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Review Article

Fluoride Exposure and Children's Neurodevelopment: Reconciling the Evidence on IQ, Dose and Dental Practice

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Abstract

Fluoride has prevented dental caries for eight decades, yet questions about its effect on the developing brain have been raised since the mid-1990s. In 2024 the US National Toxicology Program (NTP) concluded, with moderate confidence, that fluoride exposures above 1.5 mg/L in drinking water are associated with lower IQ in children. A 2025 meta-analysis of 74 studies in *JAMA Pediatrics* reported a consistent inverse association between fluoride exposure and IQ. Other researchers, writing in *Community Dentistry and Oral Epidemiology* and *The Journal of the American Dental Association*, argue that the data do not support harm at the 0.7–1.0 mg/L levels used in community water fluoridation. Large cohorts from New Zealand, Australia, Sweden and the United States support that view. This review sets the two bodies of evidence side by side. It describes the global policy response, from new US state bans to the expansion of fluoridation in North East England. It summarises current clinical guidance and documented disputes over how the evidence has been reported and released. It makes no recommendations; it sets out where the evidence agrees, where it conflicts, and what remains unknown.

Keywords: *fluoride; intelligence quotient; neurodevelopment; community water fluoridation; dental fluorosis*

1. Introduction

The fluoride–brain question has never been settled because two true statements pull in opposite directions. Fluoride reduces caries, particularly in deprived communities. Fluoride at high exposure is also a recognised developmental toxicant in animals and in endemic fluorosis regions of China, India, Iran and Mexico [1,2].

Concern specifically about the developing brain dates from the mid-1990s, when Mullenix et al. reported dose-related behavioural changes in rats exposed to fluoride before birth and after weaning [26].

The argument has always been about where between those two facts the line sits. Community water fluoridation (CWF) targets 0.7 mg/L in the United States and about 1.0 mg/L in England. The World Health Organization guideline maximum is 1.5 mg/L [3]. Naturally occurring groundwater fluoride in parts of Asia and Africa can exceed 4 mg/L.

Two recent federal US publications sharpened the debate: the NTP monograph in August 2024 [1] and its companion meta-analysis in *JAMA Pediatrics* in January 2025 [2]. A US federal court ruling in September 2024 and state-level fluoridation bans in 2025 followed [4–6]. In the same period, the UK government confirmed the largest expansion of water fluoridation in England since the 1980s [7].

A long-running debate is not, by itself, evidence of harm. It does, however, signal genuine uncertainty that clinicians should be able to explain. This review therefore has three aims:

1. To summarise the evidence that associates fluoride exposure with lower IQ in children.
2. To summarise the main methodological critiques and the evidence that finds no effect at CWF levels.
3. To summarise current policy and guidance, and documented disputes over the reporting of the evidence.

Exposure levels are reported wherever studies provide them, because most disagreement concerns effects at particular exposures.

2. Evidence for an Association

The strongest case for concern rests on two linked US government analyses and a small number of prospective birth cohorts.

2.1 The NTP monograph (2024)

The NTP began its systematic review in 2016 and published the final monograph in August 2024 after several rounds of external review, including by the National Academies of Sciences, Engineering, and Medicine [1]. It concluded, with moderate confidence, that fluoride exposures above 1.5 mg/L in drinking water are associated with lower IQ in children. Some of the included studies suggested IQ was 2–5 points lower in children with higher exposures.

Three qualifications in the monograph itself are often lost in public discussion:

- It assessed total fluoride exposure from all sources, and was not designed to evaluate fluoridated water alone.
- It stated that the evidence was insufficient to judge effects at 0.7 mg/L, the US CWF target.
- It described an association, not proof of cause and effect, and found no evidence of adverse effects on adult cognition.

2.2 The *JAMA Pediatrics* meta-analysis (2025)

Taylor and colleagues pooled 74 epidemiological studies, 52 of which were rated at high risk of bias [2]. Higher fluoride exposure was associated with lower IQ. Each 1 mg/L increase in urinary fluoride was associated with a decrease of about 1.63 IQ points.

When the analysis was restricted to the 22 low-risk-of-bias studies, the inverse association persisted. It held for water fluoride below 4, below 2 and below 1.5 mg/L. The authors acknowledged limited data and uncertainty for exposures below 1.5 mg/L.

In a December 2025 response to their critics, the same authors argued that the association is robust to study quality, design and exposure timing [11].

