Position of the American Dietetic Association: The Impact of Fluoride on Health

ABSTRACT
The American Dietetic Association reaffirms that fluoride is an important element for all mineralized tissues in the body. Appropriate fluoride exposure and usage is beneficial to bone and tooth integrity and, as such, has an important, positive impact on oral health as well as general health throughout life. Fluoride is an important element in the mineralization of bone and teeth. The proper use of topical and systemic fluoride has resulted in major reductions in dental caries (tooth decay) and its associated disability. The Centers for Disease Control and Prevention have named fluoridation of water as one of the 10 most important public health measures of the 20th century. Nearly 100 national and international organizations recognize the public health benefits of community water fluoridation for preventing dental caries. However, by the year 2000, over one third of the US population (over 100 million people) were still without this critical public health measure. Fluoride also plays a role in bone health. However, the use of high doses of fluoride for prevention of osteoporosis is considered experimental at this point. Dietetics professionals should routinely monitor and promote the use of systemic and topical fluorides, especially in children and adolescents. The American Dietetic Association strongly reaffirms its endorsement of the appropriate use of systemic and topical fluorides, including water fluoridation, at appropriate levels as an important public health measure throughout the life span.

POSITION STATEMENT
The American Dietetic Association reaffirms that fluoride is an important element for all mineralized tissues in the body. Appropriate fluoride exposure and usage is beneficial to bone and tooth integrity and, as such, has an important, positive impact on health throughout life.

Fluoride is a natural element found at varying concentrations in drinking water as well as in soil. It is considered a beneficial nutrient at optimal levels (1) and is present in trace amounts in the body. Fluoride is important for the integrity of bone and teeth. Approximately 99% of the fluoride in the body is in the hard tissues (2). When consumed in optimal amounts in water and food, and used topically in fluoridated dentifrices, oral rinses, gels, foams, and professionally applied office treatments, fluoride does the following:

- increases tooth mineralization;
- helps reduce dental enamel demineralization and promote dental enamel remineralization; and
- helps reduce dentin hypersensitivity.

The use of fluorides for the prevention of dental caries is recognized as the most effective dental public health measure in existence (3-6). Nearly 100 national and international organizations recognize the public health benefits of community water fluoridation for preventing dental caries (5,7,8). Fluoride is important for bone health as well, via its role in normal mineralization. The most recent Dietary Reference Intakes establish new recommendations for fluoride intake (1). See Table 1 for these recommendations.

FLUORIDE AND BONE
Fluoride is one of only a few known agents that can stimulate bone cell (osteoblast) proliferation and increase new mineral deposition in cancellous bone. Fluoride incorporation into bone increases the size and, thus, decreases the solubility of the bone (apatite) crystals. Larger crystals are more resistant to osteoclastic attack (osteoclasts are cells involved in bone resorption). However, the amount of fluoride in the water supply considered optimal to promote oral health (1 ppm or 1 mg/L) (10) is not considered sufficient to prevent osteoporotic fractures (11-13).

Metaanalysis of the efficacy of fluoride therapy (at fluoride levels much higher than from water fluoridation) on bone loss and fractures (14) and other comprehensive reviews (15,16) have determined that, although fluoride has an ability to increase bone mineral density in the lumbar spine, it does not cause a reduction in vertebral fractures (17) and may increase adverse effects. Evidence from randomized clinical trials is insufficient to support a role for fluoride in the prevention, decrease, or increase of fracture rates (18,19). This is supported by osteoporosis clinical practice guidelines from Canada (20) and the United States (21,22).

FLUORIDE EFFICACY IN DENTAL CARIES PREVENTION
Fluoride is an important protective factor against dental caries. Dental caries is a transmissible, multifactorial disease that is the most common chronic condition of childhood. It is five times more common than childhood asthma and seven times more common than hay fever (23). Furthermore, there is a great disparity in the distribution of dental caries in the United States, with the poor having a disproportionately high share of the disease burden (24).

