



## How Science Works: Adding fluoride to drinking water

**Fluoridation – the addition of sodium fluoride to drinking water – is a controversial topic. This Factsheet:**

- summarises the arguments for and against fluoridation
- discusses the problems scientists and politicians face when the scientific evidence is not clear-cut
- reviews recent exam questions on this topic

There is very strong scientific evidence that water fluoridation reduces the incidence of:

- dental caries – tooth decay that results in cavities in children as young as 3 and adults even up to the age of 75
- reported toothache and dental treatment needing general anaesthesia

Because of this, some scientists want fluoride added to every water supply in the UK. They argue that this would improve dental health and reduce NHS costs.

Other scientists completely disagree! They argue that adding fluoride to everyone's water:

- can harm some people's health
- would be extremely expensive
- is not justified by the scientific evidence
- would be a breach of people's human rights

So who is right? Well, there are some tricky issues to consider.

### Sources of fluoride

Fluoride occurs naturally in soil, water, plants and animals in trace quantities. In groundwater, natural fluoride concentrations range from trace quantities to over 25mg/l.

The major potential sources of ingested fluoride are water and food and drinks prepared with fluoridated water. In the 1970s fluoride started to be added to toothpastes and by 1978 96% of toothpaste on the market contained fluoride, usually at a concentration of 1000 to 1500ppm. Lower fluoride toothpastes containing about 500ppm fluoride are now available for use by children.

In areas in the UK where water is fluoridated, this usually remains the most important source of fluoride intake. The relative importance of fluoridated toothpaste as a source of ingested fluoride is greater for young children than for adults because of the greater likelihood that they will swallow it. Table 1. shows average intake by source in England and Wales.

**Table 1 Mean fluoride intake by source**

Source	Concentration/Content	Intake/ mg kg <sup>-1</sup> body weight	
		Child	Adult
Drinking water	1.2mg/l	0.084	0.034
Tooth-brushing & mouth-washing	0.145-0.66mg	0.033	0.002
Diet	0.2-0.4mg	0.010	0.006
<b>Total</b>		0.127	0.042

### Fluoride absorption

Ingested fluoride ions are rapidly absorbed from the stomach and the small intestine and some are taken up by body tissues, with long-term deposition in teeth and bones.

However, some of the factors that affect how much fluoride is absorbed are not well understood.

When a readily soluble compound such as sodium fluoride (used at water treatment works) is ingested with water, nearly all the fluoride may be absorbed. If the fluoride is taken with milk or food, however, then much less is absorbed because of the formation of insoluble complexes or precipitates. If the food and drink ingested at the same time as the fluoride has high calcium content, then again absorption will be much reduced. Factors such as the aluminium and magnesium content of the water of food as well as water pH also influence how much is absorbed. So the problem for scientists is that it is difficult to actually work out ingestion and absorption rates.

### Fluoride and dental health

Much of the evidence that water fluoridation reduces dental caries (cavities) comes from research conducted several decades ago. The Department of Health therefore commissioned the NHS at the University of York to summarise all the relevant studies.

The York review (2000), confirmed the beneficial effect of water fluoridation on dental cavities, but also pointed out that fluoridation is associated with increased prevalence of dental fluorosis (a defect of the enamel ranging from mild speckling to serious staining).

The review concluded that insufficient high-quality research had been carried out. Whether fluoridation was, on the whole, a good or bad thing was still not clear.

### Fluoridation of water supplies

The first Local Authority water fluoridation schemes were introduced in England and Wales between 1964 and 1975. Some five million people now receive water in which the fluoride content has been artificially increased to a level of one part per million.

Major schemes are in operation in Birmingham and throughout the West Midlands, and also in Tyneside. In addition, about 500,000 people receive water which naturally contains fluoride at or about the level of one part per million. A further one million people receive water which naturally contains fluoride at a lower level, but which is still considered to confer some dental benefits.

Many scientists believe that fluoridation is a safe, simple, and cost-effective public health measure to reduce the incidence of dental caries. Organisations that support fluoridation include the World Health Organisation, the British Medical Association, the British Dental Association and, in the USA its use has been endorsed by the Surgeon General, the American Medical Association and the American Dental Association.

But opponents of fluoridation view it as an infringement of personal rights and believe that it causes ill health and that there is a need for more research.

### Uncertainties in the research

Even pro-fluoridation scientists accept that it is difficult to measure accurately the beneficial effects of fluoridation. For example, many studies have tried to compare the incidence of dental caries in fluoridated and non-fluoridated areas.

These have almost always shown that the level of caries is lower in the fluoridated area. But drinking water is only one source of fluoride – the reduction in caries may be due to the fact that more people in the fluoridated area brush their teeth more regularly or effectively or they may have gained fluoride from food or drinks. If the source of the fluoride was something other than drinking water, what would be the point of spending tens of thousands of pounds annually on giving them even more fluoride – which might even harm them?

