

before — in part due to water fluoridation. Adults with gum recession are at risk for root decay because the root surface, a much softer tooth surface than enamel, becomes exposed to decay-causing bacteria in the mouth as gums recede. Data from the ongoing NHANES survey indicate that root decay experience has declined in recent years among older adults with teeth (ages 65-years and older), decreasing from 46% (NHANES 1988-1994) to 36% (NHANES 1999-2004). However, the prevalence of root decay increases markedly as adults age and escalates more rapidly after age 65. Specifically, the 75-years and older group had 23% greater prevalence of root surface decay than did the 65- to 74-years-old age group.<sup>72</sup> While most studies related to the prevention of root decay focus on professional fluoride treatments such as fluoride varnish, there is evidence that demonstrates fluoridation may have an impact on root decay.<sup>73 75</sup> For example, in Ontario, Canada, lifelong residents of the nonfluoridated community of Woodstock had a 21% higher root surface decay experience than those living in the naturally fluoridated (1.6 ppm) matched community of Stratford.<sup>74</sup> Similarly, Iowa residents more than 40 years of age living long-term in fluoridated communities had significantly less root decay than lifelong residents of nonfluoridated communities (0.56 versus 1.11 surfaces).<sup>75</sup>

Adults in the U.S. are keeping their natural teeth longer — partially due to exposure to water fluoridation. But as adults age with their teeth, it means more teeth will be at risk for tooth decay. It has been suggested in the literature that decay experience for adults could increase to the point where older adults experience similar or higher levels of new cavities than do school children.<sup>35,76,77</sup> It continues to be important to document and acknowledge the effectiveness of fluoridation in preventing tooth decay in adults because virtually all primary preventive dental programs target children and adolescents — with one exception — community water fluoridation. Fluoridation is unique in that it remains the one dental public health measure that reaches all members of a community including young, middle-aged and older adults.<sup>56</sup>

*Fluoridation is unique in that it remains the one dental public health measure that reaches all members of a community including young, middle aged and older adults.*

## 12. Are dietary fluoride supplements effective in helping to prevent tooth decay?

### Answer.

Yes. Dietary fluoride supplements can be effective in preventing tooth decay.

### Fact.

Dietary fluoride supplements are available only by prescription in the United States and are intended for use by children who are at high risk for developing tooth decay and living in areas where the primary source of water is deficient in fluoride.<sup>8</sup>

Recommendations for health professionals seeking to prescribe dietary fluoride supplements are found in *The Evidence-Based Clinical Recommendations on the Prescription of Dietary Fluoride: A Report of the American Dental Association Council on Scientific Affairs published in 2010*.<sup>8</sup> The report and a *Chairside Guide: Dietary Fluoride Supplements: Evidence-based Clinical Recommendations* can be accessed at <http://ebd.ADA.org/en/evidence/guidelines/fluoride-supplements>. The current dietary fluoride supplement schedule appears in this section as Table 1.

Additional information on this topic can be found in this Section, Question 13.

As noted in Table 3 of the report, “Clinical recommendations for the use of dietary fluoride supplements:”

The expert panel convened by the American Dental Association Council on Scientific Affairs developed the following recommendations. They are intended as a resource for dentists and other health care providers. The recommendations must be balanced with the practitioner’s professional judgment and the individual patient’s needs and preferences.

Children are exposed to multiple sources of fluoride. The expert panel encourages health care providers to evaluate all potential fluoride sources and to conduct a caries risk assessment before prescribing fluoride supplements.

As noted in the recommendations, prior to prescribing dietary fluoride supplements, accurate assessment of the fluoride content of the patient’s primary drinking water source(s) should be conducted.<sup>8</sup> The identification of the “primary” sources is sometimes

difficult due to the fact that some patients have multiple sources of drinking water during a typical day. For example, while a patient may have access to drinking water in the home, they often also spend a large part of their day accessing drinking water at day care or school, which could be a different water system. It might be necessary to contact the local, county or state health departments for information on the fluoride content of public water sources or to be referred to a certified laboratory that can provide a fluoride test for private wells.

➦ Additional information on this topic can be found in this Section, Question 4.

The ADA offers information on caries risk assessment<sup>78</sup> on the web at <http://www.ADA.org/en/member-center/oral-health-topics/caries-risk-assessment-and-management>. It should be noted that dietary fluoride supplements are recommended only for children at high risk for tooth decay.<sup>8</sup> Caries risk assessments should be completed for patients on a regular basis to determine their risk for tooth decay which can change over time.

Dietary fluoride supplements can be effective in helping to prevent tooth decay. To receive the optimal benefit from fluoride supplements, the use of supplements should begin at six months of age and continue daily until the child is 16 years old.<sup>8</sup> However, individual patterns of compliance can vary greatly.

For that reason, the report suggests that providers carefully monitor the adherence to the schedule to maximize the therapeutic benefit of supplements in caries prevention. If the health care provider has concerns regarding a lack of compliance to the schedule, it might be best to consider other sources of fluoride exposure for the patient, such as bottled water with fluoride.<sup>8</sup>

While dietary fluoride supplements can be effective in reducing tooth decay, there are a number of factors that can impede their use and resulting therapeutic value:

- Patients/parents/caregivers must have access to a professional health care provider who can provide the necessary assessments and provide prescriptions for the supplements — often repeatedly over time.
- The supplements must be obtained through a pharmacy/pharmaceutical service and refilled as necessary.
- The cost of supplements can be a financial hardship for some individuals.
- The compliance required (a child should take the supplement every day until 16 years of age) to obtain the optimal therapeutic affect often is difficult to achieve.

**Table 1. Dietary Fluoride Supplement Schedule for Children at High Caries Risk<sup>8</sup>**

Age	Fluoride ion level in drinking water (ppm)*		
	<0.3 ppm	0.3-0.6 ppm	>0.6 ppm
<b>Birth - 6 months</b>	None	None	None
<b>6 months - 3 years</b>	0.25 mg/day**	None	None
<b>3-6 years</b>	0.50 mg/day	0.25 mg/day	None
<b>6-16 years</b>	1.0 mg/day	0.50 mg/day	None

\* 10 part per million (ppm) = 1 milligram/liter (mg/L) \*\*2.2 mg sodium fluoride contains 1 mg fluoride ion

Noting the potential obstacles listed above, where feasible, community water fluoridation offers proven decay prevention benefits without the need for access to a health care professional or a change in behavior on the part of the individual. Simply by drinking water at home, school, work or play everyone in the community benefits regardless of socioeconomic status, educational attainment or other social variables.<sup>79</sup> While dietary fluoride supplements can reduce a child's risk of tooth decay, fluoridation extends that benefit to adults in the community. Additionally, the cost of dietary fluoride supplements over an extended period of time can be an economic concern to a family. In looking at overall costs, consideration should be given to the cost per person and the number of people who can benefit from a dietary fluoride supplement or community fluoridation program.<sup>77</sup>

### 13. The ADA Dietary Fluoride Supplements Schedule 2010 contains the word "none" in specific boxes. Does this mean the ADA does not recommend fluoride for children?

#### **Answer.**

No, that would be a misinterpretation of the purpose of the schedule. The schedule reflects the recommended dosage of fluoride supplements based on age and the fluoride level of the child's primary source of drinking water, in addition to what would be consumed from other sources.

#### **Fact.**

The dietary fluoride supplement schedule<sup>8</sup> (Table 1.) is just that — a supplement schedule. Children residing in areas where the drinking water is not fluoridated will receive some fluoride from other sources such as foods and beverages. Dietary fluoride supplements are designed for children over six months of age who do not receive a sufficient amount of fluoride from those sources. The dosage amounts in the table reflect the additional amount of supplemental fluoride intake necessary to achieve an optimal anti-cavity effect. To reduce the risk of dental fluorosis, children under six months of age should not take dietary fluoride supplements.

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The dietary fluoride supplement schedule should not be viewed as a recommendation of the absolute upper limits of the amount of fluoride that should be ingested each day. In 2011, the Food and Nutrition Board of the Institute of Medicine developed Dietary Reference Intakes, a comprehensive set of reference values for dietary nutrient values. The values present nutrient requirements to optimize health and, for the first time, set maximum-level guidelines to reduce the risk of adverse effects from excessive consumption of a nutrient. In the case of fluoride, levels were established to reduce tooth decay without causing moderate dental fluorosis.<sup>80</sup>

For example, the dietary fluoride supplement schedule recommends that a two-year-old child at high risk for tooth decay living in a nonfluoridated area (where the primary water source contains less than 0.3 ppm fluoride) should receive 0.25 mg of supplemental fluoride per day. This does not mean that this child should ingest exactly 0.25 mg of fluoride per day total. Instead, a two-year-old child could receive important anti-cavity benefits by taking 0.25 mg of supplemental fluoride a day without causing any adverse effects on health. This child would most probably be receiving fluoride from other sources (foods and beverages) even in a nonfluoridated area and the recommendation of 0.25 mg of fluoride per day takes this into account. In the unlikely event the child did not receive any additional fluoride from food and beverages, the 0.25 mg per day could be inadequate fluoride supplementation to achieve an optimal anti-cavity effect.


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The following statement is correct. "Fluoride supplement dosage levels have been lowered in the past as exposure to fluoride from other sources has increased." Rather than being a problem, as those opposed to the use of fluoride might imply, this is evidence that ADA policy is based on the best available science. The ADA periodically reviews the dosage schedule and issues updated recommendations based on the best available science.