Dental caries affects approximately 6% of children aged 1 year, 22% aged 2 years, 35% aged 3 years, 48% aged 4
years, over 50% of children aged 5 to 9 years, 77% of adolescents aged 12 to 17 years, and 85% of adults aged 18 years or older in the United States. Furthermore, 50% of adults over age 75 years have root caries in at least one tooth (23). High-risk groups include the following:

- children who do not regularly receive dental care and/or do not have dental insurance;
- those with active caries or a family history of active caries;
- those with high levels of acidogenic oral bacteria (eg, *Mutans Streptococci, Lactobacilli*);
- those with diminished salivary flow;
- those with a cariogenic diet; and
- those receiving inadequate fluoride exposure.

Dental caries can have important effects on general health throughout life. It can contribute to failure to thrive, inability to bite and chew (with subsequent poor nutrition), and impaired self-esteem (23).

**Fluoride is an important protective factor against dental caries.**

The relationship between fluoride and dental caries was first noted in the early part of the 20th century when it was observed that residents living in areas of the country with naturally high levels of fluoride in the water had brown-stained teeth, which were highly resistant to caries (25). It was later determined that fluoride consumption at optimal concentrations of 0.7 to 1.2 ppm in the water supply imparted protection against development of dental caries, without staining teeth.

The later part of the 20th century saw a major decline in the prevalence and severity of dental caries in many developed nations, attributed in large part to community water fluoridation and other fluoride sources (3,23). However, more than 100 million Americans still do not have access to fluoridated water (23).

**Mechanisms of Fluoride Action on Teeth**

Fluoride incorporated into the developing enamel of teeth preeruptively results in a crystal tooth structure with increased caries resistance. However, recent research has found that the primary action of fluoride occurs topically after tooth eruption into the mouth, and the benefits continue throughout life (3,26). Dental caries results when acidogenic bacteria colonized on tooth surfaces metabolize fermentable carbohydrates to sugar and from there to acids (eg, acetic, butyric, formic, lactic, and propionic acid), which demineralize tooth enamel. Fluoride functions to:

- enhance tooth mineralization and remineralization;
- decrease and reverse tooth demineralization; and
- inhibit the metabolism of the acid-producing bacteria responsible for dental caries (26).

The cycle of demineralization and remineralization of teeth continues throughout the life of the tooth and explains why the topical effects of fluoride are beneficial for all age groups.

**Systemic Effects of Fluoride on Teeth (Preeruptive and Posteruptive)**

Fluoride is found in small amounts in most soil, water, plants, and animals and, as such, is a normal component of all diets. Once absorbed into the bloodstream, fluoride is either deposited into bones and developing teeth or excreted in the urine. Preruptively, during tooth development, fluoride is incorporated into the developing tooth’s mineralizing structure and helps increase resistance to acid demineralization. After tooth eruption, ingested fluoride is secreted in the saliva and contributes topically to tooth resistance. Systemic fluoride benefits developing teeth from before birth until all teeth have erupted (typically through age 12 years). The protective effects via saliva are lifelong. Saliva contains water, protein, calcium, phosphates, fluoride, bicarbonates, and immunoglobulins. Consequently, saliva is important for enamel remineralization, acid dilution and neutralization, and oral clearance of food debris. However, preeruptive fluoride is no longer considered the major mechanism by which fluoride provides optimum protection against dental caries (27-29).

**Topical Effects (Posteruptive)**

Topical mechanisms are now considered the primary means by which fluoride imparts protection to teeth. Indeed, the topical benefits of fluoride are now considered independent of the systemic effects for preventing dental caries. The posteruptive beneficial effect of fluoride likely occurs primarily from the presence of fluoride in the fluid phase at the tooth enamel surface. The frequency of fluoride exposure to the tooth surface is of prime importance to maintain high fluoride concentration in the fluid phase of enamel surfaces that will prevent caries and enhance the remineralization of early carious lesions (29). In addition to its direct mineralizing effect on enamel, fluoride also affects oral plaque bacteria. These bacteria secrete acids onto tooth surfaces (the by-products of carbohydrate fermentation), which initiate tooth demineralization. The entry

