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Community Water Fluoridation (CWF): Evidence-Based FAQ (studies only)

- High-quality reviews and large natural experiments show fewer cavities where drinking water is fluoridated. Cochrane Review (2015)
- Stopping fluoridation has been followed by measurable increases in decay in real-world settings. McLaren et al (2017)
- Cost–benefit studies consistently find CWF saves money overall.Griffin et al (2001)
- Fluoride policy has long weighed benefits for dentition with potential risks, with maximum contaminant levels first established by the EPA in 1986 to limit exposure to high levels of naturally occurring fluoride in water. The National Academies has served as an independent reviewer of EPA limits (in 2006) and of a recent monograph (2020, 2021) produced by the National Toxicology Program (NTP) regarding fluoride's impact on neurocognitive outcomes.
- Several systematic reviews of the observational literature, including one stemming from the NTP monograph, have reported adverse effects of high fluoride exposure on *neurocognitive* endpoints, most commonly assessed via IQ. Reported adverse effects on IQ are modest and result from studies at high risk of bias.

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1) What is CWF, and what level is typically used?

CWF is the adjustment of naturally occurring fluoride in public water to a low, stable concentration intended to prevent tooth decay while minimizing fluorosis. Contemporary policy targets in many countries cluster around ~0.7 mg/L, reflecting the balance of caries prevention and fluorosis risk discussed in the scientific literature (see evidence on benefits vs. fluorosis below). Cochrane Review (2015)

Only approximately 0.6% of the U.S. population (~1.9 million people) are exposed to **naturally** occurring fluoride at levels ≥1.5 mg/L, the threshold examined in most safety studies and the level at which the NTP report found associations with lower IQ. NTP Report (2024)

Notably, many European countries do not rely on community water fluoridation. Instead, more than 70 million Europeans consume fluoridated table salt, and millions more participate in fluoridated-milk programs (particularly in Eastern Europe). In addition, many European nations have more extensive universal dental care systems with preventive fluoride treatments. By contrast, the U.S. relies principally on community water fluoridation and topical fluoride (toothpaste, varnishes), and does not widely adopt the salt- or milk-fluoride model at a national scale. Pew (2011)

2) Does fluoridation actually reduce tooth decay?

- **Systematic reviews:** The Cochrane review (2015) and its 2024 update report that fluoridation is associated with substantial reductions in caries in children, and increases the proportion of children without decay (with acknowledged heterogeneity and modern exposure to fluoride toothpastes). Cochrane Review (2015), Cochrane Review (2024)
- **Adults:** In Australia's nationally representative adult cohort, greater lifetime exposure to fluoridated water was linked to lower caries experience.Slade et al (2013)
- **Cessation studies (natural experiments):**
    - Following cessation in Calgary, Canada, multiple analyses showed worsening caries outcomes compared with a fluoridated comparison city (Edmonton).
        - The average number of cavity-affected baby-tooth surfaces in 7-year-olds rose by about 146% in Calgary after fluoridation ended, compared to roughly a 50% increase over the same period in nearby Edmonton, which retained fluoridation. McClaren et al (2016)
        - Seven to eight years after Calgary stopped fluoridating its water, nearly two-thirds of Grade 2 children (64.8%) had at least one cavity in their baby teeth, compared with about 55% in Edmonton, where fluoridation continued. McClaren et al (2021)
- When Juneau, Alaska, stopped fluoridating its water in 2007, cavity-related treatments in children rose sharply. Within five years, dental treatment costs for Medicaid-insured kids were up by as much as 111%, adding about $300 per child in annual expenses. Meyer et al (2018)

3) Is CWF cost-saving?

- Classic and contemporary economic evaluations conclude that savings from averted treatment exceed program costs, with larger net benefits in bigger systems. Estimates vary by setting but generally show net savings per person per year and large aggregate savings. Griffin et al 2001)
- According to the CDC, community water fluoridation delivers an estimated return of about $20 saved for every $1 spent in communities of 1,000 or more people — and KFF reports that roughly half of U.S. children enrolled in Medicaid or CHIP receive no dental services in a given year. CDC (2024)

4) What about dental fluorosis?