On the other hand, people in non-fluoridated areas may be getting the benefit of fluoride by consuming fluoride in their food. This would have the effect of reducing the observed differences in dental caries between fluoridated and nonfluoridated communities, which may cause an underestimation of the benefits of water fluoridation!

### Should fluoridation be targeted ?

As for many diseases in the UK, the prevalence of toothache, caries, abscesses and dental extractions needing general anaesthesia is more prevalent in the more deprived social groups than in more affluent social groups.

There is strong evidence that this is simply because more affluent children eat less sugar and brush their teeth with a fluoride toothpaste more often than do more socially deprived children.

Minority ethnic groups, particularly young children of Muslim non-English speaking mothers, have been shown to be at particularly high risk of dental caries. The British Dental Association has suggested that water fluoridation should be targeted to high risk communities in order to try to reduce the widespread geographical and social inequalities in dental health. One suggestion is that water fluoridation should be targeted at those districts with mean diseased, missing or filled teeth (dmft) at age 5 years greater than 2.0 and with water supply schemes covering around 200,000 residents.

The York Review examined the results of the fifteen UK studies published between 1969 and 1999 which investigated the associations between water fluoridation, dental caries and social class. They concluded that:

- the number of studies in the UK (fifteen) was very small
- the quality of the evidence from the studies was low
- there was no evidence that water fluoridation reduced the caries prevalence/social class gradient
- there was some evidence that water fluoridation reduces inequalities in dental health across the social classes in 5 and 12 year old children, using the dmft measure, but not when the criteria used was the percentage of children with no caries

### How Science Works

The York Review was basically saying that:

- Not enough data has been collected to be sure either way
- Other variables that could have influenced the results were not taken into account in most studies
- Some studies measured the effect of fluoridation in different ways, making comparisons difficult

This makes government decision-making extremely difficult!

### Too much fluoride damages teeth

Dental fluorosis ranges from barely-visible white striations on the teeth through to gross defects and staining of the enamel. The York Review looked at 88 studies, drawn from 30 countries, that compared rates of fluorosis in fluoridated and non-fluoridated areas. Prevalence (all levels of severity) averaged 48% in fluoridated areas and 15% in non-fluoridated areas. When the scientists just considered the prevalence of serious staining the review found the prevalence of fluorosis to be 12.5% in fluoridated areas and 6.3% in non-fluoridated areas.

However, for any given fluoride concentration in water the prevalence of serious dental fluorosis was higher in naturally fluoridated areas than in artificially fluoridated areas. To confuse matters even more, the York Review included studies in countries with hotter climates than the UK: in hot climates, water intake is typically higher than in the UK and the risk of fluorosis correspondingly greater for any given water fluoride concentration.

Some scientists suggest that many studies have underestimated the prevalence of serious fluorosis in the UK. They point to research undertaken in 2000 that found prevalence of fluorosis (in upper permanent incisor teeth) to be 3% in fluoridated Newcastle and 0.5% in non-fluoridated Northumberland.

An EU-funded study photographed hundreds of children's teeth in 7 countries to identify the prevalence of aesthetically important fluorosis. Only in Cork was the drinking water artificially fluoridated.

Area	No. of children photographed	Prevalence of aesthetically important fluorosis / %
Cork (Ireland)	325	4
Knowsley (UK)	314	1
Haarlem (Netherlands)	303	4
Athens (Greece)	283	0
Almada (Portugal)	210	1
Reykjavik (Iceland)	296	1
Oulu (Finland)	315	0

The British Society for Paediatric Dentistry suggests that children at low risk of caries should use a small pea-sized amount of lower fluoride toothpaste under parental supervision.

### Conclusions?

Should the government make water companies add fluoride to everyone's water supplies? The consensus is "Not yet" because there are gaps in the scientific research. More research is needed on:

- How much fluoride are people absorbing from non-water sources
- Individuals that are occupationally exposed to fluoride. This will help us to get a better understanding of the uptake, absorption, excretion and health effects of fluoride
- How water hardness affects the absorption of fluoride
- Individuals' lifetime intakes of fluoride, using both urinary and ingestion data,
- Whether the rate of absorption of fluoride is the same from naturally and artificially fluoridated sources
- The use of toothpastes by children

Until the picture becomes clearer, many scientists believe that mass-fluoridation should be avoided.

### Practice Question

Some scientists believe that adding fluoride to drinking water is a safe, cost-effective way of improving dental health. Others argue that fluoride is a toxin and capable of causing harm to health.

Outline the information that is needed to decide which of these views is correct (4)

The toxicity of fluoride;  
How much is needed in tap water to reduce tooth decay;  
A comparison of these amounts;  
Non-water sources of fluoride;  
Ease of absorption from naturally and non-naturally fluoridated supplies;  
Fluoride toxicity in different ages;

Answers

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