| Table 1. Dietary Reference Intakes for fluoridea |
|-----------------|-----------------|-----------------|-----------------|
| Age group       | Reference weights | Adequate intake | Tolerable upper |
| kg (lb)         | (mg/day)         | limit mg/day    |                 |
| Infants 0-6 mo  | 7 (16)           | 0.01            | 0.7             |
| Infants 6-12 mo | 9 (20)           | 0.5             | 0.9             |
| Children 1-3 y  | 13 (29)          | 0.7             | 1.3             |
| Children 4-8 y  | 22 (48)          | 1.0             | 2.0             |
| Children 9-13 y | 40 (88)          | 2.0             | 10.0            |
| Boys 14-18 y    | 64 (142)         | 3.0             | 10.0            |
| Girls 14-18 y   | 57 (125)         | 2.0             | 10.0            |
| Males 19 years and over | 76 (166) | 4.0             | 10.0            |
| Females 19 years and over | 61 (133) | 3.0             | 10.0            |

*Source: data from reference 9.*
of fluoride into the bacterial cell interferes with acid production, thus reducing potential enamel destruction. People of all ages benefit from the topical effects of fluoride whether or not they had preeruptive systemic fluoride as children (30).

INDICATIONS, SOURCES, AND EFFICACY
Fluoride is obtained from fluoridated drinking water and fluoride in foods and beverages made with fluoridated water as well as oral health products such as fluoride oral rinses, fluoride-containing dentifrices, topically applied gels and foams, and dietary fluoride supplements (eg, drops, chewable tablets, and lozenges).

Fluoridation of Community Water Supplies
Community water fluoridation is, by definition, the adjustment of fluoride in a water supply to an optimal concentration of between 0.7 and 1.2 ppm (depending on the ambient air temperature). This recommended level of fluoride (approximately 1 ppm) is considered optimal for caries prevention and safe (1). Fluoridation of public water supplies is the most cost-effective dental public health measure in existence (31). Studies continue to show that water fluoridation reduces enamel caries in children by 20% or more (32) and helps prevent root surface caries and tooth loss in adults as well. Water fluoridation is particularly beneficial for individuals living in communities with fewer resources, who have a high burden of dental caries and less access to oral health care and alternative fluoride resources (24).

Table 2. Dietary fluoride supplement schedule 1994abcd

<table>
<thead>
<tr>
<th>Age</th>
<th>Fluoride Ion Level in Drinking Water (ppm)*</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>&lt;0.3 ppm</td>
</tr>
<tr>
<td>Birth-6 mo</td>
<td>None</td>
</tr>
<tr>
<td>6 mo-3 y</td>
<td>0.25 mg/day</td>
</tr>
<tr>
<td>3-6 y</td>
<td>0.50 mg/day</td>
</tr>
<tr>
<td>6-16 y</td>
<td>1.0 mg/day</td>
</tr>
</tbody>
</table>

*Source: data from references 40 and 41.

Topical mechanisms are now considered the primary means by which fluoride imparts protection to teeth.

According to 2002 data available from the Centers for Disease Control and Prevention, over 170 million people (67% of the US population) served by public water supplies drink water with fluoride levels optimal for preventing dental caries. The goal for Healthy People 2010 objectives for the nation sets a target goal of having 75% of the population using piped water to have that water optimally fluoridated (4). However, only 24 states provide fluoride benefits to 75% or more of their residents (33); as of 2002, approximately one third of the US population was still without this critical public health measure (34). Water fluoridation is also the most cost-effective, community-based approach to dental caries prevention in the United States in terms of cost per saved tooth surface and has the benefit of reaching all segments of a population, regardless of socioeconomic status or age. The direct annual cost of fluoridation in the United States ranges from approximately $0.68 per person per year to $3.00 person per year, depending on community size (35). In most communities, $1.00 invested in fluoridation saves $38.00 or more in treatment costs (36). The diffusion of fluoride into nonfluoridated areas from bottled beverages, processed foods, and other sources can blur the effect of the water supply alone (37).

