

# Fluoride toxicity

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## Fluoride poisoning

*Classification and external resources*

[ICD-10](#)

[T59.5](#)

[DiseasesDB](#)

[29228](#)

[eMedicine](#)

[emerg/181](#)

[MeSH](#)

[D005458](#)

In high concentrations, soluble [fluoride salts](#) are [toxic](#) and skin or eye contact with high concentrations of many fluoride salts is dangerous. Referring to a common salt of fluoride, [sodium fluoride](#) (NaF), the lethal dose for most adult humans is estimated at 5 to 10 g (which is equivalent to 32 to 64 mg/kg elemental fluoride/kg body weight).<sup>[1][2][3]</sup> Ingestion of fluoride can produce gastrointestinal discomfort at doses at least 15 to 20 times lower (0.2–0.3 mg/kg) than lethal doses.<sup>[4]</sup> Although helpful for dental health in low dosage, chronic exposure to fluoride in large amounts interferes with bone formation. In this way, the greatest examples of fluoride poisoning arises from fluoride-rich ground water.<sup>[5]</sup>

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# Acute

## Mechanism

Like most soluble materials, fluoride compounds are readily absorbed by the stomach and intestines, and [excreted](#) through the urine. [Urine tests](#) have been used to ascertain rates of excretion in order to set upper limits in exposure to fluoride compounds and associated detrimental health effects.[\[6\]](#) Ingested fluoride initially acts locally on the intestinal mucosa, where it forms hydrofluoric acid in the stomach.

## Sources

Historically, most cases of acute fluoride toxicity have followed accidental ingestion of sodium fluoride based insecticides or rodenticides.[\[7\]](#) Currently, in advanced countries, most cases of fluoride exposure are due to the ingestion of dental fluoride products.[\[8\]](#) Although exposure to these product does not often cause toxicity, in one study 30% of children exposed to fluoride dental products developed mild symptoms.[\[8\]](#) Other sources include [glass-etching](#) or [chrome-cleaning](#) agents like [ammonium bifluoride](#) or [hydrofluoric acid](#),[\[9\]\[10\]](#) industrial exposure to [fluxes](#) used to promote the flow of a molten metal on a solid surface, [volcanic ejecta](#) (for example, in cattle grazing after an 1845–1846 eruption of [Hekla](#) and the [1783–1784 flood basalt eruption of Laki](#)), and metal cleaners. Malfunction of water fluoridation equipment has happened several times, including a notable incident in Alaska.[\[4\]](#)

## Organofluorine compounds

[Organofluorine compounds](#) only rarely release F<sup>-</sup> under biological conditions and thus are rarely sources of fluoride poisoning. In order for fluoride poisoning to occur, a [compound](#) must release fluoride (F<sup>-</sup>) ions. Whereas most [organofluorine compounds](#) may not release F<sup>-</sup> because of the strength of the [carbon–fluorine bond](#) and its tendency to strengthen as more [fluorine](#) atoms are added to a [carbon](#), some compounds do, such as [methoxyflurane](#). The fluorine atom is pervasive in drugs, e.g. [Prozac](#), and many other substances such as [freon](#), [Teflon](#), and [blood serum](#) ([PFOS](#), [PFOA](#), and [PFNA](#)).

## Fluoride in toothpaste

Children may experience gastrointestinal distress upon ingesting sufficient amounts of flavored toothpaste. Between 1990 and 1994, over 628 people, mostly children, were treated after ingesting too much fluoride from their toothpaste. Gastrointestinal symptoms appear to be the most common problem reported.[\[11\]](#)

## Chronic toxicity

Geographical areas associated with [groundwater](#) having over 1.5 mg/L of naturally occurring fluoride, which is above recommended levels.<sup>[12]</sup> In India an estimated 60 million people have been poisoned by well water contaminated by excessive fluoride, which is dissolved from the granite rocks. The effects are particularly evident in the bone deformations of children. Similar or larger problems are anticipated in other countries including China, Uzbekistan, and Ethiopia.<sup>[5]</sup>

The only generally accepted adverse effect of fluoride at levels used for [water fluoridation](#) is [dental fluorosis](#), which can alter the appearance of children's teeth during [tooth development](#); this is mostly mild and usually only an aesthetic concern. Compared to unfluoridated water, fluoridation to 1 mg/L is estimated to cause fluorosis in one of every 6 people (range 4–21), and to cause fluorosis of aesthetic concern in one of every 22 people (range 13.6–∞). Here, "aesthetic concern" is a term used in a standardized scale based on what adolescents would find unacceptable, as measured by a 1996 study of British 14-year-olds.<sup>[13]</sup>