In 1994, a Dietary Fluoride Supplement Workshop, co-sponsored by the ADA, the American Academy of Pediatric Dentistry and the American Academy of Pediatrics, was held in Chicago. Based on a review of scientific evidence, a consensus was reached on a

new dosage schedule developed acknowledging that numerous sources of topical and systemic fluoride are available today that were not available many years ago.<sup>81</sup>

The supplement schedule was reviewed and reissued in December 2010. At that time, the American Dental Association Council on Scientific Affairs (CSA) published evidence-based clinical recommendations for the schedule of dietary fluoride supplements.<sup>8</sup> The evidence-based review recommended that the age stratification established in the ADA's 1994 supplement schedule remain unchanged. The review also recommended that prior to prescribing fluoride supplements, the prescribing provider should assess the patient's risk for cavities and only those at high risk should receive supplements.<sup>8</sup> If at high risk, then the fluoride level of the patient's primary drinking water source should be assessed.<sup>8</sup> It should be noted that an accurate assessment of the patient's primary drinking water source can be difficult due to the various sources of fluoridated water. For example, the patient might not have access to fluoridated water in the home, but may drink fluoridated water while at day care or school. The current dietary fluoride supplement schedule appears as Table 1.<sup>8</sup>

 *Additional information on this topic can be found in this Section, Question 12.*

## 14. What are salt and milk fluoridation and where are they used?

### **Answer.**

Salt and milk fluoridation are fluoridation methods used to provide community-based fluoridation in countries outside of the United States where various political, geographical, financial or technical reasons prevent the use of water fluoridation.

### **Fact.**

The practice of salt fluoridation began in the 1950s, approximately 10 years after water fluoridation was initiated in the United States.<sup>82</sup> Based on the success several decades earlier of the use of iodized salt for the prevention of goiter, fluoridated salt was first introduced in Switzerland in 1956.<sup>83</sup>

According to a review published in 2013, salt fluoridation is available in a number of countries in Europe but its coverage varies greatly.<sup>82</sup> Germany

and Switzerland have attained a coverage exceeding two-thirds of their populations (67% and 85% respectively). In other European countries including Austria, the Czech Republic, France, Slovakia and Spain, salt fluoridation is reportedly used on a very limited scale.<sup>82</sup> Additional countries, such as Hungary, Romania, Slovenia, Croatia and Poland, have considered salt fluoridation but have failed to take action.<sup>84</sup>

European regulations (current as of 2017) permit the addition of fluoride to salt and water.<sup>82</sup> However, it appears that the majority of European countries favor the twice daily use of fluoride toothpaste as the most important measure for improving the public's dental health.<sup>84</sup> In Europe, toothpaste sold over the counter typically contains 1,500 ppm fluoride,<sup>85</sup> while toothpaste in the United States typically contains 1,000 to 1,100 ppm fluoride.<sup>86</sup>

On a historical note, prior to the political changes that occurred in the late 1980s and early 1990s in Europe, water fluoridation was widely available in the German Democratic Republic and the Czechoslovak Republic and to a lesser extent in Poland. With the end of the Communist regimes, efforts related to public health dentistry were largely discontinued. While fluoridation continued in several small towns until 1993, in general, it was abandoned.<sup>84</sup>

In North and South America, salt fluoridation is available in Belize, Bolivia, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Peru, Uruguay and Venezuela. Like in Europe, the extent of salt fluoridation varies between countries. Columbia, Costa Rica, Jamaica, Mexico and Uruguay provide fluoridated salt to nearly their entire populations while there is less coverage in other countries.<sup>82</sup>

In 2013, it was estimated that approximately 60 million people in Europe and 160 million in the Americas had access to fluoridated salt.<sup>82</sup>

The Pan American Health Organization (PAHO), a regional division of the World Health Association (WHO) with responsibilities for health matters in North, South and Central America and the Caribbean, has been active in developing strategies to implement decay prevention programs in the regions of the Americas using water and salt fluoridation.<sup>87</sup> In order to achieve the greatest reduction in tooth decay while minimizing the risk of dental fluorosis, it is advisable that a country implement only one of these two

public health measures — either community water fluoridation or salt fluoridation. The United States has implemented water fluoridation. The U.S. Food and Drug Administration has not approved fluoridated salt for use in the U.S.

Early studies evaluating the effectiveness of salt fluoridation conducted in Columbia, Hungary and Switzerland indicated that fluoride delivered via salt might produce a reduction in tooth decay similar to that seen with optimally fluoridated water.<sup>88,89</sup> When all salt destined for human consumption (both domestic salt and bulk salt that is used by commercial bakeries, restaurants, institutions, and industrial food production) is fluoridated, the decay-reducing effect could be comparable to that of water fluoridation over an extended period of time.<sup>88,89</sup> When only domestic salt is fluoridated, the decay-reducing effect is diminished.<sup>88</sup> Studies conducted in Costa Rica, Jamaica and Mexico in the 1980s and 1990s also showed significant reductions in tooth decay. However, it was noted that these studies did not include other variables that could have contributed to the reductions.<sup>88</sup>

The fact that salt fluoridation does not require a centralized piped water system is of particular value in countries that do not have such water systems. Fluoridated salt is also a very cost-effective public health measure. For example, in Jamaica, where all salt destined for human consumption is fluoridated, the use of fluoridated salt was reported to reduce tooth decay by as much as 84% at a cost of 6 cents per person per year.<sup>87</sup> In some cases, the cost to produce fluoridated salt is so low that for consumers, the cost of fluoridated salt is the same as for nonfluoridated salt.<sup>90</sup>

The implementation of salt fluoridation has unique challenges not incurred with water fluoridation. Sources of salt, the willingness of local manufacturers to produce fluoridated salt or the need to import fluoridated salt would need to be studied. Because fluoridated salt should only be consumed by the public in areas with a naturally low level of fluoride, it would be necessary to completely map the naturally occurring levels of fluoride and devise a plan to keep fluoridated salt out of the areas with moderate to high naturally occurring fluoride (to aid in reducing the risk of dental fluorosis). Additionally, a plan would need to be developed to monitor the fluoride level in urine of those consuming fluoridated salt starting with a baseline before implementation

and including follow-up testing on a regular basis. While salt fluoridation typically is not implemented through a public vote, it would be necessary to gain the cooperation of salt manufacturers and institutions of all kinds that would use salt in their food preparation.<sup>89</sup> Additionally, educational efforts would need to be directed at health professionals and health authorities to avoid referendum approaches and identify enabling regulations.<sup>83</sup>

In a number of European countries, consumers have a choice of purchasing either fluoridated or nonfluoridated salt for use in the home. While it has been argued that, unlike water fluoridation, this option to purchase fluoridated or nonfluoridated salt allows for personal choice, studies indicate that fluoridated salt is not as effective a public health measure when only a small portion of the population opts to purchase and use the product.<sup>88</sup> For example, in France, fluoridated salt for home use became available to the consumer by decree in 1986, while nonfluoridated salt remained available for purchase. By 1991, with an aggressive public health campaign, the market share of fluoridated salt was 50% and it reached a high of 60% in 1993. Then the public health campaign ended. By 2003, the market share had decreased to 27%.<sup>82,91</sup> It has been suggested that, in order to be a successful public health measure that effectively reaches those who are disadvantaged, approximately 70% of the population needs to use fluoridated salt. Conversely, usage rates less than 50% should be considered as having minimal effect on public health.<sup>82</sup> While the situation described in Europe allows for personal choice, salt programs in the Americas where all salt destined for human consumption is fluoridated would seem at odds with the issue of personal choice, yet the program is apparently working well with fluoridated salt well accepted by the public.<sup>92</sup>

A number of studies have shown an increase in the occurrence of dental fluorosis in areas where salt fluoridation programs have been implemented. For example, a 2006 cohort study examined the prevalence and severity of dental fluorosis in children before and after the implementation of salt fluoridation in Campeche, Mexico, in 1991.<sup>93</sup> The study showed, that while 85% of the dental fluorosis identified was categorized as very mild, children born in 1990-1992 were more likely to have dental fluorosis than those born in the period 1986-1989<sup>93</sup> A study published in 2009 of children in Jamaica

showed similar results.<sup>94</sup> Jamaica began a fluoridated salt program in 1987. In 1999, an area around St. Elizabeth was found to have a high prevalence of dental fluorosis. Examiners returned in 2006 to re-evaluate students in the area. While their results indicated a slightly reduced tooth decay experience for 6-year-olds in 2006 compared to 6-year-olds in 1999, they also found that 6-year-olds also had a higher prevalence of dental fluorosis in 2006 than the 6-year-olds examined in 1999. In addition to the implementation of salt fluoridation, other factors including the use of increased use of fluoridated toothpaste and mouthrinses could have played a role.<sup>94</sup> However, both of these studies point out the need to carefully monitor fluorides from multiple sources especially when implementing fluoridated salt programs.

Fluoridated milk has been suggested as another alternative to community water fluoridation in countries outside the United States. Studies on the effectiveness of milk fluoridation have been carried out in numerous countries, including but not limited to, Brazil, Bulgaria, China, Israel, Japan, Russia and the United Kingdom.<sup>95</sup> Many of these studies have found milk fluoridation programs to be an efficient and cost-effective method to prevent cavities.<sup>95</sup> For example, a 2001 study of Chilean preschoolers using fluoridated powdered milk and milk derivatives resulted in a 41% reduction in the number of primary decayed missing and filled tooth surfaces as compared to the control group that did not receive fluoridated milk.<sup>96</sup> Additionally, in the same study, the proportion of decay free children increased from 22% to 48% in the study group after four years of implementing the program.<sup>96</sup>

In 2004, the dental health of school children from the northwest of England, who were enrolled in the school milk fluoridation program, was compared to children with similar characteristics who were not consuming fluoridated milk.<sup>97</sup> The average age of the children in the study was 11 years old. In order to participate in the study, participants chosen for the test group were required to have been receiving fluoridated milk for a minimum of 6 years. First permanent molars were examined for tooth decay experience. Results from the study indicated that children consuming fluoridated milk had less tooth decay experience (1.01 DMFT) than the children who did not receive fluoridated milk (1.46 DMFT).<sup>97</sup>

A study of community milk programs in Bulgaria examined children at age 3 and again at age 8.<sup>98</sup> The study indicated that tooth decay experience was substantially lower in the cohort of children who had received fluoridated milk in school for five years compared with the cohorts of children who had received milk in school without fluoride added. At the end of the five-year trial in 2009, tooth decay experience was lower in children who received fluoridated milk (5.61 dmfs and 0.48 DMFS) than in the control community children who received milk with no fluoride (9.41 dmfs and 1.24 DMFS).<sup>98</sup>

In these two examples “dmfs” is the mean number of decayed, missing or filled tooth surfaces on primary (or baby) teeth while “DMFS” is the mean number of decayed missing or filled tooth surfaces on permanent teeth.