Dietary Fluoride Supplements
The prescription of dietary fluoride supplements for children living in nonfluoridated areas has been used as an alternative to water fluoridation. However, with the increasing intake of fluoride from a variety of sources (diffusion effect), there is an accompanying risk of dental fluorosis. Fluorosis is a developmental defect in dental enamel that causes white “chalky-looking” enamel in mild cases and unsightly brown staining in more severe cases. For this reason, supplementation is becoming less commonly recommended (38). The reasons for this change in philosophy are as follows:

- supplements can be prescribed without adequate water testing, leading to possible over-ingestion;
- the home may be nonfluoridated, but the drinks in other settings (eg, child care, school) could provide adequate fluoride; and
- the highest-risk children with the most to gain probably are the least likely to comply with a fluoride supplementation regimen (39).

In nonfluoridated areas, the Centers for Disease Control and Prevention recommends that fluoride supplementation be used only for children at high caries risk and not as a routine recommendation (3). Supplementation should begin at the age of 6 months and end by age 12 years because this is the period of greatest efficacy for the mineralization of unerupted permanent teeth (23). Table 2 provides the schedule for fluoride supplementation in nonfluoridated areas. However, before supplements are prescribed, the fluoride level of the primary water source should be identified. The local health department can provide the fluoride content of water from public systems. Private water sources, such as well water, may vary tremendously in fluoride content from location to location and
should be tested yearly for fluoride content.

To avoid the risk of developing fluorosis, fluoride supplements should not be prescribed for children living in fluoridated areas. The only exceptions would be if a child is fed exclusively on nonfluoridated, bottled water or is totally tube fed. Prenatally, there is little indication that the use of fluorides will confer meaningful systemic benefits to the developing fetus, so prenatal systemic fluoride intake in amounts higher than obtained normally through water and food is not recommended (23). Fluoride supplements are also not generally recommended for breastfed infants residing in fluoridated communities. Although the concentration of fluoride in breast milk is very low, many mothers combine breastfeeding with formula feeding and might be giving infants fluoridated water between feedings. Because foods processed or reconstituted with fluoridated water can add significantly to total fluoride consumption (particularly in infants), potential sources of high fluoride intake in children’s diets should be identified before any fluoride supplementation is recommended (39). All fluoride supplementation should be under the supervision of a physician or a dentist.

Table 3. Fluoride content of foods and beveragesa

<table>
<thead>
<tr>
<th>Food or beverage</th>
<th>Range of fluoride content per serving in ppm (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soft drinks</strong></td>
<td></td>
</tr>
<tr>
<td>Juices</td>
<td>0.02-1.28 (approximately 77% of soft drinks had fluoride levels above 0.6 ppm)</td>
</tr>
<tr>
<td></td>
<td>0.02-2.80 (over 42% had fluoride levels greater than 0.6 ppm)</td>
</tr>
<tr>
<td><strong>Bottled waters</strong></td>
<td></td>
</tr>
<tr>
<td>Nonfluoride</td>
<td>0.0-2.58</td>
</tr>
<tr>
<td>With fluoride</td>
<td>0.8-4.00</td>
</tr>
<tr>
<td>Tea</td>
<td>1-6 ppm brewed (depends on the amount of tea used, the fluoride in the water used, and the length of brewing)</td>
</tr>
<tr>
<td><strong>Infant foods</strong>b</td>
<td></td>
</tr>
<tr>
<td>Infant formulas (not reconstituted)</td>
<td>0.04-0.55</td>
</tr>
<tr>
<td>Ready to feed</td>
<td>0.04-0.10</td>
</tr>
<tr>
<td>Powder concentrate</td>
<td>0.05-0.28</td>
</tr>
<tr>
<td>Dry infant cereals</td>
<td>0.05-0.52</td>
</tr>
<tr>
<td>Ready-to-eat infant foods</td>
<td>0.01-8.38</td>
</tr>
</tbody>
</table>

To reduce the risk of fluorosis in developing permanent teeth, children should not swallow oral care products meant for topical use. For individuals at high risk of developing dental caries (especially those with special health care needs), concentrated fluoride solutions, gels, and varnishes are also effective when applied by dental professionals (46, 47). Fluoride rinses also provide additional caries-preventive benefits to children with high caries levels and who also drank fluoridated water and used fluoride-containing dentifrices (48, 49).