2.3 Key prospective cohorts

Much of the attention has fallen on two pregnancy cohorts, because they measured exposure before outcome:

- **ELEMENT, Mexico City.** Bashash et al. linked higher maternal urinary fluoride in pregnancy to lower cognitive scores at ages 4 and 6–12 [9].
- **MIREC, Canada.** Green et al. reported that higher maternal urinary fluoride was associated with lower preschool IQ in boys, in a population drinking CWF-level water [8].

Grandjean's review places these within a broader developmental neurotoxicity literature and argues for a precautionary reassessment of exposure limits [10].

2.4 What this evidence does and does not show

Taken together, these studies show a reasonably consistent signal at **higher** exposures, mostly from endemic fluorosis regions. They do not show that fluoride at 0.7–1.0 mg/L causes harm. That question is where the evidence divides. No study has defined a precise threshold of harm: 1.5 mg/L marks where the evidence becomes consistent, not a proven boundary between safe and unsafe.

3. Critiques and Contrary Evidence

The counter-case makes two arguments: the positive studies are methodologically weaker than they appear, and the best data from fluoridated populations show no effect.

3.1 Methodological critiques

- **Exposure measurement.** Most pregnancy cohorts used single spot urine samples. Urinary fluoride varies with recent intake, hydration and time of day, so a single sample may misclassify long-term exposure.
- **Study quality.** Two-thirds of the studies in the meta-analysis were rated high risk of bias, many from endemic regions with co-exposures such as arsenic, lead, iodine deficiency and coal-burning pollution.
- **The MIREC data.** Guichon et al. argue that MIREC's fluoride and IQ measurements are not valid enough to support policy conclusions [13].
- **Dose–response.** Kumar et al. reanalysed the maternal urinary fluoride studies using the US EPA's data-quality criteria [12]. None of the four met the standard. The pooled estimate was not significant ($\beta = -1.06$; 95% CI −3.63 to 1.50). In five studies from fluoridated areas the standardised mean difference was 0.04 (95% CI −0.06 to 0.14), and benchmark-dose models found no functional relationship.

3.2 Population studies at CWF levels

Study	Setting	Size	Finding
Kumar, Levy & Warren, JADA 2026 [14]	Narrative review of systematic reviews	—	No causal link between CWF and children's IQ
Warren et al., PNAS 2026 [18]	USA, followed from adolescence	10,317	No adverse effect of municipal fluoridation on adolescent IQ or later-life cognition
Do et al., J Dent Res 2025 [16]	Australia, national cohort	357	No association between early-childhood fluoride exposure and neurodevelopment
Aggeborn & Öhman, J Polit Econ 2021 [17]	Sweden, population registers	National registers, cohorts born 1985–1992	No effect of natural water fluoride on cognitive ability; small benefits for labour-market outcomes
Broadbent et al., Am J Public Health 2015 [15]	New Zealand, Dunedin cohort	~1,000	No IQ difference by CWF exposure in childhood

These studies have their own limits. Several use area-level exposure rather than individual biomarkers, and observational designs cannot exclude residual confounding. Their strength is size and relevance: they examine the exposures that most UK and US children actually receive.

3.3 Where the two camps agree

Despite the heat of the debate, the camps share more ground than headlines suggest:

- Both sides accept that exposures well above 1.5 mg/L are associated with adverse effects on the developing brain.
- The evidence at 0.7–1.0 mg/L is uncertain or null, not proven harmful.
- Better exposure measurement, such as repeated or 24-hour urine samples, is needed.

3.4 Transparency and competing interests in the evidence base

The disagreement about fluoride extends beyond the data themselves to how evidence has been reported, reviewed and released. Four features of the public record are relevant.

- **Delayed publication of the NTP review.** The NTP sent its draft monograph to external peer reviewers in November 2021. Publication of a revised version, scheduled for May 2022, was cancelled shortly beforehand amid objections from other federal agencies to its methods and conclusions. The draft documents became public in March 2023 following a subpoena in the US federal litigation, and the final monograph appeared in August 2024 [1,4]. A former NTP director has stated publicly that release was blocked, and press reporting described dental organisations urging federal officials to amend the report [27].
- **Contested interpretation of the York Review.** The 2000 systematic review commissioned by the UK Department of Health found that fluoridation was likely to reduce caries, that the quality of the evidence was generally low, and that fluoridation was associated with dental fluorosis [28]. The chair of its advisory group later stated that the review's results had been widely misrepresented, that it had not shown fluoridation to be safe, and that legitimate scientific controversy would continue until higher-quality studies were available [29]. A subsequent analysis described selective use of the review by both supporters and opponents of fluoridation [30].
- **Competing interests on both sides.** An analysis of trials of fluoride varnishes and gels found that industry sponsorship had limited impact on the overall evidence, but that preventive effects were smaller in more recent trials than in earlier ones [31]. Non-financial interests are also present: the author of a 2015 English study reporting higher hypothyroidism prevalence in fluoridated areas declared involvement in a campaign against fluoridation, and the study's ecological design was criticised by Public Health England authors [32,33]. Several of the critiques summarised in Section 3.1 are written by authors publicly associated with promoting community water fluoridation, and the US litigation was brought by advocacy organisations [4,12,13].
- **Delayed reporting of an osteosarcoma finding.** A 2001 Harvard doctoral thesis reported an association between fluoridated water exposure in boys aged about 6–8 years and later osteosarcoma; it was published only in 2006 [35]. It appeared alongside a cautionary letter from the thesis supervisor, who led the larger parent study [34]. An advocacy organisation filed a complaint alleging that the supervisor had misrepresented the thesis findings in a federal grant report, and Harvard and the NIEHS opened a review [36]. The larger study, published in 2011, found no significant association between bone fluoride levels and osteosarcoma [37].

