

Dental fluorosis

KEY POINTS

- There are some 90 different causes of markings on the enamel surfaces of teeth. These are known as 'enamel defects'.
- One of the 90 or so causes of enamel defects is called 'fluorosis'.
- In most cases, fluorosis appears as barely visible pearly white flecks on the surface of teeth and is undetectable except by an expert.
- The more obvious, cosmetically unacceptable forms of fluorosis are uncommon in the UK.
- The risk of fluorosis can be reduced if parents follow dentists' advice on supervising how their children use fluoride toothpaste and on whether or not they should also be given fluoride supplements.



1. What is dental fluorosis?

Dental fluorosis appears as markings on the enamel surface of teeth. It is one of 90 or so 'enamel defects' that may affect teeth, and is caused when children ingest excessive amounts of fluoride while their teeth – primary and permanent – are developing in the gums (i.e., before the teeth erupt into the mouth).

From a cosmetic point of view, the permanent front teeth are the most important, as they are the most visible teeth over someone's lifetime. The time when these teeth are most susceptible to developing fluorosis extends from when a child is born to six years of age, although some research suggests that the first two years of life is the most critical period (1) (2). From about the age of seven onwards, children's permanent teeth will have already developed and their risk of fluorosis is thereafter unaffected by the amount of fluoride they ingest from whatever source.

Most cases undetectable except by an expert

In most cases, dental fluorosis appears as barely visible pearly white flecks on the surface of the tooth and is undetectable except by an expert. In other words, most people whose teeth are affected by fluorosis are unlikely to notice it. Nor are they likely to notice the majority of cases of fluorosis in other people.

As already stated, there are about 90 different causes of 'enamel defects' or markings on teeth, of which three or four causes – including dental fluorosis – are the most commonly occurring. In the UK, it is estimated that around 40% of people are likely to have teeth with enamel defects of one kind or another. About half of these cases – affecting around 20% of the population – are dental fluorosis, mainly in its mildest forms (3).

These mildest forms of dental fluorosis give teeth a 'pearlescent' appearance. Some people regard these teeth as being whiter than teeth that are unaffected by fluorosis. Indeed, one study has shown that adolescent children think that teeth with the mildest forms of fluorosis are more attractive than those without fluorosis (4).



Very mild dental fluorosis (TF1) giving teeth an attractive, 'pearlescent' appearance

Cosmetically unsightly forms less common in the UK

The most severe forms of dental fluorosis, which are characterised by much more noticeable markings, are uncommon in the UK. Dental practitioners report that they rarely see such cases of unsightly, cosmetically unacceptable dental fluorosis among people born in this country. The brown staining associated with the worst types of fluorosis is generally seen when there is a combination of high naturally occurring levels of fluoride in water supplies, malnutrition and hot climatic conditions.

It should also be stressed that the diagnosis of dental fluorosis is not straightforward. Differentiating between enamel defects attributable to fluorosis and defects attributable to other causes requires teeth to be examined under good lighting after they have been dried. As a result, it has been difficult to estimate the true prevalence of this cosmetic condition in the UK.

Offsetting the small risk of fluorosis against the prevention of significant levels of tooth decay

It is important to keep fluorosis in perspective. Not only is there evidence that the mildest forms of fluorosis may be considered to be 'attractive' by some people, but the same study suggests that children with fluorosis have significantly less tooth decay than those without it (4).

Furthermore, tooth decay poses a health risk to significant numbers of young children, especially in those communities within the UK with higher than average levels of social deprivation (5), (6), (7). Tooth decay in children's front teeth may also be unsightly and painful. The adverse cosmetic and health aspects of tooth decay – and the role of fluoride in reducing tooth decay – should be taken into account when the risk of dental fluorosis is discussed.

Dental fluorosis is caused by excessive ingestion of fluoride as teeth are being formed during early childhood. The fluoride may be ingested from toothpaste, dietary fluoride supplements and water. The British Dental Association and other specialist organisations believe that an especially important factor in the development of cosmetically significant fluorosis is the routine swallowing of fluoride toothpaste by young children.



Rampant tooth decay in children's front teeth is especially unsightly, as well as being potentially very painful.

Dental fluorosis affects a proportion of people living in communities whose water supplies contain naturally occurring fluoride only and a proportion of those living in areas where the natural fluoride in water has been artificially supplemented to help prevent tooth decay.

2. The prevalence of fluorosis

Estimates in the York report

In 2000, a research team at the University of York published the findings of its systematic review of 88 previously conducted studies into the relationship between water fluoridation and dental fluorosis (8).