Studies completed on milk fluoridation to date largely target children. There has been only a very small number that have looked at the role fluoridated milk might play for adults. These studies have largely examined fluoridated milk and its possible effect on root decay. For example, a study published in 2011 and conducted in Sweden indicated that fluoridated milk could be of value in remineralizing early tooth decay in root surfaces.<sup>99</sup>

It was estimated that as of 2013, more than one million children worldwide were receiving fluoridated milk.<sup>94</sup> The majority of studies conducted have indicated that fluoridated milk is effective in preventing tooth decay under certain conditions. It is most effective if the consumption of fluoridated milk starts before 4 years of age and continues until the permanent teeth are present in the mouth. Most successful programs are conducted through schools where the natural fluoride levels in water are low and children are able to consume fluoridated milk for a minimum of 200 days a year.<sup>95</sup> While these conditions prevent fluoridated milk from being recommended as a public health measure for an entire community, fluoridated milk might be the most appropriate and effective means of fluoride exposure for children in some circumstances.

## 15. Can the consistent use of bottled water result in individuals missing the benefits of optimally fluoridated water?

### Answer.

Yes. The majority of bottled waters on the market do not contain optimal levels (0.7 mg/L) of fluoride.

### Fact.

There is not a large body of research regarding the risk for tooth decay associated with the consumption of bottled water. However, a lack of exposure to fluoride could increase an individual's risk for tooth decay. The vast majority of bottled waters do not contain significant amounts of fluoride.<sup>100</sup> Individuals who drink bottled water as their primary source of water could be missing the decay preventive effects of optimally fluoridated water available from their community water supplies. These consumers should seek advice from their dentists about their risk for tooth decay and specific fluoride needs.

While drinking water from the tap is regulated by the U.S. Environmental Protection Agency (EPA), bottled water is regulated by the U.S. Food and Drug Administration (FDA).<sup>101</sup> The FDA has established maximum allowable levels for physical, chemical, microbiological, and radiological contaminants in bottled water.<sup>102</sup>

*Individuals who drink bottled water as their primary source of water could be missing the decay preventive effects of optimally fluoridated water available from their community water supplies.*

Noting that fluoride can occur naturally in source waters used for bottled water or can be added by a bottled water manufacturer, the FDA has approved standards for the fluoride content of bottled water.<sup>102</sup> However, the FDA regulations require the fluoride content of bottled water to be listed on the label only if fluoride is added during processing.<sup>103</sup> If the fluoride level is not shown on the label of the bottled water, the company can be contacted, or the water can be tested to obtain this information. Most consumers are unaware that the vast majority of bottled waters, especially those treated by distillation or reverse

osmosis, are largely fluoride-free. Unknowingly, individuals who drink bottled water as their primary source of water could be missing the decay preventive effects of optimally fluoridated water available from their community water supplies. The American Dental Association supports the labeling of bottled water with the fluoride content to aid consumers in making informed decisions about choices of drinking water.<sup>104</sup>

Recognizing the benefit of fluoride in drinking water, in 2006 the FDA issued the "FDA Health Claim Notification for Fluoridated Water and Reduced Risk of Dental Caries"<sup>105</sup> which states that bottled water meeting the specific standards of identity and quality set forth by FDA, and containing greater than 0.6 mg/L up to 1.0 mg/L total fluoride, can be labeled with the following health claim: "Drinking fluoridated water may reduce the risk of [dental caries or tooth decay]." This health claim is not intended for use on bottled water products specifically marketed for use by infants.<sup>105</sup>

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According to a 2017 press release from the Beverage Marketing Corporation,<sup>106</sup> bottled water surpassed carbonated soft drinks in 2016 to become the largest beverage category by volume in the United States. Per capita consumption of bottled water was approximately 39.3 gallons in 2016, while the average consumption of carbonated soft drinks was approximately 38.5 gallons per person per year. The majority (67.3%) of U.S. bottled water is sold in single-serving PET (polyethylene terephthalate or plastic resin<sup>107</sup>) bottles. Bottled water is also sold via bulk deliveries to homes and offices (approximately 11%) and by retail sales in different sizes of gallon containers (approximately 9%).<sup>106</sup>

Individuals choose to drink bottled water for various reasons. Some find it a calorie-free substitute for carbonated soft drinks or other sugary beverages. Others dislike the taste of their tap water or have concerns about the possible contaminants in their local water supply.

In a small study published in 2012, a convenience sample of caretakers and adolescents at an urban clinic found that 17% drank tap water exclusively, 38% drank bottled water exclusively and 42% drank both. Bottled water was ranked significantly higher

in taste, clarity, purity and safety than tap water. Only 24% of caretakers of children and adolescents knew whether or not fluoride was in their drinking water. The authors concluded that perception of the qualities of water were responsible for choices of drinking water.<sup>108</sup> Similar findings have been echoed in earlier studies.<sup>109-111</sup> Additionally, cultural influences can affect drinking water preferences. In some Latino communities, parents were less likely to give tap water to their children because they believed tap water would make them sick based in part on the fact that many have come to the U.S. from places with poor water quality where water-borne illness was common.<sup>111</sup> Besides missing the decay preventive effects of fluoridated tap water, it has been determined that families spend hundreds of dollars more each year on purchasing water than if they were to consume tap water.<sup>109,111</sup>

## 16. Can home water treatment systems such as water filters, reverse osmosis and water softeners remove fluoride from drinking water?

### **Answer.**

Some types of home water treatment systems can reduce the fluoride levels in water supplies. Individuals who drink water processed by home water treatment systems as their primary source of water could be losing the decay preventive effects of optimally fluoridated water available from their community water supply.


### **Fact.**

There are many kinds of home water treatment systems including reverse osmosis systems, distillation units, water softeners and water filters such as carafe filters, faucet filters, under the sink filters and whole house filters. There has not been a large body of research regarding the extent to which these treatment systems affect the fluoride content of optimally fluoridated water.

However, it has been consistently documented that reverse osmosis systems and distillation units remove significant amounts of fluoride from the water supply.<sup>112,113</sup> Studies regarding water softeners show clearly that the water softening process does not significantly change fluoride levels.<sup>114,115</sup>

With water filters, the fluoride concentration remaining in the water depends on the type and quality of the filter being used, the status of the filter and the filter's age. Most carbon filters do not remove fluoride. However, some filters containing activated alumina can remove significant amounts of the fluoride. Additionally, some filters containing bone char also can remove significant amounts of fluoride.<sup>113,116</sup> Accordingly, each type of filter should be assessed individually.

Individuals who drink water processed by home water treatment systems as their primary source of water could be losing the decay preventive effects of optimally fluoridated water available from their community water supply. Therefore, it might be necessary to contact the installer, distributor or manufacturer of the water treatment system or water filter in question to determine whether the item removes fluoride. Information regarding the existing level of fluoride in a community's public water system can be obtained by asking a local dentist or contacting the local or state health department or the local water supplier. If the consumer is using a private well, it is suggested that it be tested yearly for fluoride levels.

 *Additional information on this topic can be found in this Section, Question 4.*



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## 17. Does fluoride in the water supply, at the levels recommended for the prevention of tooth decay, adversely affect human health?

### Answer.

The overwhelming weight of scientific evidence supports the safety of community water fluoridation.

### Fact.

For generations, millions of people have lived in areas where fluoride is found naturally in drinking water in concentrations as high or higher than the optimal level recommended to prevent tooth decay. Research conducted among these persons confirms the safety of fluoride in the water supply.<sup>1-5</sup>

As with other nutrients, fluoride is safe and effective when used and consumed as recommended. No charge against the benefits and safety of fluoridation has ever been substantiated by generally accepted scientific knowledge. A number of reviews on fluoride in drinking water have been issued over the years. For example, in 1951<sup>6</sup> the National Research Council (NRC), of the National Academies,

issued its first report stating fluoridation was safe and effective. Additional reviews by the NRC followed in 1977<sup>7</sup> and 1993<sup>8</sup> with the most recent NRC review completed in 2006.<sup>9</sup> Additional reviews completed over the ten year period from 2007-2017 include:

- 2017 Australian Government. National Health and Medical Research Council (NHMRC). *Information Paper — Water Fluoridation: Dental and Other Human Health Outcomes.*<sup>10</sup>
- 2016 O’Mullane DM, Baez RJ, Jones S, Lennon MA, Petersen PE, Rugg-Gunn AJ, Whelton H, Whitford GM. *Fluoride and Oral Health.*<sup>11</sup>
- 2016 American Water Works Association. *Water Fluoridation Principles and Practices. AWWA Manual M4. Sixth edition.*<sup>12</sup>
- 2015 Water Research Foundation. *State of the Science: Community Water Fluoridation.*<sup>13</sup>
- 2015 The Network for Public Health Law. *Issue Brief: Community Water Fluoridation.*<sup>14</sup>

