36. Fluoride

36.1 Function and Essentiality  No essential function for fluoride (F) has been proven in humans. However, it forms calcium fluorapatite (3Ca3[PO4]2CaF2) in tooth and bone and may have a role in bone mineralisation. It protects against dental caries and assists remineralisation of bone and teeth in pathological demineralising conditions. An inverse relationship between the prevalence of dental caries and the fluoride concentration of the drinking water was observed in the 1940s and the addition of fluoride to the drinking water to a level of 1ppm (1mg/l) leads to a decrease in the prevalence of caries (for review see 1,2). A compilation of 113 water fluoridation studies, from all over the world, found that artificial water fluoridation is effective in reducing caries experience by approximately 50%, regardless of climate, race or social conditions2.

36.2 Requirements  Ionic fluoride is rapidly and nearly completely absorbed passively from the stomach but protein-bound organic fluoride is less bioavailable3. As there does not appear to be a physiological requirement for fluoride, the Panel set no RNI. Nevertheless, because of its role in the prevention of dental caries, the Panel endorses the recommendation for the continued fluoridation of water supplies to achieve levels of 1ppm.

36.3 Intakes  Total fluoride intakes depend on the concentration of fluoride in the water supplies. However, only about 10% of the UK population receives a water supply which has either been fluoridated or has a naturally-occurring fluoride content at or around 1 ppm. The MAFF Total Diet Study has estimated that adults had a mean intake of 1.82mgF/d in non-fluoridated water areas or 2.90mgF/d in fluoridated water areas, assuming an average consumption of 1.1L water daily4. Tea contains high concentrations of fluoride and provides 70% of the average fluoride intake. Extreme tea consumers drinking tea made from fluoridated water may reach intakes of 12mg/day5. A study of adolescents in the UK estimated from dietary records that the intake of fluoride from drinks (water, soft drinks and tea) was 0.96mg/d6.

36.4 The concentration of fluoride in breast milk is low and ranges from 5–25µg/L1 (0.26–1.3µmol/L)7. The consumption of fluoride by infants aged six months to one year and fed with a British milk formula reconstituted with unfluoridated water has been estimated to be 0.010–0.012mg/kg body weight/d8. Consumption of drinking-water fluoridated to a concentration of 1ppm results in a daily oral fluoride intake of 0.22mg/kg body weight in a 1 month-old bottle-fed baby (daily fluid intake 200ml/kg body weight, contributing 0.2mg/kg body weight, and

1 1µmol = 19µg
fluoride from reconstituted feed contributing 0.02 mg/kg body weight). The daily intake per kg body weight falls with increasing age. A child aged 3–4 years, weighing 15 kg, drinking 1 litre of water daily, and ingesting 0.3 mg fluoride daily from food (+) and 0.5 mg fluoride daily from toothpaste, would consume 0.12 mg/kg body weight daily.

36.5 Supplements The British Dental Association recommends fluoride supplements as a protection against dental caries for infants and young children in areas where the water supply contains less than 0.7 ppm F. The dosage depends on the age of the child and the level of fluoride in the local water supply (see Table 1).

Table 1 Recommended fluoride supplement level (mg/day) depending on age and fluoride concentration in the drinking water.

<table>
<thead>
<tr>
<th>Age</th>
<th>Concentration of Fluoride in drinking water</th>
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<tbody>
<tr>
<td></td>
<td>&lt;0.3 ppm</td>
</tr>
<tr>
<td>6 months to 2 years</td>
<td>0.25</td>
</tr>
<tr>
<td>2-4 years</td>
<td>0.50</td>
</tr>
<tr>
<td>4-16 years</td>
<td>1.00</td>
</tr>
</tbody>
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(From: *)