The studies had been carried out in 30 countries, including some with naturally occurring fluoride levels in water of up to 5 parts per million (i.e., five times higher than that used in UK fluoridation schemes). The review found that, from the available evidence, there is a relationship between the fluoride level in water and the amount of dental fluorosis. As the fluoride level increases, the amount and severity of dental fluorosis in the population also increases.

This is nothing new. The relationship between fluoride levels in water and the amount of dental fluorosis has been known about since the 1930s. Indeed, the beneficial effects of fluoride in water were first discovered during investigations of people with 'mottled teeth' in areas of the world where levels of natural fluoride in water were very high (9).

From its review of studies, the University of York team estimated the prevalence of dental fluorosis of all levels of severity (including the mildest forms) to be 48% in fluoridated areas (both naturally fluoridated and artificially fluoridated) and 15% in non-fluoridated areas.

However, the difference in prevalence between fluoridated and non-fluoridated areas was much smaller when levels of cosmetically significant fluorosis were compared. In this case, York estimated the prevalence to be 10% to 12% in fluoridated areas and 6% in non-fluoridated areas. The estimate for fluoridated areas included data from studies carried out in both artificially fluoridated communities and those with naturally occurring fluoride in water at the same or higher concentrations.



Dental fluorosis (TF3) - at the lower end of the range of severity classified by York as being 'of aesthetic concern'.

Using data from European studies, a Medical Research Council working group estimated that a realistic figure for the prevalence of fluorosis of aesthetic concern was around 3% to 4% in artificially fluoridated areas and around 1% in non-fluoridated areas.

Revised estimates in Medical Research Council report

Following publication of the York review of water fluoridation, the Department of Health asked the Medical Research Council (MRC) to consider its findings and make recommendations on priorities for further research. With regard to dental fluorosis, further analysis of the data carried out by the York team on behalf of an MRC working group indicated that the risk of cosmetically significant fluorosis was greater in naturally fluoridated areas than in artificially fluoridated areas, even when the fluoride concentrations were exactly the same (10).

This was an unexpected finding, which called into question the relevance of York's original estimates of up to around a 12% prevalence of fluorosis of aesthetic concern in artificially fluoridated areas. Having considered this and other information, the MRC working group suggested that a more realistic prevalence figure would be around 3% to 4% in artificially fluoridated areas and around 1% in non-fluoridated areas. Studies conducted in the UK and Ireland between 1997 and 2003 (see table 1) support the MRC's calculations.

Table 1: The prevalence of dental fluorosis of aesthetic concern in recent UK/Irish studies

| Authors and year of publication | Age group (years) of children examined | Year in which fieldwork conducted | Area(s) where study was conducted | Fluoridated (F) or Non-Fluoridated (NF) | % prevalence of fluorosis of aesthetic concern |
|---------------------------------|--|-----------------------------------|---|---|--|
| Tabari et al 2000 (11) | 8 - 9 | 1998 | Newcastle Northumberland | F NF | 3% 1% |
| Cochran et al 2004 (12) | 8 | 1997 - 1998 | Cork Knowsley and five other European cities | F NF | 4% 1% |
| Tavener et al 2004 (13) | 8 - 9 | 2001 - 2002 | North West England | NF | 1% |
| Whelton et al 2003 (14) | 8 | 2001 - 2002 | Rep. of Ireland Rep. of Ireland North Ireland | F NF NF | 4% 0% 0% |
| Chadwick and Pendry 2004 (15) | 12 | 2003 | United Kingdom | NF | 1% |

A study of fluorosis in several European cities (12), published in 2004, estimated prevalence to be between 0% and 4%. Fluorosis prevalence in Cork, the only one of these cities to have a fluoridated water supply, was 4% (see table 2).

Table 2: The prevalence of cosmetically significant fluorosis in European cities

| | Number of children photographed | Prevalence of cosmetically significant fluorosis |
|-----------------------------|---------------------------------|--|
| Cork, Ireland (fluoridated) | 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% |

Balancing the small increase in fluorosis against significant reductions in tooth decay

When public health decisions are made about water fluoridation, it is important to set this relatively small increase in the prevalence of fluorosis against the expected reductions in tooth decay across a whole population.

York's own review of the dental benefits suggested that, on average, children in fluoridated areas have 2.25 fewer teeth decayed, missing and filled than those in non-fluoridated areas (an estimated 40% reduction in tooth decay overall). In addition, York estimated that nearly 15% more children in fluoridated areas were completely free of tooth decay than in non-fluoridated areas. These are significant dental health benefits.

Furthermore, there is evidence that fluoridation benefits adults as well as children. A systematic review of studies of adults with lifelong residence in fluoridated and non-fluoridated communities found that those who had drunk fluoridated water for all or most of their lives had, on average, between 27% and 35% fewer teeth affected by decay (15).