- 2015 Ireland Health Research Board. *Health Effects of Water Fluoridation: An Evidence Review*.<sup>15</sup>
- 2015 U.S. Department of Health and Human Services Federal Panel on Community Water Fluoridation. *U.S. Public Health Service Recommendation for Fluoride Concentration in Drinking Water for the Prevention of Dental Caries*.<sup>16</sup>
- 2014 Public Health England. *Water Fluoridation: Health Monitoring Report for England*.<sup>17</sup>
- 2014 Royal Society of New Zealand and the Office of the Prime Minister's Chief Science Advisor. *Health Effects of Water Fluoridation: a Review of the Scientific Evidence*.<sup>18</sup>
- 2013 U.S. Community Preventive Services Task Force. *The Guide to Community Preventive Services. Preventing Dental Caries: Community Water Fluoridation*.<sup>19</sup>
- 2011 European Commission of the European Union Scientific Committee on Health and Environmental Risks (SCHER). *Fluoridation*.<sup>20</sup>
- 2008 Health Canada. *Findings and Recommendations of the Fluoride Expert Panel*.<sup>21</sup>
- 2007 Australian Government National Health and Medical Research Council *A Systematic Review of the Efficacy and Safety of Fluoridation; Part A: Review Methodology and Results*.<sup>22</sup>

*The overwhelming weight of scientific evidence supports the safety of community water fluoridation.*

## 18. Are additional studies being conducted to determine the effects of fluorides in humans?

### **Answer.**

Yes. Since its inception, fluoridation has undergone a nearly continuous process of re-evaluation. As with other areas of science, additional studies on the effects of fluorides in humans can provide insight as to how to make effective choices for the use of fluoride. The American Dental Association and the U.S. Public Health Service support this on-going research.

### **Fact.**

For more than 70 years, detailed reports have been published on multiple aspects of fluoridation. The accumulated dental, medical and public health evidence concerning fluoridation has been reviewed and evaluated numerous times by academicians, committees of experts, special councils of governments and most of the world's major national and international health organizations. The consensus of the scientific community is that water fluoridation, at the level recommended to prevent tooth decay, safely provides oral health benefits which in turn supports improved general health. The question of possible secondary health effects caused by fluorides consumed in optimal concentrations throughout life has been the object of thorough medical investigations which have failed to show any impairment of general health throughout life.<sup>10-22</sup>

*The consensus of the scientific community is that water fluoridation, at the level recommended to prevent tooth decay, safely provides oral health benefits which in turn supports improved general health.*

In scientific research, there is no such thing as "final knowledge." New information is continuously emerging and being disseminated. Government agencies, such as the U.S. National Institutes of Health, National Institute of Dental and Craniofacial Research, and others continue to fund fluoride research. One example is the National Toxicology Program's systematic review using animal studies to evaluate potential neurobehavioral effects from exposure to fluoride during development which began in 2015 and continues in 2017.<sup>23</sup>

In 2011, the U.S. Department of Health and Human Services and the U.S. Environmental Protection Agency (EPA) issued a joint press release<sup>24</sup> outlining important steps the respective agencies were taking to ensure that standards and guidelines on fluoride in drinking water continue to ensure the safety of the public while supporting good dental health, especially in children. Those actions resulted in the 2015 report issued by the U.S. Public Health Service<sup>16</sup> regarding the recommended level of fluoride in drinking water and the EPA activity was informational to the 2016 EPA Six-Year Review<sup>325</sup> in which the Agency completed a detailed review of drinking water regulations including the regulation for naturally occurring fluoride in water.

### 19. Why did the U.S. Public Health Service issue a report in 2015 recommending 0.7 milligrams per liter (mg/L) as the optimal level for fluoride in drinking water for all temperature zones in the U.S.?

#### Answer.

The U.S. Public Health Service (USPHS) updated and replaced its 1962 Drinking Water Standards related to community water fluoridation to establish a single value of 0.7 mg/L as the optimal concentration of fluoride in drinking water. This concentration provides the best balance of protection from tooth decay while limiting the risk of dental fluorosis.<sup>16</sup>

#### Fact.

The previous U.S. Public Health Service recommendations for optimal fluoride concentrations were based on average ambient air temperatures of geographic areas and ranged from 0.7-1.2 mg/L. In 2011, the U.S. Department of Health and Human Services (HHS) issued a notice of intent in the *Federal Register*<sup>26</sup> proposing that community water systems adjust the amount of fluoride to 0.7 mg/L to achieve an optimal fluoride level.

The new guidance was based on several considerations that included:

- Scientific evidence related to effectiveness of water fluoridation on caries prevention and control across all age groups.
- Fluoride in drinking water as one of several available fluoride sources.

- Trends in the prevalence and severity of dental fluorosis.
- Current evidence on fluid intake in children across various ambient air temperatures.

As part of the process leading to the notice of intent, the U.S. Department of Health and Human Services (HHS) convened a federal interdepartmental, interagency panel of scientists to review the scientific evidence relevant to the 1962 USPHS Drinking Water Standards for fluoride concentrations in drinking water in the United States and to update these recommendations based on current science. Panelists included representatives from the Centers for Disease Control and Prevention, the National Institutes of Health, the U.S. Food and Drug Administration, the Agency for Healthcare Research and Quality, the Office of the Assistant Secretary for Health, U.S. Environmental Protection Agency, and the U.S. Department of Agriculture.<sup>16</sup>

A public comment period followed the publication of the notice of intent during which time more than 19,000 comments were received. The vast majority (more than 18,000) were variations on a letter submitted by an organization opposing community water fluoridation. Comments received were summarized and reported to the full federal panel. The panel then spent several years reviewing each comment in light of the best available science. After completing their extensive review, the panel did not alter the recommendation based on the following:

- Community water fluoridation remains an effective public health strategy for delivering fluoride to prevent tooth decay and is the most feasible and cost-effective strategy for reaching entire communities.
- In addition to drinking water, other sources of fluoride exposure have contributed to the prevention of dental caries and an increase in dental fluorosis prevalence.
- Caries preventive benefits can be achieved and the risk of dental fluorosis reduced at 0.7 mg/L.
- Recent data do not show a convincing relationship between water intake and outdoor air temperature. Thus, recommendations for water fluoride concentrations that differ based on outdoor temperature are unnecessary.<sup>16</sup>

In 2015 the USPHS published a final report establishing guidance for water systems that are actively fluoridating or those that may initiate fluoridation in the future.<sup>16</sup> For community water systems that add fluoride to their water, the USPHS recommends a uniform fluoride concentration of 0.7 mg/L (parts per million [ppm]) for the entire United States to maintain caries (tooth decay) prevention benefits and reduce the risk of dental fluorosis.

The USPHS further noted that surveillance of dental caries (tooth decay), dental fluorosis, and fluoride intake through the National Health and Nutritional Examination Survey will be done to monitor changes that might occur following implementation of the recommendation.<sup>16</sup>

## 20. What is the recommendation for the maximum level of naturally occurring fluoride in drinking water contained in the 2016 EPA Six-Year Review 3?

### Answer.

As established by the U.S. EPA, the maximum allowable level of naturally occurring fluoride in drinking water is 4 milligrams/liter (mg/L or ppm). Under the Maximum Contaminant Level (MCL) standard, if the naturally occurring level of fluoride in a public water supply exceeds the MCL, the water supplier is required to lower the level of fluoride below the MCL — a process called defluoridation. The MCL is a federally enforceable standard.<sup>27</sup> (Additional details regarding the EPA maximum contaminant standards can be found in the Figure 3.)

### Fact.

Under the Safe Drinking Water Act (SDWA),<sup>27</sup> the EPA is required to periodically review the existing National Primary Drinking Water Regulations (NPDWRs) “not less often than every 6 years.” This review is a routine part of the EPA’s operations as dictated by the SDWA.

In April 2002, the EPA announced the results of its preliminary revise/not revise decisions for 68 chemical NPDWRs as part of its first Six-Year Review of drinking water standards.<sup>28</sup> Fluoride was one of the 68 items reviewed. While the EPA determined that it fell under the “Not Appropriate for Revision at this Time” category, the agency asked the National Academies (NA) to update the risk assessment for fluoride. Prior to this time, the National Academies’ National Research Council (NRC) completed a review

of fluoride for the EPA which was published as “Health Effects of Ingested Fluoride” in 1993.<sup>9</sup>

The National Research Council’s Committee on Toxicology created the Subcommittee on Fluoride in Drinking Water<sup>9</sup> which reviewed toxicologic, epidemiologic, and clinical data published since 1993, and exposure data on orally ingested fluoride from drinking water and other sources (e.g., food, toothpaste, dental rinses). Based on these reviews, the Subcommittee evaluated independently the scientific and technical basis of the U.S. Environmental Protection Agency’s (EPA) maximum contaminant level goal (MCLG) of 4 milligram per liter (mg/L or ppm) and secondary maximum contaminant level (SMCL) of 2 mg/L in drinking water.