Dental fluorosis refers to the mottling of the enamel that occurs with high levels of fluoride exposure during tooth formation, being most common in the first 6-8 years of life during enamel mineralization. Fluorosis can be very mild, mild, moderate, or severe. Mild fluorosis is typically considered a cosmetic concern, but more severe forms of fluorosis significantly impact tooth structure and integrity in addition to undesirable aesthetic impacts. Most fluorosis in contemporary U.S. samples is mild, i.e., cosmetic. Hung et al (2023), KFF (2024). Moderate and severe forms of fluorosis are considered rare within the USA (NCHS 2010), although concerns about increasing routes of exposure to fluoride (i.e., increased use of fluoride-containing products) have led to suggestions that cumulative exposure is increasing. NHANES, the only

nationally representative cohort with fluorosis assessment, has suggested that fluorosis prevalence has increased over time; however, concerns about NHANES data quality from dental evaluations and changes in sampling methodologies have arisen (NCHS 2019), leaving uncertainty in prevalence estimates in the USA.

- Iowa Fluoride Study (longitudinal): quantified children's total fluoride intake and described how higher intake relates to mild fluorosis, helping frame the "balancing" concept used in policy.Warren et al (2009)
- A recent NHANES-based analysis (JAMA Network Open, 2023): demonstrated that higher water and plasma fluoride were associated with higher odds of fluorosis. Community water fluoridation levels >0.3mg/L were associated with increased odds of any fluorosis. Analyses to consider interactions between water fluoride concentrations and fluoride supplementation use were underpowered. These data suggest that non-water fluoridation exposure is likely significant and thus higher water fluoride levels increase the risk of fluorosis, although the majority of this is likely to be mild. The benefits of community water fluoridation for caries prevention must ultimately be weighed against mild fluorosis' impact on dental-related quality of life.

5) What does the best evidence say about neurodevelopment (IQ and cognition)?

Several cohorts assessing fluoride exposure have indicated an adverse effect of fluoride exposure on IQ across neurodevelopment. Fluoride exposure has been assessed using water fluoride levels and spot urine fluoride levels. Exposure assessment has included fluoride measurement during pregnancy and childhood, although few cohorts have more than a single measure - childhood exposure levels may reflect prenatal exposure levels as well, and vice versa. Below are select, frequently cited analyses linking higher fluoride to lower IQ.

    - Green et al., 2019 (Canada; JAMA Pediatrics): higher maternal urinary fluoride and modeled intake during pregnancy were associated with lower child IQ (sex-specific patterns in some analyses).Green et al (2019)
    - Till et al., 2020 (Canada; JAMA Pediatrics): infants fed formula reconstituted with fluoridated water showed lower nonverbal IQ at ages 3–4 compared with non-fluoridated; study focused on an infant subgroup.Till et al (2020)
    - Taylor et al., 2025 (JAMA Pediatrics meta-analysis): Most recent review prepared by the NTP estimating the relationship between both estimates of water fluoridation level and urinary fluoride levels and IQ. Pooling studies with individual-level urinary fluoride found an average ~1–2 IQ-point decrease per 1 mg/L increase in urinary fluoride, including analyses restricted to studies below common regulatory thresholds; interpretation should consider that urinary fluoride is not the same as water concentration and reflects multiple sources. Taylor et al (2025)
        - Of note, 52 of the 74 studies reviewed in the meta-analysis were rated high risk of bias, and 45 were conducted in China, where environmental and nutritional conditions differ from those in the U.S. The authors reported a 1–2 point lower average IQ among children with higher fluoride

exposure — a difference that falls within the typical measurement error of most IQ tests and reflects exposures generally higher than those seen in optimally fluoridated U.S. water systems. Taylor et al (2025)

