

Fluoride

Science, safety, and effectiveness

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Fluoride, as a caries preventive therapy, is being challenged by some national and state leaders. A ruling by the California courts fueled controversy regarding the safety of ingested or systemic fluorides, stating there was the potential for a safety risk with community water fluoridation (CWF).¹ The ruling deviated from the results of a National Toxicology Program study in which researchers found no CWF safety issues, even at twice the recommended fluoride level.² In July 2025, the US Food and Drug Administration (FDA) held a hearing on the clinical use and safety of orally ingestible prescription fluoride supplements.

Questions like those posed in the FDA hearing are being asked of oral health care providers. Our patients want to know the whys and hows as well as the science of fluorides, caries prevention, and safety. Oral health care providers speaking with patients, families, and community and political leaders should be familiar with the topic and conversant on fluoride hesitancy and fluoride science.

THE WHY

This readership knows all too well the ravages of caries and the negative health outcomes of missing school or work, toothaches, infection, and tooth loss as well as the need for expensive treatment that in young people or those with medical issues can involve sedation, general anesthesia, and even the risk of death. In the 1930s, researchers discovered that people consuming naturally fluoridated water benefited with a 30% through 50% reduction in caries, leading to the promotion of fluoride as an effective caries therapeutic.³ Consuming fluoridated water provides frequent low-dose fluoride exposures systemically and topically, resulting in optimal caries prevention with maximum safety at minimal cost. Fluoride supplements or vitamins can be recommended for children consuming inadequately fluoridated water; 0.7 ppm fluoride is the US recommendation.⁴ The dosage and use of fluoride supplements evolved on the basis of access to fluoridated drinking water, child development, dental development, and each child's needs and risk of developing caries.

THE HOW

Many patients do not understand the developmental mechanism of caries or how fluorides can help. Tooth minerals are composed of the chemical known as carbonate-substituted hydroxyapatite. When exposed to acids produced by the oral biofilm as it metabolizes carbohydrates, the tooth minerals dissolve, causing caries. The incorporation of fluoride into the tooth's mineral makes it less acid soluble. Decreased acid solubility due to fluoride incorporation into the tooth mineral during development and mineralization results in tighter packing of the mineral ions, making them more adherent and thus more resistant to being pulled apart by acids.⁵ When the biofilm-produced acids have partially dissolved tooth minerals, the highly reactive fluoride ions can attach to the damaged mineral crystals and then recruit calcium and phosphate ions to be deposited, thereby rebuilding the lost mineral content.

DO FLUORIDE SUPPLEMENTS REDUCE CARIES?

Since its first clinical application, results from both human and animal studies showed that fluoride supplements decreased the incidence of caries in permanent teeth, with little evidence supporting a reduction in caries in primary teeth.⁶ Use of fluoride supplements in a special health care needs population (aged 6-12 years) resulted in a 30% reduction in caries over a 2-year period.⁷

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DOES EXPOSURE TO FLUORIDE SUPPLEMENTS OR OPTIMALLY FLUORIDATED WATER CAUSE UNHEALTHY CHANGES IN THE ORAL OR GUT MICROBIOME?

Fluoride has a variety of effects on microbes in the oral cavity. For example, fluoride can inhibit acid production and interfere with a specific enzyme associated with the ability of the cariogenic oral bacteria *Streptococcus mutans* to adhere to and colonize the tooth surface.⁸ There are few human studies on the effects of fluoride on the oral and gut microbiome. In a 2025 systematic review of 42 animal studies and 4 human studies, researchers concluded that sodium fluoride at levels less than 2 mg/L had positive effects on the microbiome diversity and composition.⁹

The convergence of evidence suggests that fluoride is not associated with negative changes in the microbiome and appears to have positive effects on maintaining a healthy oral and gut microbiota at the levels of recommended fluoride.

DO FLUORIDE SUPPLEMENTS OR OPTIMALLY FLUORIDATED WATER CAUSE NEGATIVE NEUROBEHAVIORAL OR OTHER HEALTH CONCERNS?

In numerous human studies, researchers have evaluated fluoride's potential neurobehavioral effects. Multiple systematic reviews are available, including the National Toxicology Program report.² In the report, researchers reviewed 74 studies and concluded there was no association between fluoride exposure below 1.5 ppm fluoride in drinking water (more than twice the recommended community water fluoride concentration in the United States) and outcomes such as IQ.² Results from other

systematic reviews on this topic support no association between IQ and fluoride consumed at optimal levels.^{2,10} Results from a long-term study in New Zealand evaluating IQ and fluoride supplement use before age 5 years showed no change in IQ throughout childhood and up to age 38 years.¹¹

Some investigators have suggested disruption of thyroid gland function could cause fluoride to have a neurobehavioral effect.¹² In a systematic review of fluoride toxicity that included 89 human studies, 199 animal studies, and 10 major in vitro reviews, researchers found limited evidence supporting the association of thyroid hor-

mone disruption, sex hormone disruption, and kidney dysfunction at CWF levels used in the United States and Canada.¹²

The convergence of evidence contends negative cognitive or neurobehavioral outcomes are not associated with consuming fluoride supplements or CWF.

WHAT HEALTH OUTCOMES ARE LIKELY TO OCCUR IF FLUORIDES ARE NOT USED FOR CARIES PREVENTION?

More than 70% of the US population have access to CWF.¹³ This is changing, with some states removing the autonomy for municipalities to choose CWF and the FDA considering the removal of fluoride supplement availability. The result of reduced access to fluoride in those communities that have removed water fluoridation will be an increase in caries, missed school days, increased health care costs, emergency department visits, oral health disparities, and an overall decrease in the population's health and quality of life.¹⁴

HOW EFFECTIVE ARE OTHER CARIES PREVENTIVE THERAPEUTICS?

Fluoride is the most effective therapeutic measure applied to the management of the rampant and costly human disease of caries. There are no chemotherapeutic substitutes that work as well as the combination of systemic and topical fluorides. The availability of fluoride supplements will be needed more than ever as a result of large segments of the population losing access to CWF. New topical agents and remineralizing approaches to manage caries are not as effective as fluorides.

People in the United States and around the globe have benefited from CWF and fluoride supplements since the 1940s. Researchers have investigated safety concerns around fluoride since

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the element was discovered and isolated in the late 1800s. The evidence indicates systemic fluoride consumption at the low concentrations used for CWF and fluoride supplements is safe. Given the consequences of unchecked caries for children, the discomfort, and the expense of treatment, oral health care organizations continue to urge the FDA, health leaders, and state and local leaders to recognize and recommend the continued availability and use of CWF and fluoride supplements. ■

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DISCLOSURE

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