On March 22, 2006, almost three years after work began, the NRC issued a 500-page report titled *Fluoride in Drinking Water — A Scientific Review of the EPA’s Standards*<sup>9</sup> to advise the EPA on the adequacy of its fluoride MCLG (maximum contaminant level goal) and SMCL (secondary maximum contaminant level) to protect children and others from adverse effects. (For additional information on the EPA maximum contaminant standards, please refer to Figure 3.) The report contained two major recommendations related to the MCLG:

In light of the collective evidence on various health end points and total exposure to fluoride, the committee concludes that EPA’s MCLG of 4 mg/L should be lowered. Lowering the MCLG will prevent children from developing severe enamel fluorosis and will reduce the lifetime accumulation of fluoride into bone that the majority of the committee concludes is likely to put individuals at increased risk of bone fracture and possibly skeletal fluorosis, which are particular concerns for subpopulations that are prone to accumulating fluoride in their bones.<sup>9</sup>

To develop an MCLG that is protective against severe enamel fluorosis, clinical stage II skeletal fluorosis, and bone fractures, EPA should update the risk assessment of fluoride to include new data on health risks and better estimates of total exposure (relative source contribution) for individuals. EPA should use current approaches for quantifying risk, considering susceptible subpopulations, and characterizing uncertainties and variability.<sup>9</sup>

The 2006 NRC report<sup>9</sup> contained one major recommendation related to the Secondary Maximum Contaminant Level (SMCL):



The prevalence of severe enamel fluorosis is very low (near zero) at fluoride concentrations below 2 mg/L. From a cosmetic standpoint, the SMCL does not completely prevent the occurrence of moderate enamel fluorosis. EPA has indicated that the SMCL was intended to reduce the severity and occurrence of the condition to 15% or less of the exposed population. The available data indicate that fewer than 15% of children will experience moderate enamel fluorosis of aesthetic concern (discoloration of the front teeth) at that concentration. However, the degree to which moderate enamel fluorosis might go beyond a cosmetic effect to create an adverse psychological effect or an adverse effect on social functioning is not known.<sup>9</sup>

Additionally, the Subcommittee identified data gaps and made recommendations for future research relevant to future revisions of the MCLG and SMCL for fluoride.<sup>9</sup>

It should be emphasized that the 2006 NRC report was not a review of fluoride as used in community water fluoridation. In fact, the 2006 NRC Report in Brief<sup>29</sup> states: "The committee did not evaluate the risks or benefits of the lower fluoride concentrations (0.7 to 1.2 mg/L) used in water fluoridation. Therefore, the committee's conclusions regarding the potential for adverse effects from fluoride at 2 to 4 mg/L in drinking water do not apply at the lower water fluoride levels commonly experienced by most U.S. citizens."<sup>29</sup>

In response to the recommendations noted above from the NRC report, in 2011, the EPA completed and peer-reviewed a quantitative dose-response assessment based on the available data for severe dental fluorosis as recommended by the NRC.<sup>30</sup> Additionally, the EPA completed and peer-reviewed a document on the environmental exposure of children and adults to fluoride and the relative source contribution for water which is needed in order to derive the MCLG from the dose-response assessment.<sup>30</sup> These efforts were being undertaken during Six-Year Review 2 and so no action on fluoride was taken during Six-Year Review 2.

In December 2016, the EPA announced the review results for the Agency's third Six-Year Review (called Six-Year Review 3),<sup>25</sup> in which the Agency completed a detailed review of 76 national primary drinking water regulations. The regulation for naturally occurring fluoride in water was examined as part of this review and is included among the list of regulated contaminants considered to be "Low priority and/or

no meaningful opportunity" under "Not Appropriate for Revision at this Time."<sup>25</sup>

The announcement of the results of the EPA's Six-Year Review 3 in the *Federal Register*<sup>31</sup> indicates that, with the reviews of fluoride conducted since the first Six-Year Review (including but not limited to the 2006 NRC report and the EPA Fluoride Risk Assessment and Relative Source Contribution) and noting that other contaminants are of much greater concern, the EPA is recommending that no further action be taken at this time to change the current MCL/MCLG of 4 mg/L (the maximum level of naturally occurring fluoride allowed in drinking water).<sup>31</sup>

## 21. What is the Secondary Maximum Contaminant Level (SMCL) for naturally occurring fluoride in drinking water established by the EPA?

### Answer.

The Secondary Maximum Contaminant Level (SMCL) for naturally occurring fluoride in water is 2 mg/L (or ppm). This is a non-enforceable federal standard.

### Fact.

In addition to the MCL, the EPA has established a Secondary Maximum Contaminant Level (SMCL) of 2.0 mg/L and requires consumer notification by the water supplier if the naturally occurring fluoride level exceeds 2.0 mg/L. The SMCL, while not federally enforceable, is intended to alert families that regular consumption of water with natural levels of fluoride greater than 2.0 mg/L by young children could cause moderate to severe dental fluorosis in the developing permanent teeth.<sup>32</sup> The notice to be used by water systems that exceed the SMCL must contain the following points:

1. The notice is intended to alert families that children under nine years of age who are exposed to levels of fluoride greater than 2.0 mg/liter may develop dental fluorosis.
2. Adults are not affected because dental fluorosis occurs only when developing teeth are exposed to elevated fluoride levels.
3. The water supplier can be contacted for information on alternative sources or treatments that will insure the drinking water would meet all standards (including the SMCL).<sup>32</sup>

**Figure 3. USEPA Standards and USPHS Recommendation for Fluoride in Drinking Water**

### **U.S. Environmental Protection Agency (EPA) Standards for Fluoride in Drinking Water**

The EPA standards for fluoride in drinking water apply to the *naturally occurring* fluoride in water. They are the:

- Maximum Contaminant Level Goal (**MCLG**) – 4 mg/L
- Maximum Contaminant Level (**MCL**) – 4 mg/L
- Secondary Maximum Contaminant Level (**SMCL**) – 2 mg/L

**MCLG** — The MCLG is the level of contaminants in drinking water at which no adverse health effects are likely to occur. This health goal is based solely on possible health risks and exposure over a lifetime with an adequate margin of safety. The current MCLG for fluoride is 4 mg/L and is set at this level to provide protection against the increased risk of crippling skeletal fluorosis.

**MCL** — The MCL is an enforceable standard which is set as close to the health goal as possible, considering the benefit to the public, the ability of public water systems to detect and remove contaminants using suitable treatment technologies and cost. In the case of fluoride, the MCL is set at the MCLG.

Under the MCL standard, if the naturally occurring level of fluoride in a public water supply exceeds 4 mg/L, the water supplier is required to lower the level of fluoride or defluoridate. Community water systems that exceed the fluoride MCL of 4 mg/L must notify persons served by that system as soon as practical, but no later than 30 days after the system learns of the violation.

**SMCL** — Secondary standards are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as tooth discoloration). The EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards. Tooth discoloration and/or pitting is caused by excess fluoride exposures during the formative period prior to eruption of the teeth in children. The level of the SMCL was set based upon a balancing of the beneficial effects of protection from tooth decay and the undesirable effects of excessive exposures leading to discoloration.

Under the SMCL, if water exceeds 2 mg/L, the water system is to notify consumers that regular consumption of water with fluoride above 2 mg/L, may increase the risk for fluorosis in young (under 9 years of age) children. Community water systems that exceed the fluoride secondary standard of 2 mg/L must notify persons served by that system as soon as practical but no later than 12 months from the day the water system learns of the exceedance.

### **U.S. Public Health Service (USPHS) Recommendation for Fluoride in Drinking Water**

In 2015, the USPHS published a final report establishing guidance for water systems that are actively fluoridating or those that may initiate fluoridation in the future. For community water systems that add fluoride to their water, the USPHS recommends a uniform fluoride concentration of 0.7 mg/L for the entire United States to maintain caries (tooth decay) prevention benefits and reduce the risk of dental fluorosis.

### **Why is the EPA MCL of 4 mg/L different from the USPHS recommendation of 0.7 mg/L?**

The two benchmarks have different purposes and are set under different authorities. The EPA MCL of 4 mg/L is set to protect against risks from exposure to too much fluoride. The USPHS recommended level of fluoride on 0.7 mg/L is set to promote the benefit of fluoride in preventing tooth decay while minimizing the chance for dental fluorosis.

Information Source: EPA Fact Sheet: Questions and Answers on Fluoride. 2011. Available at <https://www.epa.gov/dwsixyearreview/fact-sheet-questions-and-answers-fluoride>

 Additional information on these topics can be found in this Section, Questions 19, 20 and 21.

## 22. Does the total intake of fluoride from air, water and foods in a community in the United States with drinking water fluoridated at the recommended level pose significant health risks?

### Answer.

The total intake of fluoride from air, water and foods in a community in the United States with drinking water fluoridated at the recommended level does not pose significant health risks.

### Fact.

#### Fluoride from the Air

The atmosphere normally contains negligible concentrations of airborne fluorides. Studies reporting the levels of fluoride in air in the United States suggest that ambient fluoride contributes very little to a person's overall fluoride intake.<sup>9,30</sup>

#### Fluoride from Water

For generations, millions of people have lived in areas where fluoride is found naturally in drinking water in concentrations as high as or higher than those recommended to prevent tooth decay. Research conducted among these people confirms the safety of fluoride in the water supply.<sup>1-5</sup>

A ten-year comparison study of long-time residents of Bartlett and Cameron, Texas, where the water supplies contained 8.0 and 0.4 mg/L of fluoride, respectively, included examinations of organs, bones and tissues. Other than a higher prevalence of dental fluorosis in the Bartlett residents (8.0 mg/L fluoride), the study indicated that long-term consumption of fluoride from water and food sources (resident average length of fluoride exposure was 36.7 years), even at these levels more than 10 times higher than recommended for tooth decay prevention, resulted in no clinically significant physiological or functional effects.<sup>5</sup>

In the United States, the natural level of fluoride in ground water varies from very low levels to over 4 mg/L. Public water systems in the U.S. are monitored by the Environmental Protection Agency (EPA), which requires that public water systems not exceed a naturally occurring fluoride level of 4 mg/L.<sup>31</sup> The recommended level for fluoride in drinking water in the United States has been established at 0.7 mg/L by the U.S. Public Health Service.<sup>16</sup> This level has been

established to reduce tooth decay while minimizing the occurrence of dental fluorosis.

Individuals living in a community with water fluoridation get a portion of their daily fluoride intake from fluoridated water and a portion from dietary sources which would include foods and other beverages. Water and water-based beverages are the chief source of dietary fluoride intake. Conventional estimates are that approximately 75% of dietary fluoride comes from water and water-based beverages.<sup>33,34</sup> When considering water fluoridation, an individual consuming one liter of water fluoridated at 0.7 mg/L receives 0.7 milligram of fluoride.