Fluoride products carrying the American Dental Association seal of approval on the product label have undergone extensive clinical testing to demonstrate their effectiveness and safety (40). To reduce the risk of fluorosis in developing permanent teeth, children should not swallow oral care products meant for topical use. The American Dental Association does not recommend the use of fluoride mouth rinses or fluoride dentifrices by children under the age of 6 years, without direct supervision, for this reason (40). For young children who can be relied on to not swallow dentifrice, only a pea-size amount should be used on the toothbrush, and the dentifrice, rinse, or gel should be expectorated thoroughly and not swallowed (2, 50).

Determining Fluoride Intake

Because of the wide availability of fluoride sources, the varied fluoride levels in foods and beverages, the effects of home water treatments and filtration systems, and the variability of fluoride in bottled waters, total fluoride intake is virtually impossible to determine (51). However, the new nationally representative database of the fluoride concentration in food and beverages consumed in the United States (52).

Water

Water and water-based beverages are the chief sources of dietary fluoride. It is estimated that, on average, approximately 80% of dietary fluoride comes from tap and bottled water and water-based beverages such as teas, coffee, carbonated beverages, beers, and ready-to-drink juices and drinks (53). The estimated amount of fluoride consumed from fluoridated drinking water alone by adults ranges from 1.8 to 2.7 mg per day (9). The average child under age 6 years consumes less than a half liter of water a day and would consume less than 0.5 mg/day of fluoride from optimally fluoridated drinking water (54). In recent years, there has
been a trend toward consumption of less tap water in the home and greater consumption of drinks processed elsewhere, including bottled waters (55). The fluoride in well water and commercial bottled waters can vary significantly in fluoride content and should be tested by local or state public health departments or private laboratories to monitor fluoride content. Home water purification and filter systems can also affect the fluoride content of the water.

### Food and other Beverages Containing or Made with Fluoridated Water

In general, the fluoride content of branded, purchased foods is low. However, fluoride content can increase substantially if foods are cooked or reconstituted using fluoridated water (56).

#### Like other vitamins and minerals such as iron and vitamins A and D, fluoride can be toxic when consumed in excessive amounts.

Breast milk (regardless of mother’s fluoride intake) (57) and cow’s milk are very low in fluoride as are ready-to-feed infant formulas (58). Fluorosis risk may increase when concentrated liquid or powdered formula is reconstituted with fluoridated water (59). Soy-based formulas are higher in fluoride than milk-based products (2,60). Table 3 summarizes the fluoride content of common beverages and foods.

### FLUORIDE SAFETY

As with other nutrients and elements, fluoride research of more than 50 years has shown that fluoride is safe and effective when used and consumed properly (1).

#### Dental Fluorosis

Fluorosis is a hypomineralization of tooth enamel that results from excessive fluoride ingestion prior to tooth eruption (during enamel development) (64,65). Compared with periods before the discovery of fluoride’s carries preventive benefits, there has been an increase in the prevalence of mild fluorosis in the United States and many developed nations (10,66,67), which can be primarily attributed to young children swallowing fluoride dentifrice or the misuse of dietary fluoride supplements. In addition, some risk can be attributed to the use of powdered infant formula reconstituted with fluoridated water (in fluoridated areas only) and the diffusion (halo) effect of increased fluoride from foods and beverages processed in fluoridated areas (68,69).