- Key Limitations:
    - **Water Fluoridation Levels** - While water fluoridation levels can be useful as a proxy for fluoride exposure, their relationship to IQ may well be confounded by unadjusted for regional differences between areas with high vs low water fluoride levels that simultaneously impact IQ, including genetics, education level, poverty, nutrition (e.g. global malnutrition, micronutrient status), and exposure to other neurotoxicants (e.g., heavy metals). No cohorts have been explicitly designed to test the relationship between fluoride and IQ and thus lack a comprehensive assessment of relevant confounders to adjust for.
    - **Urinary Fluoride** - Biomarkers of fluoride exposure in cohort participants' urine might be considered to be superior exposure variables relative to local water fluoride levels. Unfortunately, urinary fluoride as a biomarker of exposure is limited and minimally circumvents concerns about confounding. Gold-standard approaches to assess cumulative fluoride exposure are burdensome in large cohorts, requiring repeated collections of 24-hour urines for fluoride analysis (WHO 2014). Cohorts commonly utilize 'spot' urines (convenience urine voids) to assess fluoride levels, which do not reflect cumulative or daily exposure to fluoride. Fluoride in plasma peaks shortly after consuming fluoridated water or food prepared with fluoridated salt and returns to baseline levels within a few hours, primarily (but not entirely) being excreted in the urine. Thus, an entire day's worth of urine needs to be collected and analyzed to attempt to estimate daily exposure, and multiple days must be collected to attempt to estimate usual mean exposure levels. No cohorts in any systematic review have multiple 24-hour urine fluoride levels to estimate usual exposure. Urinary fluoride levels, even when ideally collected, still present issues for causal inference. Only about half of fluoride intake is excreted in urine in children, reflecting accumulation in growing tissues (i.e., bone) and net losses through other routes (e.g., sweat); thus, even multiple 24-hour urine measures of fluoride remain an imperfect metric of exposure to fluoride as it is only moderately correlated with intake. Factors that contribute to variation in fluoride retention and excretion are poorly described but may present as confounders in the relationship between urinary fluoride and IQ. One factor that is well-described is the impact of urinary pH on fluoride excretion; as the alkalinity of urine increases, so does fluoride excretion. Diet is a major variable that impacts urinary pH, with diets high in vegetable products and low in animal products (reflecting both nutritional attributes that may impact IQ as well as socioeconomic differences) resulting in more alkaline urine, increasing urinary fluoride levels. No cohorts have adjusted for these likely significant confounding factors.
    - **Data Quality** - As pointed out by Jane, Heathers, and Grimes, a significant fraction of the literature on fluoride and IQ is published in the journal Fluoride, a non-indexed publication established and overseen by anti-fluoride activists.

Substantially larger adverse relationships between fluoride and IQ are observed when assessing investigations published in Fluoride versus investigations published in any other journal. These authors further point out numerous statistical issues observed in the NTP systematic review and meta-analysis, as well as implausible values in primary data.

- **Representativeness** - No studies in the most recent systematic review from the NTP came from America. A substantial majority of studies came from China that compared geographic regions with naturally occurring fluoride levels in water much higher than the 0.7 mg/L recommended by international authorities.
  - Studies examining CWF in developed countries (i.e., New Zealand), similar to the USA's fluoride exposure, and adjusting for relevant measured confounders have not demonstrated differences in IQ. Broadbent et al (2015)

How to synthesize this: Potential links between fluoride exposure and adverse neurodevelopmental outcomes may have some biological plausibility, but existing data have substantial limitations and are of limited relevance to the USA setting. Issues with study design, exposure assessment, and publication bias limit drawing causal relationships between fluoride exposure and IQ. A precautionary reading of the available data supports potential filtration of naturally occurring high fluoride levels to lower fluoride concentrations; the available data indicate a water fluoride concentration of 0.7mg/L as protective against dental caries and low risk for adverse neurodevelopmental effects, affirming current USA CWF recommendations. There is a substantial need for well-conducted analyses of USA cohorts assessing the relationship between fluoride exposure and IQ to confirm existing fluoridation practices and consider revising EPA water contamination levels.