#### Fluoride in Foods

In looking at the fluoride content of foods and beverages over time, it appears that fluoride intake from dietary sources has remained relatively constant.<sup>35</sup> Except for products prepared (commercially or by the individual) or cooked with fluoridated water, the fluoride content of most foods and beverages is not significantly different between fluoridated and nonfluoridated communities. When fluoridated water is used to prepare or cook the samples, the fluoride content of foods and beverages is higher. This difference has remained relatively constant over time.<sup>33,35</sup>

Launched in 2004 and updated in 2005, the National Fluoride Database is a comprehensive, nationally representative database of the fluoride concentration in 427 foods across 27 food groups and beverages consumed in the United States.<sup>34</sup> This database for fluoride was designed for use by epidemiologists and health researchers to estimate fluoride intake and to assist in the investigation of the relationships between fluoride intake and human health. The database contains fluoride values for beverages, water, and some lower priority foods.<sup>34</sup>

The fluoride content of fresh solid foods in the United States generally ranges from 0.01 to 1.0 part per million.<sup>35</sup> The foods highest in fluoride are fish and shellfish, reflective of the fluoride found in ocean water, and the presence or absence of bone fragments such as those in sardines.<sup>35</sup> (Fluoride has an affinity for calcified tissues such as bones.) Cereals, baked goods, breads, and other grain products were estimated to have fluoride concentrations between 0.06 and 0.72 ppm. The majority of vegetables (leafy, root, legumes, green or yellow) have a relatively low fluoride concentration (ranging from 0.01 to 0.5 ppm)

with fruits generally having lower concentrations (ranging from 0.01 to 0.2 ppm) than in vegetables. Raisins are one exception in the fruit category with a higher fluoride concentration due to the use of certain pesticides and concentration through drying.<sup>35</sup>

Brewed teas can contain fluoride concentrations of 1 ppm to 6 ppm depending on the amount of dry tea used, the water fluoride concentration and the brewing time.<sup>36</sup> The fluoride value for unsweetened instant tea powder appears very high when reported as a dry powder because this product is extremely concentrated. However, when one teaspoon of the unsweetened tea powder is added to an eight ounce cup of tap water, the value for prepared instant tea is similar to the values reported for regular brewed tea.<sup>34</sup>

Foods and beverages commercially processed (cooked or reconstituted) in cities fluoridated to the recommended level generally contain higher levels of fluoride than those processed in nonfluoridated communities. These foods and beverages are consumed not only in the city where processed, but also are often distributed to and consumed in nonfluoridated areas.<sup>37</sup> This “halo” or “diffusion” effect results in increased fluoride intake by people in nonfluoridated communities, providing them increased protection against tooth decay.<sup>38,39</sup> As a result of the widespread availability of these various sources of fluoride, the difference between tooth decay rates in fluoridated areas and nonfluoridated areas is somewhat less than several decades ago but this difference is still significant. Failure to account for the diffusion effect results in an underestimation of the total benefit of water fluoridation especially in areas where large amounts of fluoridated products are brought into nonfluoridated communities.<sup>38</sup>

The average daily dietary intake of fluoride (expressed on a body weight basis) by children residing in communities with water fluoridated at 1.0 mg/L is 0.05 mg/kg/day (milligram per kilogram of body weight per day).<sup>40</sup> In communities without optimally fluoridated water, average intakes for children are about 50% lower.<sup>40</sup> Dietary fluoride intake by adults in communities where water is fluoridated at 1.0 mg/L averages 1.4 to 3.4 mg/day, and in nonfluoridated areas averages 0.3 to 1.0 mg/day.<sup>40</sup> With the 2015 recommendation that drinking water be fluoridated at 0.7 mg/L, average intakes would be 30% lower in fluoridated communities than when they were fluoridated at 1.0 mg/L.

## 23. How much fluoride is recommended to maximize the tooth decay prevention benefits of fluoride?

### Answer.

As with all nutrients, the appropriate amount of daily fluoride intake varies with age and body weight. Fluoride is safe and effective when used and consumed properly.

### Fact.

In 1997, the Food and Nutrition Board of the Institute of Medicine developed a comprehensive set of reference values for dietary nutrient intakes.<sup>40</sup> These new reference values, the Dietary Reference Intakes (DRI), replace the Recommended Dietary Allowances (RDA) which had been set by the National Academy of Sciences since 1941. The new values present nutrient requirements to optimize health and, for the first time, set maximum-level guidelines to reduce the risk of adverse effects from excessive consumption of a nutrient. Along with calcium, phosphorus, magnesium and vitamin D, DRIs for fluoride were established because of its proven preventive effect on tooth decay. (See Table 2 in this Question.)

The Adequate Intake (AI) establishes a goal for intake to sustain a desired indicator of health without causing side effects. In the case of fluoride, the AI is the daily intake level required to reduce tooth decay without causing moderate dental fluorosis. The AI for fluoride intake from all sources (fluoridated water, foods, beverages, fluoride dental products and dietary fluoride supplements) is set at 0.05 mg/kg/day. Using the established AI of 0.05 mg/kg, the amount of fluoride for optimal health to be consumed each day has been calculated by sex and age group (expressed as average weight).<sup>40</sup>

The Tolerable Upper Intake Level (UL) establishes a maximum guideline. The UL is higher than the AI and is not the recommended level of intake. The UL is the estimated maximum intake level that should not produce unwanted effects on health. The UL for fluoride intake from all sources (fluoridated water, foods, beverages, fluoride dental products and dietary fluoride supplements) is set at 0.10 mg/kg/day (milligram per kilogram of body weight per day) for infants, toddlers, and children through eight years of age. For older children and adults, who are no longer at risk for dental fluorosis, the UL for fluoride is set at

**Table 2. Reference Intakes for Fluoride****Food and Nutrition Board of the Institute of Medicine 1997<sup>40</sup>**

Age Group	Reference Weights kg (lbs)*	Adequate Intake (mg/day)	Tolerable Upper Intake (mg/day)
Infants 0-6 months	7 (16)	0.01	0.7
Infants 7-12 months	9 (20)	0.5	0.9
Children 1-3 years	13 (29)	0.7	1.3
Children 4-8 years	22 (48)	1.0	2.2
Children 9-13 years	40 (88)	2.0	10.0
Boys 14-18 years	64 (142)	3.0	10.0
Girls 14-18 years	57 (125)	3.0	10.0
Males 19 years and over	76 (166)	4.0	10.0
Females 19 years and over	61 (133)	3.0	10.0

\* Value based on data collected during 1988-94 as part of the Third National Health and Nutrition Examination Survey (NHANES III) in the United States.<sup>40</sup>

10 mg/day regardless of weight. Using the established ULs for fluoride, the amount of fluoride that can be consumed each day to reduce the risk of moderate enamel fluorosis for children through age eight, has been calculated by sex and age group (expressed as average weight).<sup>40</sup> (See Table 2.)

As a practical example, daily intake of 2 mg of fluoride is adequate for a 9- to 13-year-old child weighing 88 pounds (40 kg). This was calculated by multiplying 0.05 mg/kg/day (AI) times 40 kg (weight) to equal 2 mg. At the same time, that 88 pound (40kg) child could consume 10 mg of fluoride a day as a tolerable upper intake level.

Children living in a community with water fluoridation get a portion of their daily fluoride intake from fluoridated water and a portion from dietary sources which would include foods and other beverages. When considering water fluoridation, an individual must consume one liter of water fluoridated at 0.7 mg/L to receive 0.7 milligrams (0.7 mg) of fluoride. Children under six years of age, on average, consume less than one-half liter of drinking water a day.<sup>35</sup> Therefore, children under six years of age would consume, on average, less than 0.35 mg of fluoride a day from drinking optimally fluoridated water (at 0.7 mg/L).

If a child lives in a nonfluoridated area and is determined to be at high risk for tooth decay, the dentist or physician may prescribe dietary fluoride supplements.<sup>41</sup> As shown in Table 1 "Dietary Fluoride Supplement Schedule" (See Benefits Section, Question 12.), the current dosage schedule recommends supplemental fluoride amounts that are below the AI for each age group.<sup>41</sup> The dosage schedule was designed to offer the benefit of decay reduction with a margin of safety to prevent mild to moderate enamel fluorosis. For example, the AI for a child 3 years of age is 0.7 mg/day. The recommended dietary fluoride supplement dosage for a child 3 years of age in a nonfluoridated community is 0.5 mg/day. This provides leeway for some fluoride intake from processed foods and beverages, and other sources.

Tooth decay rates are declining in many population groups because children today are being exposed to fluoride from a wider variety of sources than decades ago.<sup>16</sup> Many of these sources are intended for topical use only; however, some fluoride is ingested inadvertently by children.<sup>42,43</sup> By reducing the inappropriate ingestion of fluoride from toothpaste, the risk of dental fluorosis can be reduced without jeopardizing the benefits to oral health.

