, but primarily through topical application from many sources), but rather that putting fluoride in drinking water today plays a relatively minor role when compared to other variables.

* Excessive fluoride ingestion from all sources causes dental fluorosis. This is not "just" a cosmetic effect. Dental fluorosis interferes with the integrity of tooth enamel. Many experts conclude that moderate and severe fluorosis can increase the risk of tooth decay. Severe dental fluorosis rises sharply when drinking water levels of fluoride exceed 2 ppm [parts per million].

Depending on the level of exposure, a number of adverse health effects may be linked to fluoride ingestion. In humans, they include bone cancer, bone fracture, skeletal fluorosis, arthritis, impaired thyroid hormone status, impaired neurodevelopment of children, and calcification of the pineal gland. Data are often inconsistent and important information gaps remain. In general, the threshold exposure level at which the risks of various health effects significantly increase is not well understood.

In 2006, an expert committee convened by the National Academy of Sciences issued a report reviewing the appropriateness of the U.S. Environmental Protection Agency's current maximum contaminant level for fluoride in drinking water. The NAS committee concluded:

1) "under certain conditions fluoride can weaken bone and increase the risk of fracture;"

2) "high concentrations of fluoride exposure might be associated with alterations in reproductive hormones, effects on fertility, and developmental outcomes, but [study] design limitations make those studies insufficient for risk evaluation,"

3) "the consistency of results [in a few epidemiologic studies in China] appears significant enough to warrant additional research on the effects of fluoride on intelligence"

4) "the chief endocrine effects of fluoride exposures in experimental animals and in humans

include decreased thyroid function, increased calcitonin activity, increased parathyroid hormone activity, secondary hyperparathyroidism, impaired glucose tolerance, and possible effects on timing of sexual maturity. Some of these effects are associated with fluoride intake that is achievable at fluoride concentrations in drinking water of 4 mg/L [milligrams per liter] or less, especially for young children or for individuals with high water intake."

5) "the evidence on the potential of fluoride to initiate or promote cancers, particularly of the bone, is tentative and mixed. Assessing whether fluoride constitutes a risk factor for osteosarcoma is complicated by the rarity of the disease and the difficulty of characterizing biologic dose because of the ubiquity of population exposure to fluoride and the difficulty of acquiring bone samples in non-affected individuals." The committee said that a soon-to-be published study "will be an important addition to the fluoride database, because it will have exposure information on residence histories, water consumption, and assays of bone and toenails. The results of that study should help to identify what future research will be most useful in elucidating fluoride's carcinogenic potential."

That study has now been published. It reports a significant association between exposure to fluoride in drinking water in childhood and the incidence of osteosarcoma among males.[7]

Risks are not limited to humans. Fluoride added to drinking water ultimately ends up in surface water where levels can be high enough to threaten survival and reproduction of aquatic organisms, particularly near the point of discharge.[8]

One health endpoint, the potential impact of fluoride on brain development, illustrates the importance of considering the context of public health interventions:

* We know that adequate thyroid hormone levels are essential during pregnancy (fetal requirement), infancy, and childhood for normal brain development. Even relatively minor deficits in maternal thyroid hormone levels during pregnancy can have long lasting impacts on the function of children's brains.[9]

* Excessive fluoride ingestion lowers thyroid hormone levels.[10] The threshold at which that effect becomes biologically or clinically important is uncertain. But we know that it happens in areas with high naturally-occurring fluoride in drinking water, and it may also be true in areas with fluoride in drinking water in the range of 1-2 ppm, particularly when iodine intake is inadequate.

* Several studies of children in Chinese communities with fluoride drinking water levels of 2.5-4 ppm consistently show significantly lower IQ levels compared to children in communities with minimal fluoride in drinking water.[11] These studies were controlled for other contributory factors.

* Based on biomonitoring studies, the CDC estimates that 36% of women in the U.S. have inadequate iodine intake. Moreover, approximately 6-7% of women (the prevalence increases as women age) have sub- clinical hypothyroidism. Sub-clinical hypothyroidism is characterized by elevated thyroid stimulating hormone (TSH) and normal thyrotropin (the thyroid hormone T4).

Without blood tests, sub-clinical hypothyroidism is usually unrecognized because it does not cause symptoms. Sub-clinical hypothyroidism during pregnancy is associated with decreased IQ in children when measured years later.[12]

* Biomonitoring studies conducted by the CDC (NHANES) and other institutions show virtually ubiquitous human exposure to other environmental contaminants that also interfere with thyroid hormone levels or function. They include polychlorinated biphenyls (PCBs), brominated flame retardants, perfluorinated compounds, and perchlorate (a common drinking water and food contaminant from rocket fuel, explosives, and imported nitrate fertilizer). In 2006 CDC scientists reported that ANY amount of perchlorate exposure significantly lowered thyroid hormone levels in women with inadequate iodine intake.[13]

* Few, if any, communities choosing to add fluoride to drinking water are likely to have looked into the iodine status of local residents as well as aggregate exposures to thyroid disrupting compounds, including fluoride, from all sources combined. Yet, collectively, these factors are undeniably relevant to brain development of children born in those communities. Regrettably, the CDC's discussion of the safety of fluoride in drinking water does not even mention potential impacts on the developing brain.[14]

With respect to current and historical perspectives, the NAS committee noted that, on average, fluoride exposure from drinking water in fluoridated communities is near or exceeds the level that raises health concerns.[15] That is, virtually no "margin of safety" exists between levels of fluoride intended to be beneficial and those that may be harmful. This is in sharp distinction from the margin of safety when essential nutrients such as iodine, vitamin D, or vitamin C are added to food. In those cases, maximum potential intake is orders of magnitude lower than exposures that may have toxic effects. Population-wide monitoring of fluoride exposures in the U.S. is surprisingly inadequate. This is particularly disturbing since, despite vigorously recommending putting fluoride into drinking water, the CDC has failed to monitor systematically the levels of fluoride in the population -- despite steadily increasingly sources of fluoride, increasing dental fluorosis, and their well-known and highly useful population-wide monitoring program for a number of other environmental agents (NHANES). Why not fluoride? The NAS review said, "Fluoride should be included in nationwide biomonitoring surveys and nutritional studies... In particular, analysis of fluoride in blood and urine samples taken in these surveys would be valuable."