Consumption of fluoride at levels beyond those used in fluoridated water for a long period of time causes [skeletal fluorosis](#). In some areas, particularly the Asian subcontinent, skeletal fluorosis is endemic. It is known to cause irritable-bowel symptoms and joint pain. Early stages are not clinically obvious, and may be misdiagnosed as (seronegative) [rheumatoid arthritis](#) or [ankylosing spondylitis](#).<sup>[14]</sup>

Other adverse effects may be possible at fluoride intake levels above the recommended dosage, and defluoridation is recommended in these cases. In 1986, the [United States Environmental Protection Agency](#) (EPA) established a [maximum contaminant level](#) (MCL) for fluoride at a concentration of 4 milligrams per liter (mg/L), which is the legal limit of fluoride allowed in the water. In 1993, a review by the [National Academy of Sciences](#) conducted at the behest of EPA concluded that the 4 mg/L MCL was appropriate.<sup>[15]</sup> However, in 2006, a 12-person committee of the [US National Research Council](#) (NRC) reviewed the health risks associated with fluoride consumption<sup>[16]</sup> and came to the differing conclusion that the MCL should be lowered. In response to these studies, the EPA has made no change to the MCL.<sup>[17][18]</sup> U.S. government officials lowered recommended limits for fluoride in water on Friday Jan. 7, 2011, saying some children may be getting tooth damage from too much. The Health and Human Services Department lowered its recommended levels to 0.7 milligrams of fluoride per liter of water -- the lower limit of the current recommended range of 0.7 to 1.2 milligrams. see:<http://www.reuters.com/article/2011/01/08/us-usa-fluoride-idUSTRE7064CM20110108>

Excess fluoride consumption has been studied as a factor in the following:

- A weakening of [bones](#), leading to an increase in hip and wrist fracture. At the level used in fluoridated water, decreased fractures are expected, <sup>[13]</sup> but the U.S. National Research Council found the overall evidence "suggestive but inadequate for drawing firm conclusions about the risk or safety of exposures at [2 mg/L]", but states that fractures do seem to increase as fluoride is increased from 1 mg/L to 4 mg/L, suggesting a "continuous exposure-effect" [dose-response relationship](#) at these levels.<sup>[16]:170</sup>

- Adverse effects on the kidney. Within the recommended dose, no effects are expected, but chronic ingestion in excess of 12 mg/day are expected to cause adverse effects, and an intake that high is possible when fluoride levels are around 4 mg/L.<sup>[16]:281</sup> Those with impaired kidney function are more susceptible to adverse effects.<sup>[16]:292</sup>
- Four epidemiological studies have noted a correlation between increased fluoride and low IQ.<sup>[16]:205-223</sup> The most rigorous of these compared an area with mean water concentration of  $0.36 \pm 0.15$  mg/L (range 0.18–0.76 mg/L) to an area with  $2.47 \pm 0.79$  mg/L (range 0.57–4.50 mg/L). Most of these studies did not publish important details, making them difficult to evaluate. If these correlations are caused by fluoride, the mechanism is not known, but the National Research Council speculates that effects on the thyroid could lead to poor test results.<sup>[16]:208</sup> Two Chinese meta-analyses which included the previously mentioned studies have also noted this correlation.<sup>[19][20]</sup> The high-fluoride areas studied had fluoride levels above those used in water fluoridation.
- The NRC report stated that "many of the untoward effects of fluoride are due to the formation of AlF<sub>x</sub> [aluminum fluoride] complexes".<sup>[16]:219</sup> This topic has been identified previously as cause for concern.<sup>[21]</sup> The NRC noted that rats administered fluoride had twice as much aluminum in their brains.<sup>[16]:212</sup> When water (1 ppm fluoride) is boiled in aluminum cookware more aluminum is leached and more aluminum fluoride complexes are formed. However, an epidemiological study found that a high-fluoride area had one-fifth the Alzheimer's that a low-fluoride area had,<sup>[22]</sup> and a 2002 study found that fluoride increased the urinary excretion of aluminum.<sup>[23]</sup>
- Fluoride's suppressive effect on the thyroid is more severe when iodine is deficient, and fluoride is associated with lower levels of iodine.<sup>[21]</sup> Thyroid effects in humans were associated with fluoride levels 0.05–0.13 mg/kg/day when iodine intake was adequate and 0.01–0.03 mg/kg/day when iodine intake was inadequate.<sup>[16]:263</sup> Its mechanisms and effects on the endocrine system remain unclear.<sup>[16]:266</sup>

## History

Danish researcher Kaj Roholm published *Fluorine Intoxication* in 1937, which was praised in a 1938 review by dental researcher [H. Trendley Dean](#) as "probably the outstanding contribution to the literature of fluorine".<sup>[24]</sup> Since that time, the fluoridation of public water has been widely implemented and has been hailed as one of the top medical achievements of the 20th Century.<sup>[25]</sup> The effects of fluoride-rich ground water became recognized in the 1990s.<sup>[5]</sup>

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