For example, it has been reported in a number of studies that young children inadvertently swallow an average of 0.30 mg of fluoride from fluoride toothpaste at each brushing.<sup>44-48</sup> If a child brushes twice a day, 0.60 mg of fluoride could be ingested inappropriately. This could slightly exceed the Adequate Intake (AI) values from Table 2. The 0.60 mg consumption is 0.10 mg higher than the AI value for children 6 to 12 months and is 0.10 mg lower than the AI for children from 1-3 years of age.<sup>40</sup> Although toothpaste is not meant to be swallowed, children could consume the daily recommended Adequate Intake amount of fluoride from toothpaste alone. In order to decrease the risk of dental fluorosis, the American Dental Association (ADA) recommends:<sup>49</sup>

- For children younger than 3 years, caregivers should begin brushing children's teeth as soon as they begin to come into the mouth by using fluoride toothpaste in an amount no more than a smear or the size of a grain of rice (Figure 4). Brush teeth thoroughly twice per day (morning and night) or as directed by a dentist or physician. Supervise children's brushing to ensure that they use the appropriate amount of toothpaste.
- For children 3 to 6 years of age, caregivers should dispense no more than a pea-sized amount (Figure 4) of fluoride toothpaste. Brush teeth thoroughly twice per day (morning and night) or as directed by a dentist or physician. Supervise children's brushing to minimize swallowing of toothpaste.<sup>49</sup>

➤ *Additional information on this topic can be found in this Section, Question 29.*

**Figure 4. Examples of Toothpaste Amounts for Children<sup>49</sup>**



For children under three years old, use no more than a smear or grain of-rice sized amount of fluoride toothpaste.



For children three to six years old, use only a pea sized amount of fluoride toothpaste.

It should be noted that the amounts of fluoride discussed here are intake, or ingested, amounts. When fluoride is ingested, a portion is retained in the body and a portion is excreted.

➤ *Addition information on this topic can be found in this Section, Question 25.*

## 24. Is there a need for prenatal dietary fluoride supplementation?

### Answer.

There is no scientific basis to suggest any need to increase a woman's daily fluoride intake during pregnancy or breastfeeding to protect her health. At this time, scientific evidence is insufficient to support the recommendation for prenatal fluoride supplementation for decay prevention for infants.

### Fact.

The Institute of Medicine determined that, "No data from human studies document the metabolism of fluoride during lactation. Because fluoride concentrations in human milk are very low (0.007 to 0.011 ppm) and relatively insensitive to differences in the fluoride concentrations of the mother's drinking water, fluoride supplementation during lactation would not be expected to significantly affect fluoride intake by the nursing infant or the fluoride requirement of the mother."<sup>40</sup>

A 2005 a randomized, double blind study<sup>50</sup> compared the amount of fluoride incorporated into primary teeth exposed to prenatal and post natal fluoride supplements to primary teeth that were exposed to only postnatal fluoride. The study concluded that teeth exposed to prenatal and postnatal fluoride supplements had no additional measurable fluoride other than that attributable to postnatal fluoride alone.<sup>50</sup> This study confirmed the findings of a 1997 randomized, double blind study that evaluated the effectiveness of prenatal dietary supplementation which concluded that the data did not support the hypothesis that prenatal fluoride had a strong decay preventive effect on primary teeth.<sup>51</sup>

25. When fluoride is ingested, where does it go?


**Answer.**

Much of the ingested fluoride is excreted. Of the fluoride retained, almost all is found in calcified (hard) tissues, such as bones and teeth.

**Fact.**

After ingestion of fluoride, such as drinking a glass of fluoridated water, the majority of the fluoride is absorbed from the stomach and small intestine into the blood stream. This causes a short-term increase in fluoride levels in the blood. Fluoride is distributed through the body by plasma (a component of blood) to hard and soft tissues. Following ingestion, the fluoride plasma levels increase quickly and reach a peak concentration within 20–60 minutes. The concentration declines rapidly, usually approximating the baseline levels within three to six hours, due to the uptake of fluoride by calcified tissues and excretion in urine. In adults, approximately 50% of the fluoride absorbed each day becomes associated with calcified tissues within 24 hours while the remainder is excreted in the urine. Approximately 99% of the fluoride present in the body is in calcified tissues (mainly bone).<sup>52</sup>

Ingested or systemic fluoride becomes incorporated into forming tooth structures. Fluoride ingested regularly during the time when teeth are developing is deposited throughout the tooth structure and contributes to long lasting protection against tooth decay.<sup>53–57</sup>

 *Additional information on this topic can be found in the Benefits Section, Question 2.*

An individual's age and stage of skeletal development will affect the rate of fluoride retention. The amount of fluoride taken up by bone and retained in the body is inversely related to age. A greater percentage of fluoride is absorbed in young bones than in the bones of older adults.<sup>52</sup> However, once fluoride is absorbed into bones, it is released back into plasma (a component of blood) when fluoride levels in plasma fall. This absorption and release cycle continues throughout the life span.<sup>52</sup>

26. Will drinking water that is fluoridated at the recommended level adversely affect bone health?

**Answer.**

According to the best available science, drinking water that has been fluoridated at the recommended level does not have an adverse effect on bone health.

**Fact.**

Several systematic reviews have concluded that fluoride at the level used in community water fluoridation has no adverse effect on bone health. A systematic review published in 2000 concluded that there was no clear association between water fluoridation and hip fracture.<sup>59</sup> Twenty-nine studies that looked at the association between bone fracture/ bone development and water fluoridation were included in the review. The evidence regarding other types of bone fractures was similar.<sup>59</sup> A systematic review published in 2017<sup>10</sup> concurred with the earlier review concluding that there is evidence that fluoridated water at recommended levels is not associated with bone fracture.<sup>10</sup>

In addition to the systematic reviews, a number of individual studies have investigated the bone health of individuals residing in communities with fluoride in drinking water at the recommended levels and higher than recommended levels. Most of these studies have focused on whether there exists a possible link between fluoride and bone fractures. Additionally, the possible association between fluoride and bone cancer has been studied. None of the studies provide a legitimate reason for altering public health policy regarding fluoridation and bone health concerns.

The following studies, listed in chronological order, add to the body of evidence indicating that there is no association between consumption of optimally fluoridated water and bone fracture.

The Iowa Fluoride Study/Iowa Bone Development Study<sup>60</sup> looked at the association of fluoride intake with bone measures (bone mineral content and bone mineral density) in a cohort of Iowa children. Assessment of the participants' dietary fluoride intake had been ongoing since birth with parents completing detailed fluoride questionnaires at numerous time periods through 15 years of age. These children had combined fluoride intake estimated from a number of sources including water, other beverages, selected

foods, dietary fluoride supplements and fluoride toothpaste. Estimated fluoride intake was noted during different time periods and cumulatively from birth to 15 years of age. The findings indicate that fluoride exposures at typical levels for most U.S. adolescents in fluoridated areas do not have significant effects on bone mineral measures. These findings are generally comparable with those from the analyses of this cohort at age 11 years.<sup>61</sup> During the intervening 4 years, cohort members generally experienced a substantial increase in bone mass accrual. For example, mean whole-body bone mineral content showed mean increases of approximately 61% in females and 96% in males. Despite the acceleration of bone growth near puberty, the associations between fluoride intake and bone outcome measures remained weak and none was significant after adjustment for other variables.<sup>60</sup>

In one of the largest studies of its kind with nearly half a million subjects, Swedish researchers looked at residents' chronic consumption of various levels of fluoride and the risk of hip fracture. All individuals born in Sweden between January 1, 1900 and December 31, 1919, alive and living in their municipality of birth at the time of the start of follow-up, were eligible for the study. Information on the study population was linked to the Swedish health registers. Estimated individual drinking water fluoride exposure was stratified into 4 categories: very low, < 0.3 mg/L; low, 0.3 to 0.69 mg/L; medium, 0.7 to 1.49 mg/L; and high, ≥ 1.5 mg/L. Published in 2013, the researchers found Swedish residents chronically exposed to various levels of fluoride in drinking water did not show any differences in rates of either hip fracture or low-trauma osteoporotic hip fracture due to fluoride exposure.<sup>62</sup>

A study published in 2005 evaluated the bone mineral density levels and rate of bone fracture of 1,300 women living in three separate communities. To be included in the study, the women had to be ambulatory. The ages of the women ranged from 20 years to 92 years. The size and demographics of the three communities were similar. One part of the study looked at whether fluoride was associated with adverse bone-related outcomes. The study measured fluoride serum levels, fluoride exposure, and bone metabolism as related to fluoride exposure and fluoride's interaction with other important bone factors including age, menopause status and medications. The study concluded that long-term exposure to fluoride was not associated with adverse effects on bone health.<sup>63</sup>

A study published in 2001<sup>64</sup> examined the risk of bone fractures, including hip fractures associated with long-term exposure to fluoridated water in six Chinese populations. The water fluoride concentrations ranged from 0.25 to 7.97 mg/L. A total of 8,266 male and female subjects, all of whom were 50 years old or older participated in the study. The results showed an interesting and potentially important finding regarding overall bone fractures. Whereas there appeared to be a trend for higher fracture rates from 1.00 to 4.00 mg/L, the fracture rate in the 1.00 to 1.06 mg/L category was lower than the rate in the category with the lowest fluoride intake (0.25 to 0.34 mg/L). The study concluded that long-term fluoride exposure from drinking water containing 4.32 mg/L or more increases the risk of overall bone fracture, as well as hip fracture, while water fluoride levels of 1.0 to 1.06 mg/L decreased the risk of overall fractures relative to negligible fluoride in water.<sup>64</sup> (Note that 4.32 mg/L is more than six times the fluoride level currently recommended for community water fluoridation in the United States).

While a number of studies reported findings at a population level, both the Hillier and Phipps studies published in 2000, examined risk on an individual, rather than a community basis, taking into account other risk factors such as medications, age of menopause, alcohol consumption, smoking, dietary calcium intake and physical activity. Using these more rigorous study designs, these two studies reported no effect of the risk of hip fracture<sup>65</sup> and no increase in the risk of hip fracture in those drinking fluoridated water,<sup>66</sup> respectively.

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*According to the best available science, drinking water that has been fluoridated at the recommended level does not have an adverse effect on bone health.*

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## 27. What is dental fluorosis or enamel fluorosis?