Conclusions:

Because of

a) uncertainties surrounding fluoride exposure levels from all sources,[16]

b) concurrent exposures to other environmental agents that interact with fluoride or add to the impacts of fluoride,

c) estimates of efficacy and benefits of adding fluoride to drinking water compared with alternative interventions, and

d) potential adverse health effects at current and anticipated exposure levels,

** intentionally fluoridating community drinking water is no longer justified. Adding fluoride to drinking water for the purpose of preventing tooth decay provides virtually no population-wide margin of safety. Under current circumstances, people should not be essentially forced to drink water treated with fluoride when dental benefits can be achieved through topical application and other means.

** An immediate moratorium on the practice of adding fluoride to community drinking water is justified. Risks, benefits, efficacy, and alternatives must be fully, impartially, and transparently re- evaluated, based on current information and data gaps. Moreover, an ethical review of the practice is warranted.

Public health interventions can take many directions. Few, however, are as intrusive as intentionally putting a biologically active chemical into drinking water. Everyone in the community, without exception, is exposed without any opportunity to "opt out" based on individual circumstances. Promoters of this kind of intervention, therefore, have a special responsibility and should at least:

1) Regularly, comprehensively, and transparently re-evaluate benefits and risks of the intervention, based on current science and available alternatives,

2) Regularly monitor and disclose exposure levels in current contexts/circumstances (in humans and wildlife),

3) Ensure an adequate margin of safety, including for the most vulnerable, and

4) Consider the ethical dimensions of intentionally adding a biologically active chemical to public drinking water.

In 2006, the American Dental Association issued an interim guidance advising parents not to reconstitute infant formula with fluoridated water because of the risk of causing dental fluorosis. In general, however, public health agencies and professional associations that advocate putting fluoride into drinking water have failed to provide up-to-date, regular, comprehensive, and transparent re-evaluations of benefits and risks of fluoridating drinking water, based on the most current science and available alternatives. They have not systematically monitored fluoride levels in people and wildlife, adjusting recommendations according to their findings. Rather, they have continued to stress, and often exaggerate, benefits of ingested fluoride while downplaying the risks. Hopefully, the NAS review will prompt an impartial re-evaluation of the justification, safety, and appropriateness of this 50-year-old practice.

[1] http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5403a1.htm

[2] http://www.cdc.gov/nchs/products/pubs/pubd/hestats/iodine.htm

[3] Discussed in a recent National Academy of Sciences report, "Fluoride in Drinking Water: A Scientific Review of EPA's Standards" (2006) This is a review of the appropriateness of EPA's 4 ppm maximal contaminant level goal for fluoride in drinking water. The committee was not charged with considering the risks and benefits of adding fluoride to drinking water for preventing tooth decay.

The CDC agrees that the benefits of fluoride are primarily from topical application in children and adults. See http://www.cdc.gov/mmwr/preview/mmwrhtml/mm4841a1.htm

[4] NAS review http://books.nap.edu/openbook.php?record_id=11571&page=R1

[5] The CDC considers 0.7-1.2 ppm fluoride in drinking water to be optimal

[6] Brunelle J, Carlos J. Recent trends in dental caries in US children and the effect of water fluoridation. Journal of Dental Research. Vol 69, special issue. 723-727, 1990.

[7] Bassin E, Wypij D, Davis R, Mittleman M. Age-specific fluoride exposure in drinking water and osteosarcoma (United States). Cancer Causes Control. 17(4):421-428, 2006.

[8] Camago J. Fluoride toxicity to aquatic organisms: a review. Chemosphere. 50(3):251-64, 2003.

[9] LaFranchi S, Haddow J, Hollowell J. Is thyroid inadequacy during gestation a risk factor for adverse pregnancy and developmental outcomes? Thyroid. 15(1):60-71, 2005.

[10] Discussed in the NAS review. See http://books.nap.edu/openbook.php?record_id=11571&page=224.

[11] Discussed in the NAS review. See http://books.nap.edu/openbook.php?record_id=11571&page=205.

[12] LaFranchi S, Haddow J, Hollowell J. Is thyroid inadequacy during gestation a risk factor for adverse pregnancy and developmental outcomes? Thyroid. 15(1):60-71, 2005.

[13] Blount B, Pirkle, J, Osterloh J, et al. Urinary perchlorate and thyroid hormone levels in adolescent and adult men and women living in the United States. Environ Health Perspect 114(2):1865-71, 2006.

[14] http://www.cdc.gov/fluoridation/safety.htm

[15] See http://books.nap.edu/openbook.php?record_id=11571&page=83. For example, in 2005 the American Dental Association declared that the "tolerable upper intake" of fluoride for children 0-8 years of age is 0.10 mg/kg/day. In 1997, the Institute of Medicine found that the average intake of fluoride from drinking water for children living in fluoridated communities was 0.05-0.13 mg/kg/day.

[16] See page 87 of the NAS review for recommendations regarding exposure data gaps.