New Zealand oral health survey figures for fluorosis

A 2008/09 oral health survey in New Zealand found that 54.5% of children and adults between 8 and 30 years old in fluoridated areas showed no signs whatever of dental fluorosis, even in its very mildest forms, compared with 56.9% of those in non-fluoridated areas (16).

No one in any age group, whether in a fluoridated or non-fluoridated area, was found to have severe fluorosis. However, for levels of fluorosis classified between 'very mild' and 'moderate', slightly more people in New Zealand's non-fluoridated areas were found to be affected than in its fluoridated areas.

Table 3: Findings of New Zealand Oral Health Survey on prevalence of fluorosis

| Level of fluorosis | Prevalence of fluorosis among 8-30 year olds | | |
|------------------------|--|-----------------------------|---------------------------------|
| | All | Living in fluoridated areas | Living in non-fluoridated areas |
| None (level 0) | 55.5% | 54.5% | 56.9% |
| Questionable (level 1) | 27.2% | 30.6% | 22.7% |
| Very mild (level 2) | 10.2% | 10.2% | 10.3% |
| Mild (level 3) | 5.1% | 3.0% | 7.8% |
| Moderate (level 4) | 2.0% | 1.7% | 2.3% |
| Severe (level 5) | 0.0% | 0.0% | 0.0% |

A New Zealand survey from 2008/09 suggested a prevalence of 4.7% of fluorosis of aesthetic concern in fluoridated areas compared with 10.1% in non-fluoridated areas.

The York report on water fluoridation, published in 2000, classified dental fluorosis of potential aesthetic concern to be any level of fluorosis that was 'mild' (TF3) or worse. On this basis, the New Zealand figures suggest a prevalence of 4.7% of fluorosis of aesthetic concern in fluoridated areas and 10.1% in non-fluoridated areas.

The figure for fluoridated areas is around the same as the UK Medical Research Council's estimate based on studies conducted of dental fluorosis in Europe. However, the prevalence for non-fluoridated areas of New Zealand appears to be considerably higher. It is possible that the use of fluoride tablets and supplements in those areas may have contributed to the higher than expected levels of dental fluorosis.

A study published in 2012 found a negligible prevalence of severe dental fluorosis in both fluoridated Newcastle upon Tyne (0.1%) and non-fluoridated Manchester (0.2%). The clinically most significant difference between the cities was in the prevalence of mild fluorosis - 6% in Newcastle and 1% in Manchester.

The New Zealand oral health survey confirmed significant dental health benefits from fluoridation. Results showed that, on average, children aged between 2 and 17 in fluoridated areas had 38% fewer teeth affected by decay than those in non-fluoridated areas. Adults aged 18 and over in fluoridated areas were found, on average, to have 22% fewer teeth affected by those than those in non-fluoridated areas. Further details are given in the *Dental Benefits* section of *One in a Million*.

Comparison of prevalence in Newcastle and Manchester

A study by McGrady et al, published in 2012, examined levels of dental fluorosis among 11-13 year olds in fluoridated Newcastle upon Tyne and non-fluoridated Manchester (17). It found that the prevalence of TF5 (severe) fluorosis was 0.1% in Newcastle compared with 0.2% in Manchester. The prevalence of TF4 (moderate) fluorosis was 1% in Newcastle and 0% in Manchester. The clinically most significant difference between the two cities was in the prevalence of TF3 (mild) fluorosis, which was found to be 6% in Newcastle and 1% in Manchester.

Table 4: Findings of study comparing fluorosis levels among 11-13 year olds in Newcastle and Manchester

| Level of fluorosis | Prevalence of fluorosis among 11-13 year olds | |
|--------------------|---|----------------------------|
| | Fluoridated Newcastle | Non-fluoridated Manchester |
| TF0 (none) | 45% | 73% |
| TF1 (questionable) | 39% | 24% |
| TF2 (very mild) | 9% | 2% |
| TF3 (mild) | 6% | 1% |
| TF4 (moderate) | 1% | 0% |
| TF5 (severe) | 0.1% | 0.2% |

Dental examinations found that 11-13 year old children in fluoridated Newcastle had, on average, 34% fewer decayed, missing and filled teeth than those in non-fluoridated Manchester. Further details are given in the *Dental Benefits* section of *One in a Million*.

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York's own review of the dental benefits suggested that, on average, children in fluoridated areas have 2.25 fewer teeth decayed, missing and filled than those in non-fluoridated areas (an estimated 40% reduction in tooth decay overall). In addition, York estimated that nearly 15% more children in fluoridated areas were completely free of tooth decay than in non-fluoridated areas. These are significant health benefits.