These observations do not by themselves establish either harm or safety. They indicate that funding sources, declared interests and publication history are part of the evidence that readers need to weigh.

4. The Global Policy Landscape

Governments facing the same evidence have moved in opposite directions, which itself shows how much the decision depends on values as well as data.

Jurisdiction	Current position	Recent change
WHO	Guideline maximum 1.5 mg/L in drinking water [3]	None
USA (federal)	CDC recommends 0.7 mg/L; EPA enforceable maximum 4.0 mg/L	Sept 2024: federal court found fluoridation at current levels an unreasonable risk under the Toxic Substances Control Act and ordered EPA to respond [4]. Apr 2025: EPA announced an expedited review of fluoride health risks [22]
USA (states)	Fluoridation mostly a local decision	2025: Utah (HB 81) and Florida (SB 700) became the first states to ban CWF [5,6]
England	About 10% of the population receives fluoridated water, mainly West Midlands and North East	Mar 2025: government confirmed expansion to a further 1.6 million people in the North East [7]
Ireland	About 71% receive fluoridated water	Target lowered from 0.8–1.0 to 0.6–0.8 mg/L in 2007 [23]
Continental Europe	Most countries do not fluoridate water; several (e.g. Germany, Switzerland, France) use fluoridated salt	—
Canada	Municipal decision	Calgary reinstated fluoridation in 2025 after ending it in 2011

Two further observations are relevant. First, countries that do not fluoridate water have not generally concluded that it is neurotoxic; most cite cost, consent or alternative delivery such as salt and toothpaste. Second, studies from Calgary reported increased caries in children after fluoridation stopped [14,19]. Recent English studies report a smaller caries benefit than in earlier decades [20,21].

5. Biological Plausibility and the Pineal Gland

Animal studies give the human findings some biological plausibility, but mostly at doses far above human CWF exposure. The NTP's 2016 review of animal evidence found low-to-moderate evidence of effects on learning and memory [1]. Proposed mechanisms include oxidative stress, mitochondrial dysfunction, altered neurotransmitter signalling and thyroid disruption. Fluoride crosses the placenta, which is why prenatal exposure has drawn particular attention.

The pineal gland is frequently raised by patients, often via social media. The scientific basis is a cadaver study by Luke, which found that fluoride accumulates in the calcified pineal gland of elderly people, at levels comparable to teeth, and correlates with pineal calcium [24]. The gland lies outside the blood–brain barrier and has a high blood flow, which may explain this accumulation.

What this study did not show is clinically important. It did not demonstrate impaired pineal function or melatonin output in humans. Pineal calcification is also very common with age, regardless of fluoridation, and is routinely used as a radiographic landmark. The pineal hypothesis therefore remains a research question rather than an established harm.

6. Current Clinical and Regulatory Guidance

Guidance on fluoride use in children currently differs by route of exposure and by jurisdiction. This section summarises it without endorsement.

- **United Kingdom.** *Delivering Better Oral Health* advises a smear of toothpaste containing at least 1,000 ppm fluoride under age 3, a pea-sized amount of 1,000–1,500 ppm from 3 to 6, and fluoride varnish twice yearly for children aged 3 and over [25].
- **United States.** The US Preventive Services Task Force recommends fluoride varnish from primary tooth eruption [39]. In October 2025 the FDA advised that ingestible fluoride supplements should not be given to children under 3 or to older children at low or moderate caries risk, and took enforcement action against unapproved products [38]. The American Dental Association disagreed with the change [40].
- **Continental Europe.** Most countries do not fluoridate water; several use fluoridated salt (Section 4).
- **WHO.** Guideline maximum of 1.5 mg/L in drinking water [3].