### Table for Fluoride Content of Beverages and Foods

<table>
<thead>
<tr>
<th>Age</th>
<th>Fluoride</th>
<th>Comments</th>
</tr>
</thead>
</table>
| Pregnant women; visit dentist at least once during pregnancy | - Fluoride supplementation *not indicated*  
- Use fluoridated toothpaste/rinse and drink fluoridated water | |
| Infants, birth to 6 mo | - Oral supplementation *not recommended*  
- Use fluoridated water if available | - See fluoride supplement schedule from Table 2 |
| Infant 6 to 12 mo (make first dental visit by 12 mo) | - Use fluoridated water  
- Oral fluoride supplements only if prescribed by dentist or pediatrician | - Fluoride supplements should be used only in accordance with the American Dental Association guidelines |
| Toddler 12-24 mo | - Use fluoridated water or oral supplements if prescribed by dentist or pediatrician | - Toothpaste should *not* be used until age 18 to 24 mo or until the child will spit it out after use  
- Use only a pea-sized amount of toothpaste per day to minimize fluoride ingestion  
- Caregiver supervision is essential  
- Use pea-sized amount of toothpaste  
- Advise older preschoolers against ingesting toothpaste and rinses  
- Caregiver supervision is essential |
| Children 2-3 y, regular dental visits | - Use fluoridated water or supplements as directed  
- Introduce topical fluoride by use of toothpaste | |
| Children 3-12 years | - Fluoridated water  
- Fluoridated dentifrice  
- Fluoride supplements only if prescribed by a dentist  
- Home fluoride rinses or gels for high-risk children if recommended by dentist | - Minimal risk of fluorosis  
- Fluoridated dentifrice  
- Fluoride supplements only if prescribed by a dentist  
- Home fluoride rinses or gels for high-risk people, if recommended by dentist |
| Adolescents, adults, and elders | - Fluoridated water  
- Fluoridated dentifrice  
- Home fluoride rinses or gels for high-risk people, if recommended by dentist | - No risk of fluorosis |

**Figure.** Age-specific guidelines for fluoride throughout the life cycle. Source: data from reference 76.
To reduce the risk of mild fluorosis, the quantity of fluoride used on a child’s toothbrush should be no more than a small pea-size amount for children under age 6 years, and the toothpaste, rinse, or gel should be expectorated thoroughly rather than swallowed. The American Dental Association recommends that children over the age of 2 years brush with a pea-size amount of fluoride toothpaste only. Children should be supervised while brushing and taught to spit out, rather than swallow, the toothpaste. Parents should consult with the child’s dentist or physician prior to using fluoride toothpaste for children under age 2 years. Fluoride mouth rinses are not recommended for children under age 6 years because they may swallow the rinse. Parents and caregivers should judiciously monitor the use of all fluoride-containing products by children under age 6 years.

Like other vitamins and minerals such as iron and vitamins A and D, fluoride can be toxic when consumed in excessive amounts. Therefore, fluoride products should be kept out of reach of small children.

Decisions to fluoridate community water supplies are made at the local level, and this process is used to the advantage of those opposing water fluoridation. The charges raised by opponents tend to be more sophisticated variations on themes used since the inception of water fluoridation, namely, unproven adverse health consequences (eg, cancer, acquired immunodeficiency syndrome) and infringement on freedom of choice. Their strong appeals and messages associating fluoridation with cancer and acquired immunodeficiency syndrome, although disproved, can and have had a powerful influence on the public. Although antifluoridationists have gained much publicity in an attempt to create the illusion of scientific controversy over fluoridation, claims of health hazards from water fluoridation at the appropriate level are unfounded.

**Dietetics professionals should advocate for the appropriate use of fluoride as part of total health promotion.**

**ROLE OF THE DIETETICS PROFESSIONALS**

Dietetics professionals should become knowledgeable about fluorides and routinely promote and monitor the appropriate use of systemic and topical fluorides, especially in children and adolescents. Dietetics professionals should recommend that children have their first dental visit within 6 months of eruption of the first tooth and no later than 12 months of age. They should also monitor fluoride usage by obtaining information regarding the fluoridation of local water supplies from state departments of public health and referring children to dental professionals when indicated.

The Figure provides suggested age-specific fluoride recommendations. Toward this end, alliances and referral systems among dietetics professionals, dental hygienists, and dentists need to be strengthened in the pursuit of optimal oral health.

**CONCLUSIONS**

Fluoridation of public water supplies has been recognized as one of the most effective dental public health measure in existence. When fluoride is provided in optimal amounts, it potentially conveys major dental health benefits to all age groups. Still, approximately one third of the US population on public water systems fails to receive the maximum benefits possible from community water fluoridation. Water and toothpaste are the mainstays of fluoride delivery for all ages, and other approaches should be considered only if the child is at high risk for dental caries. Dietetics professionals should advocate for the appropriate use of fluoride as part of total health promotion. The American Dietetic Association strongly reaffirms its endorsement of the use of systemic and topical fluorides, including water fluoridation, as an important health promotion measure.

**References**


6. Clarkson JJ, McLoughlin J. Role of fluoride in oral health pro-