36.6 Guidance on high intakes Excessive fluoride intakes can cause dental fluorosis and very high intakes can lead to skeletal fluorosis. Dental fluorosis affects the enamel during the formation of the teeth before they erupt, and can range from very mild mottling, which is only detectable by close examination of dried teeth in good light, to severe fluorosis with pitting of the enamel and widespread brown staining of the teeth. In areas where the water contains 1 ppm fluoride, about 10% of children show some tooth mottling indicative of very mild dental fluorosis. More pronounced mottling is seen in children living in areas where the fluoride concentration is higher. Two surveys have shown that bottle-fed infants have a higher prevalence of mottling and a higher fluorosis index than do breast-fed infants but they were within the aesthetically acceptable level. The prevalence of very mild and mild fluorosis has increased in the USA since the 1940s when water fluoridation was introduced but the largest increases have been in non-fluoridated areas.

36.7 Excessive intakes of fluoride over a prolonged period of time (20–80 mg/d for 10–20 years) can lead to skeletal fluorosis, resulting in ossification of the ligaments and fusion of the spine (for review, see 1). Occupational skeletal fluorosis was most commonly seen in people working in aluminium production, magnesium foundries, flourspar processing and superphosphate manufacture, prior to the introduction of adequate controls. Endemic, as opposed to occupational, skeletal fluorosis occurs in parts of the Indian sub-continent, China and Africa but has not been observed in temperate countries (where the quantity of water drunk is generally lower) with drinking water concentrations less than 4 ppm. In an area of the USA where the water naturally contained 8 ppm, radiological and clinical examination of residents found no evidence of deleterious bone changes from fluoride exposure although bone thickening was seen in 10–15% of the population. Acute toxic doses range
from 1 to 5 mg/kg body weight; doses exceeding 15 to 30 mg/kg body weight may be fatal.

36.8 Safe Intakes A water fluoride concentration of 1 ppm contributes substantially to protection against dental caries, without causing cosmetically significant dental mottling. Therefore fluoride intakes, expressed as mg/kg body weight/day, associated with this level of water fluoride concentration can be considered safe. Fluoride intakes in infants and children in unfluoridated areas without supplementation are below that required for optimal dental health.

36.8.1 Infants up to 6 months Fluoride intakes of about 0.22 mg/kg body weight/day (0.9 mg/day) are found in the first month of life in formula-fed infants in areas with fluoridated water. This falls to about 0.13 mg/kg body weight/day (1.0 mg/day) in 6 month old infants. Intakes of fluoride up to 0.22 mg/kg body weight/day in infants up to 6 months are safe.

36.8.2 Infants and children up to 6 years Fluoride intake per kg body weight falls with increasing age. Up to 6 years, which is the period of mineralisation of the crowns of the anterior permanent teeth (i.e. those that are vulnerable to cosmetically significant dental mottling), fluoride intakes of up to 0.12 mg/kg body weight/day (1.8 mg/day for a child aged 3–4 years; 2.3 mg/day for a child aged 5–6 years) are found in areas with fluoridated water and are not associated with cosmetically significant dental mottling. Intakes of fluoride of 0.12 mg/kg body weight/day in infants and children between 6 months and 6 years of age are safe.

36.8.3 Children over 6 years and adults After 6 years of age it is no longer possible for further exposure to fluoride to give rise to cosmetically significant mottling but the dental benefit from continued exposure persists. An adult weighing 60 kg, drinking 1.1 litres of fluoridated water daily, and ingesting 2 mg fluoride from food would have a daily fluoride intake of 0.05 mg/kg body weight (3 mg/day). This exposure is less than those associated with skeletal fluorosis and has not been shown to be associated with adverse effects. Intakes of fluoride of 0.05 mg/kg body weight daily in children aged over 6 years and in adults are therefore safe. Consumers of exceptionally large quantities of tea, in areas with fluoridated water, may have fluoride intakes several times greater (estimated as up to 12 mg/day in a 60 kg adult or 0.2 mg/kg/day). Fluoride may be less readily absorbed from tea than from water, but nevertheless the absence of any reports of adverse effects from such exposures in the UK indicates that there is a further wide safety margin above the more usual intakes in fluoridated areas.

36.9 References