No guideline currently addresses combined exposure from water, toothpaste, diet and professional products in a single intake limit for children.

7. Research Gaps

- **Individual exposure at low doses.** Prospective cohorts in fluoridated populations need repeated or 24-hour urine samples, not single spot samples.
- **Windows of vulnerability.** Pregnancy, infancy (including formula feeding) and early childhood need separate analysis.
- **Total-intake modelling.** Toothpaste ingestion, diet, tea and water should be modelled together, not water alone.
- **Effect modifiers.** Iodine status, sex and socioeconomic factors may change susceptibility.
- **UK data.** England's statutory four-yearly health monitoring of fluoridation schemes, with the next report due in 2026, is an opportunity to include neurodevelopmental outcomes [7].

8. Conclusion

The evidence shows an association between higher fluoride exposure and lower IQ, with moderate confidence above 1.5 mg/L. At community water fluoridation levels the findings conflict: some cohorts report an association, while large population studies report none. No threshold of harm has been established, combined exposure from all sources has rarely been measured, and the publication history of key reviews has itself been contested. These uncertainties, rather than a settled answer, are what clinicians and parents currently face.

Declarations

Ethics and consent: Not applicable. This review contains no patient data.

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References

1. National Toxicology Program. NTP monograph on the state of the science concerning fluoride exposure and neurodevelopment and cognition: a systematic review. NTP Monograph 08. Research Triangle Park, NC: NTP; 2024. doi:10.22427/NTP-MGRAPH-8. Link

2. Taylor KW, Eftim SE, Sibrizzi CA, et al. Fluoride exposure and children's IQ scores: a systematic review and meta-analysis. JAMA Pediatr. 2025;179(3):282-292. doi:10.1001/jamapediatrics.2024.5542

3. World Health Organization. Guidelines for drinking-water quality. 4th ed, incorporating the first and second addenda. Geneva: WHO; 2022.

4. Food & Water Watch, Inc. v. US Environmental Protection Agency, No. 17-cv-02162-EMC (N.D. Cal. Sept 24, 2024).

5. Utah H.B. 81, Fluoride Amendments (2025). Effective 7 May 2025.

6. Florida S.B. 700 (2025), Ch. 2025-22, Laws of Florida. Effective 1 July 2025.

7. Department of Health and Social Care. Community water fluoridation expansion in the north east of England: consultation outcome. London: DHSC; 2025. Link

8. Green R, Lanphear B, Hornung R, et al. Association between maternal fluoride exposure during pregnancy and IQ scores in offspring in Canada. JAMA Pediatr. 2019;173(10):940-948.

9. Bashash M, Thomas D, Hu H, et al. Prenatal fluoride exposure and cognitive outcomes in children at 4 and 6–12 years of age in Mexico. Environ Health Perspect. 2017;125(9):097017.

10. Grandjean P. Developmental fluoride neurotoxicity: an updated review. Environ Health. 2019;18:110.

11. Taylor KW, Eftim SE, Sibrizzi CA, et al. Addressing critiques of the evidence linking fluoride and children's IQ. Ann Glob Health. 2025;91(1):83. doi:10.5334/aogh.4853

12. Kumar JV, Moss ME, Liu H, Fisher-Owens S, Rugg-Gunn A, Kuring J. Fluoride and neurodevelopmental hazard modelling: an assessment of concentration-response analysis. Community Dent Oral Epidemiol. 2026;54(1):101-111. doi:10.1111/cdoe.70027

13. Guichon JR, Cooper C, Rugg-Gunn A, Dickinson JA. Flawed MIREC fluoride and intelligence quotient publications: a failed attempt to undermine community water fluoridation. Community Dent Oral Epidemiol. 2024;52(4):365-374. doi:10.1111/cdoe.12954

14. Kumar JV, Levy SM, Warren JJ. An update on community water fluoridation, part 2: fluoride exposure and children's intelligence (IQ) scores. J Am Dent Assoc. 2026;157(5):471-486. doi:10.1016/j.adaj.2026.02.010

15. Broadbent JM, Thomson WM, Ramrakha S, et al. Community water fluoridation and intelligence: prospective study in New Zealand. Am J Public Health. 2015;105(1):72-76.