6) What about cancer and bone health?

- **Osteosarcoma:** A bone-fluoride case–control study measuring fluoride in bone found no association with osteosarcoma risk. Later re-analyses also report no positive association. Kim et al (2011)
- **Fracture risk:** Large, well-adjusted fracture studies at community levels remain mixed but largely do not show increased overall fracture risk at typical fluoridation levels; where elevated risks are reported, they are usually at higher natural fluoride concentrations than used in CWF (see Cochrane's discussion and adult studies context).Cochrane Review (2015)

7) Why do many programs target ~0.7 mg/L?

Because benefit–risk trade-off evidence suggests that caries prevention remains meaningful at low concentrations while limiting fluorosis—especially given today's background exposures from toothpaste, varnish, and foods. Longitudinal intake data and modern reviews underpin this single low target (rather than older, temperature-based ranges). Warren et al (2009)

Note: the US Public Health Service updated its optimal levels to 0.7 mg/L in 2015, reduced from the previous optimal range (0.7-1.2 mg/L) established in 1962. This 0.7 mg/L value is in line with many other countries, but is lower than the current WHO water quality recommendations of 1.5 mg/L. This deviation from WHO guidelines reflects a thoughtful consideration of the USA-specific context and exposure to other sources of fluoride, thereby facilitating an optimal risk-benefit ratio for USA communities.

8) Does fluoridation advance equity?

- Following cessation in Calgary, analyses examined socioeconomic gradients, revealing patterns consistent with broader inequalities once fluoridation was discontinued—underscoring CWF's potential to mitigate disadvantage by reducing population-level disease. McClaren et al (2016)
- Reviews note that in settings where access to dental care is constrained, population measures like CWF can reduce treatment needs across groups. Cochrane Review (2015)
- Evidence from cessation and ecological studies suggests CWF particularly benefits low-income and rural populations, who face higher barriers to regular dental care. McClaren et al (2016), Meyer et al (2018)
- Beyond pain and infection, severe oral disease is linked to broader impacts: children with poor oral health miss more school and perform worse academically, and observational studies associate advanced periodontal disease and tooth loss with higher cardiovascular risk. While community water fluoridation hasn't been shown to change heart-disease rates directly, its role in preventing decay and supporting better oral health may help reduce some of these downstream burdens. Jackson et al (2015)

9) How does CWF compare with toothpaste and fluoride varnish?

- They're complementary. Widespread toothpaste use likely narrows absolute effect sizes versus mid-20th-century trials, yet additional caries reduction from CWF persists across diverse settings—especially where routine care is limited. Cochrane Review (2015)
- CWF provides two pathways of protection:
    - **Topical protection:** Direct contact when drinking water throughout the day
    - **Systemic protection:** Fluoride enters your body's system and re-emerges in saliva, providing continuous low-level protection
    - While toothpaste delivers a higher fluoride concentration, it only works briefly after brushing. Water fluoridation provides protection all day through saliva, especially between meals when teeth are most vulnerable to acid attacks. Studies show that using both fluoridated water and fluoride toothpaste provides the greatest protection against cavities. ADA

10) Bottom line for policy and practice

- The preponderance of dental outcomes research supports CWF as an effective, population-wide caries prevention measure with favorable economics. Cochrane Review (2015)
- Safety evidence is nuanced: recent prenatal-exposure studies warrant practical precautions for pregnancy/infancy (e.g., discuss water sources used to reconstitute formula), while lifecourse community data at CWF levels have not shown IQ differences. Policymakers commonly address this by retaining low targets and continuing surveillance/research. Till et al (2020)
- Untreated dental caries and poor oral health can affect more than teeth. Children with dental pain or infection are more likely to experience **delayed growth, difficulty eating, and disrupted sleep**, all of which can impair development. They also miss more school days and show poorer academic performance compared to peers without dental disease. Severe or untreated decay can progress to **systemic infections**, occasionally leading to emergency department visits, hospitalizations, or costly procedures such as extractions under general anesthesia. These complications impose a **significant financial and emotional burden** on families, particularly those without consistent access to dental care. Jackson et al (2011), Sun et al (2015), Allareddy (2014), Filstrup et al (2003)