Furthermore, there is evidence that fluoridation benefits adults as well as children. A systematic review of studies of adults with lifelong residence in fluoridated and non-fluoridated communities found that those who had drunk fluoridated water for all or most of their lives had, on average, between 27% and 35% fewer teeth affected by decay (18).

3. Maximising the dental benefits of fluoride while minimising the risk of fluorosis

Dental advice to parents of children up to seven years of age

Is it possible to achieve the maximum possible dental benefits from fluoridated water at the same time as minimising the risk of fluorosis?

Dental advice to parents in the UK is to supervise their children's toothbrushing very carefully up to the age of seven, making sure that only a smear or pea-sized amount of fluoride toothpaste is placed on the brush and that their child spits it out after brushing (19). Given that a major factor in dental fluorosis is believed by many experts to be the swallowing of fluoride toothpaste by young children, this advice is relevant to parents in both fluoridated and non-fluoridated areas. Children should brush their teeth no more than twice a day. The Department of Health, British

Dental Association and British Society for the Study of Community Dentistry recommend that those aged seven and under should use a toothpaste with a fluoride concentration of 1,000 parts per million (ppm). Over this age, toothpastes with a 1,500 ppm fluoride concentration are more effective.

In some other countries where a significant majority of people are supplied with fluoridated water, such as the United States and Irish Republic, dental advice is that children under two years old should use non-fluoride toothpastes. In Australia, which also has extensive fluoridation schemes, the advice is that they should use toothpaste with a lower than 500 ppm fluoride concentration (20).



Clearly, this is a matter that bodies with public health responsibilities in the UK and elsewhere will keep under constant review in their efforts to prevent tooth decay and, at the same time, minimise the risk of fluorosis.

Another potential source of fluoride intake for young children is from fluoride drops and tablets. These should be given only on the advice of a dentist or doctor. When such advice is given, the drops or tablets should be taken at a different time of day from toothbrushing with a fluoride toothpaste (21). It is extremely unlikely that dentists or doctors would recommend the use of fluoride drops or tablets in areas supplied with artificially or naturally fluoridated water at the 1 ppm concentration.

4. Perceptions of fluorosis

NHS Dental Epidemiology Programme survey of 12 year olds' perceptions of white marks on their teeth

A report published in 2011 by the NHS Dental Epidemiology Programme shows little variation between the proportions of 12-year olds in different regions of England who have noticed white marks on their teeth (possible signs of dental fluorosis) or are bothered about such marks (22). Of the 89,442 children surveyed nationally, 15.7% said they had noticed white marks on their teeth, while 84.3% said they had no white marks or did not know whether they had any. Across

Of the small minority of 12-year old children across England who said they had noticed white marks on their teeth (15.7%), only about a quarter said they were bothered by those marks. This represented just 4% of all the children who took part in the survey.

Overall, Irish adolescents asked to rate the aesthetic acceptability of different levels of fluorosis gave the same rating to teeth that were unaffected as they did to teeth with questionable or very mild fluorosis. A photograph depicting dental caries was rated least favourably of all.

the regions, the numbers who said they had white marks ranged from 14.6% to 18.4%.

In the West Midlands, where nearly three out of four people are supplied with fluoridated water, 16.8% of 12-year olds said they had noticed white marks on their teeth. In London, where there is no fluoridation scheme in operation, the figure was 17.4%.

Of the small minority of 12-year olds across England who thought their teeth had white marks, about a quarter said they were bothered by them. This represented just 4% of all the children who took part in the survey. Again, there was little difference between regions. In the mainly fluoridated West Midlands, 4.7% of those questioned said the marks bothered them. In non-fluoridated London, the figure was 5.1%.

Children who said they had white marks were then shown three photographs of teeth. One photograph was of teeth with no 'enamel opacities'. One showed teeth with mild opacities. One showed teeth with aesthetically significant marks.

The children were asked to say which one of the photographs was the closest match to their own teeth. Interestingly, 30.7% of those who had said they had white marks on their own teeth chose the photograph of teeth with no marks, whilst 26.4% of those who had said the white marks bothered them also chose the photograph with no marks.

Irish study of adolescents' perceptions of different levels of fluorosis and dental caries

An Irish study, published in 2011, asked adolescents aged 14-15 to indicate the aesthetic acceptability of photographs of teeth with and without fluorosis (23). Overall, participants gave the same rating to photographs of teeth unaffected by fluorosis (TF0) or with questionable (TF1) or very mild fluorosis (TF2), suggesting that they could see little difference between them. A photograph depicting mild fluorosis (TF3) was rated less favourably, whilst a photograph depicting dental caries was rated least favourably of all.

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