16. Do LG, Sawyer A, Spencer AJ, et al. Early childhood exposures to fluorides and cognitive neurodevelopment: a population-based longitudinal study. J Dent Res. 2025;104(3):243-250. doi:10.1177/00220345241299352

17. Aggeborn L, Öhman M. The effects of fluoride in drinking water. J Polit Econ. 2021;129(2):465-491. doi:10.1086/711915

18. Warren JR, Rumore G, Sicinski K, Herd P, Engelman M. Municipal water fluoridation, adolescent IQ, and cognition across the life course: evidence from the Wisconsin Longitudinal Study. Proc Natl Acad Sci U S A. 2026;123(16):e2536005123. doi:10.1073/pnas.2536005123

19. Iheozor-Ejiofor Z, Walsh T, Lewis SR, et al. Water fluoridation for the prevention of dental caries. Cochrane Database Syst Rev. 2024;10(10):CD010856. doi:10.1002/14651858.CD010856.pub3

20. Goodwin M, Walsh T, Whittaker W, et al. The CATFISH study: an evaluation of a water fluoridation program in Cumbria, UK. Community Dent Oral Epidemiol. 2024;52(4):590-600. doi:10.1111/cdoe.12967

21. Moore D, Nyakutsikwa B, Allen T, et al. How effective and cost-effective is water fluoridation for adults and adolescents? The LOTUS 10-year retrospective cohort study. Community Dent Oral Epidemiol. 2024;52(4):413-423. doi:10.1111/cdoe.12930

22. US Environmental Protection Agency. EPA to review scientific information on potential health risks of fluoride in drinking water [press release]. 7 April 2025.

23. Sharma V, O'Connell B, O'Flaherty E, et al. Longitudinal analysis of fluoride levels in Irish water supplies: a 52-year review. Community Dent Oral Epidemiol. 2026;54(4):418-426. doi:10.1111/cdoe.70055

24. Luke J. Fluoride deposition in the aged human pineal gland. Caries Res. 2001;35(2):125-128.

25. Office for Health Improvement and Disparities. Delivering better oral health: an evidence-based toolkit for prevention. London: OHID; 2021 (updated).

26. Mullenix PJ, Denbesten PK, Schunior A, Kernan WJ. Neurotoxicity of sodium fluoride in rats. Neurotoxicol Teratol. 1995;17(2):169-177. doi:10.1016/0892-0362(94)00070-t

27. Health officials delayed report linking fluoride to brain harm. Mother Jones; republished by Salon. 16 March 2023.

28. McDonagh MS, Whiting PF, Wilson PM, et al. Systematic review of water fluoridation. BMJ. 2000;321(7265):855-859. doi:10.1136/bmj.321.7265.855

29. Cheng KK, Chalmers I, Sheldon TA. Adding fluoride to water supplies. BMJ. 2007;335(7622):699-702.

30. Wilson PM, Sheldon TA. Muddy waters: evidence-based policy making, uncertainty and the 'York review' on water fluoridation. Evidence & Policy. 2006;2(3):321-331.

31. Reda S, Elhennawy K, Meyer-Lückel H, Paris S, Schwendicke F. Industry sponsorship in trials on fluoride varnish or gels for caries prevention. Community Dent Oral Epidemiol. 2017;45(4):289-295.

32. Peckham S, Lowery D, Spencer S. Are fluoride levels in drinking water associated with hypothyroidism prevalence in England? A large observational study of GP practice data and fluoride levels in drinking water. J Epidemiol Community Health. 2015;69(7):619-624. doi:10.1136/jech-2014-204971

33. Newton JN, Young N, Verne J, Morris J. Water fluoridation and hypothyroidism: results of this study need much more cautious interpretation. J Epidemiol Community Health. 2015;69(7):617-618. doi:10.1136/jech-2015-205917

34. Bassin EB, Wypij D, Davis RB, Mittleman MA. Age-specific fluoride exposure in drinking water and osteosarcoma (United States). Cancer Causes Control. 2006;17(4):421-428.

35. Douglass CW, Joshipura K. Caution needed in fluoride and osteosarcoma study. Cancer Causes Control. 2006;17(4):481-482.

36. Did Harvard study downplay risk of fluoride? NBC News / Associated Press. 2005.

37. Kim FM, Hayes C, Williams PL, et al. An assessment of bone fluoride and osteosarcoma. J Dent Res. 2011;90(10):1171-1176. doi:10.1177/0022034511418828

38. US Preventive Services Task Force. Screening and interventions to prevent dental caries in children younger than 5 years: recommendation statement. JAMA. 2021;326(21):2172-2178. doi:10.1001/jama.2021.20007

39. US Food and Drug Administration. Ingestible fluoride drug products: what health care professionals should know. Silver Spring, MD: FDA; 31 October 2025.

40. American Dental Association. Statement from the ADA on FDA action to limit fluoride supplements for children 3 and younger [press release]. Chicago: ADA; 31 October 2025.

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