Select study references:

Effectiveness & cessation

- Iheozor-Ejiofor Z, et al. *Cochrane Database Syst Rev*. 2015; update 2024. Cochrane Review (2015)
- Slade GD, et al. *J Dent Res*. 2013;92(4):376-382. (Adults) Slade et al (2013)
- McLaren L, Patterson S, Thawer S, et al. *Measuring the short-term impact of fluoridation cessation on dental caries in Grade 2 schoolchildren using tooth surface indices.* Community Dent Oral Epidemiol. 2016;44:274–282. McClaren et al (2016)
- McLaren L, et al. *Public Health*. 2017 (short-term cessation); *Community Dent Oral Epidemiol*. 2022/2021 (extended follow-up). McClaren et al (2017)

Economics

- Griffin SO, et al. *J Public Health Dent*. 2001. (Cost savings across community sizes) Griffin et al (2001)
- Ran T, et al. *Am J Prev Med*. 2016. (Contemporary cost–benefit; net savings) Ran et al (2016)
- O'Connell J, et al. *Health Affairs*. 2016. (National savings estimates) O'Connell (2016)

Fluorosis & intake balance

- Warren JJ, et al. *J Public Health Dent*. 2009. (Longitudinal intake vs caries/fluorosis) Warren et al (2009)

- Hung M, et al. *JAMA Netw Open*. 2023. (NHANES; water/plasma fluoride vs fluorosis) Hung et al (2023)
- Levy SM, et al. *Am J Epidemiol*. 2010. (Fluorosis associations; infant formula contribution) Levy et al (2010)

Neurodevelopment

- Green R, et al. *JAMA Pediatr*. 2019. (Maternal urinary fluoride & child IQ) Green et al (2019)
- Till C, et al. *JAMA Pediatr*. 2020. (Infant formula with fluoridated water & IQ) Till et al (2020)
- Taylor KW, et al. *JAMA Pediatr*. 2025. (Meta-analysis of urinary fluoride & IQ) Taylor et al (2025)
    - Critique of Taylor et al by Jane, Heathers and Grimes
- Broadbent JM, et al. *Am J Epidemiol*. 2015. (CWF-level exposure & IQ across life) Broadbent et al (2015)

Cancer/Bone

- Kim FM, et al. *J Dent Res*. 2011. (Bone fluoride & osteosarcoma: no association) and follow-up re-analyses. Kim et al (2011)

Authoritative Reports

- WHO Guidelines for Drinking-water Quality
- WHO - Assessment of Renal Fluoride Excretion
- US Public Health Service CWF Guidelines
- CDC Scientific Statement on Community Water Fluoridation
- National Academies - 2006 - Fluoride In Drinking Water Review of EPA Standards
- National Toxicology Program 2025 Monograph
    - National Academies Review 1
    - National Academies Review 2

Takeaways:

- “Multiple independent reviews show fewer cavities with fluoridation—even today with universal toothpaste use.” Cochrane Review (2015)
- “When cities stop fluoridation, children’s decay goes up within a few years.” McClaren et al (2017)
- “Every dollar invested in fluoridation typically returns more than a dollar in avoided dental treatment.” Griffin et al (2001)
- “Most fluorosis observed in modern surveys is mild; maintaining low, stable water fluoride helps balance benefit vs. fluorosis.” Hung et al (2023)

- “On neurodevelopment, some prenatal-exposure studies (using urinary fluoride) find small average IQ differences; a lifecourse cohort exposed to CWF-range water found no IQ change.” Taylor et al (2025)
- “Because community water systems reach everyone, fluoridation helps close gaps in dental access and prevents decay among children living below the poverty line.” Yale

The Evidence Collective

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