### Answer.

Dental fluorosis is a change in the appearance of the tooth enamel that only occurs when younger children consume too much fluoride, from all sources, over long periods when teeth are developing under the gums.<sup>36</sup> In the United States, most commonly these changes are not readily apparent to the affected individual or casual observer and require a trained specialist to detect. This type of dental fluorosis found in the United States has no effect on tooth function and can make the teeth more resistant to decay.<sup>67</sup> Photographs of mild dental fluorosis can be viewed at <https://www.ADA.org/en/member-center/oral-health-topics/fluoride-topical-and-systemic-supplements>. (Note that mild dental fluorosis is generally less evident than on these photographs. This is because the teeth were dried very well to improve the photography and this makes the mild dental fluorosis stand out, but if the tooth had saliva on it as it usually does, then it would be less noticeable.)

### Fact.

The crown of the tooth (the part covered in enamel) is formed under the gums before the teeth erupt. Enamel formation of permanent teeth, other than third molars (wisdom teeth), occurs from about the time of birth until approximately eight years of age.<sup>68</sup> Because dental fluorosis occurs only while teeth are forming under the gums, teeth that have erupted are not at risk for dental fluorosis; therefore, older children and adults are not at risk for the development of dental fluorosis.<sup>69</sup> It should be noted that there are many other developmental changes that affect the appearance of tooth enamel which are not related to fluoride intake. In other words, not all opaque or white blemishes on teeth are caused by fluoride. Furthermore, dental fluorosis occurs among some people in all communities, even in communities that do not have community water fluoridation, or that have a low natural concentration of fluoride in their drinking water.<sup>70-72</sup>

### Classification of Dental Fluorosis

Dental fluorosis has been classified in a number of ways. One of the most widely used classifications was developed by Dean in 1942.<sup>73</sup> (See Table 3.)

In using Dean's Fluorosis Index, each tooth in an individual's mouth is rated according to the fluorosis

index in Table 3. The individual's dental fluorosis score is based upon the most severe form of fluorosis recorded for two or more teeth. Dean's Fluorosis Index, which has been used since 1942, remains popular for prevalence studies in large part due to its simplicity and the ability to make comparisons with findings from a number of earlier studies.<sup>74</sup>

In 2010, a report by the U.S. National Center for Health Statistics described the prevalence and changes in prevalence and severity of dental fluorosis in the United States and among adolescents between 1986–1987 and 1999–2004.<sup>75</sup> According to the report, in 1999–2004, 40.7% of adolescents had dental fluorosis. It should be noted that dental fluorosis can occur not only from fluoride intake from water but also from fluoride products, such as toothpaste, mouthrinses and excessive use of fluoride supplements during the ages when teeth are forming. A 1994 analysis of five studies showed that the amount of dental fluorosis attributable to water fluoridation at 1.0 mg/L was approximately 13%.<sup>76</sup> In other words, at that time the amount of dental fluorosis would have been reduced by only 13% if water was not fluoridated. Now it would be less of a reduction, since fluoridation uses the lower level of 0.7 mg/L. The majority of dental fluorosis in the U.S. is caused by the inappropriate ingestion of fluoride products.<sup>76</sup>

The vast majority of dental fluorosis in the United States is the very mild or mild type. This type of dental fluorosis is not readily apparent to the affected individual or casual observer and often requires a trained specialist to detect. In contrast, the moderate and severe forms of dental fluorosis, characterized by esthetically (cosmetically) objectionable changes in tooth color and surface irregularities, respectively, are not common in the United States. Most investigators regard even the more advanced forms of dental fluorosis as a cosmetic effect rather than a functional adverse effect.<sup>40</sup> In 1993, the U.S. Environmental Protection Agency, in a decision supported by the U.S. Surgeon General, determined that objectionable dental fluorosis is a cosmetic effect with no known health effects.<sup>77</sup> However, in 2003, the EPA requested that the National Research Council (NRC) evaluate the adequacy of its MCLG for fluoride to protect public health. A committee was convened to review recent evidence and eventually developed the 2006 report titled, *Fluoride in Drinking Water — A Scientific Review of the EPA's Standards*.<sup>9</sup> As part of that report, a majority of the committee members found severe dental fluorosis to be an adverse health

effect based on suggestive but inconclusive evidence that severe dental fluorosis (characterized by pitting of the enamel) increased the risk of tooth decay. All members of the committee agreed that the condition damages the tooth and that the EPA standard should prevent the occurrence of this unwanted condition. The prevalence of severe enamel fluorosis is very low below 2 mg/L of fluoride in drinking water in the U.S.<sup>9</sup>

➦ *Additional information on this topic can be found in this Section, Questions 20 and 21.*

*The vast majority of dental fluorosis in the United States is the very mild or mild type. This type of dental fluorosis is not readily apparent to the affected individual or casual observer and often requires a trained specialist to detect.*

Limited research on the psychological effects of dental fluorosis on children and adults has been conducted. However, a 2009 literature review that assessed the relationships between perceptions of dental appearance/oral health related quality of life (OHRQoL) and dental fluorosis concluded that very mild to mild dental fluorosis has little impact and in some cases evidence suggested enhanced quality of life with mild dental fluorosis.<sup>78</sup> When evaluating the oral health related quality of life of children by tooth decay (cavities) and dental fluorosis experience, a 2007 study concluded that cavities were associated with a negative impact while mild dental fluorosis had a positive impact on children's and parents' quality of life.<sup>79</sup>

Very mild to mild dental fluorosis has no effect on tooth function and can make the tooth enamel more resistant to decay. A study published in 2009<sup>67</sup> investigated the relationship between dental fluorosis and tooth decay in U.S. schoolchildren. The study concluded that teeth with dental fluorosis were more resistant to tooth decay than were teeth without dental fluorosis. Not only should the cavity preventive benefits of fluoridation be considered when evaluating policy to introduce or retain water fluoridation, but the cavity preventive benefits of mild dental fluorosis should also be considered.<sup>67</sup>

*Very mild to mild dental fluorosis has no effect on tooth function and can make the tooth enamel more resistant to decay.*

A report published in 2010<sup>75</sup> described the prevalence (total percentage of cases in a population) of dental fluorosis in the United States and discussed the changes in the prevalence and severity of dental fluorosis among adolescents between 1986–1987 and 1999–2004. The report used data from the National Health and Nutrition Examination Survey (NHANES) 1999–2004 and the 1986–1987 National Survey of Oral Health in U.S. School Children. The data represented persons from 6 to 49-years of age and varied races and ethnicities including non-Hispanic black and Mexican-American persons. The oral exams for both surveys were conducted by trained dental examiners and included a dental fluorosis assessment of permanent teeth. The Dean's Fluorosis Index was used to determine the prevalence and severity of dental fluorosis.

The data published in 2010<sup>75</sup> showed that less than one-quarter of persons aged 6–49 in the United States had some form of dental fluorosis. For the remaining three-quarters of persons in this age group, 60.6% were unaffected by dental fluorosis and 16.5% were classified as having questionable dental fluorosis. The percent distribution of the types of dental fluorosis in persons aged 6–49 years observed was:

Very mild fluorosis	16.0%
Mild fluorosis	4.8%
Moderate fluorosis	2.0%
Severe fluorosis	less than 1%

While moderate and severe dental fluorosis comprise less than 3% of dental fluorosis in all persons aged 6–49, the prevalence of moderate or severe dental fluorosis in this age group comprised a very small portion (less than 10%) of the total number of all cases of dental fluorosis. In other words, approximately 90% of all dental fluorosis observed was very mild to mild form.<sup>75</sup>

In regards to dental fluorosis in adolescents, children aged 12–15 years in 1999–2004 had higher prevalence of dental fluorosis compared with the same aged children in 1986–1987.<sup>75</sup>

In reviewing this report,<sup>75</sup> it should be noted that dental fluorosis was not assessed in NHANES 1988–1994 and so it was not possible to compare the NHANES 1999–2002 to the earlier NHANES report. The only other previously collected national data on dental fluorosis were the 1986–1987 National Institute of Dental Research (NIDR) National Survey of Oral Health in U.S. School Children. Differences in study design between NIDR 1986–1987 and NHANES 1999–2002 should be considered when drawing inferences about changes in prevalence and severity of enamel fluorosis.<sup>75</sup> Examples of differences in these two surveys include but are not limited to:

- NIDR survey is a school-based survey while the NHANES is a household survey.
- NHANES did not collect residential histories; NIDR did gather residential histories but it is unknown if NIDR reported dental fluorosis data only for those with a single residence history.
- NIDR collected water samples from schools for fluoride analysis; NHANES did not collect water samples for analysis until the 2013–14 survey cycle.

As defined in Table 3, very mild dental fluorosis is characterized by small opaque, paper-white areas covering less than 25% of the tooth surface. The risk of teeth forming with the very mildest form of dental fluorosis must be weighed against the benefit that the individual will have fewer cavities thus saving dental treatment costs, avoiding patient discomfort and reducing tooth loss.<sup>81,82</sup> In addition, the risk of dental fluorosis can be viewed as an alternative to having tooth decay,<sup>83</sup> which is a disease that causes cosmetic problems, pain, missed school and work, and can lead to infection and, in advanced cases, life-threatening health effects. This is in contrast to dental fluorosis which is not a disease and is not life-threatening.

*The risk of teeth forming with the very mildest form of dental fluorosis must be weighed against the benefit that the individual will have fewer cavities thus saving dental treatment costs, avoiding patient discomfort and reducing tooth loss.*

**Table 3. Dental Fluorosis Classification by H.T. Dean – 1942<sup>75</sup>**

<b>Classification</b>	<b>Criteria-Description of Enamel</b>
<b>Normal</b>	Smooth, glossy, pale creamy-white translucent surface
<b>Questionable</b>	A few white flecks or white spots
<b>Very Mild</b>	Small opaque, paper-white areas covering less than 25% of the tooth surface
<b>Mild</b>	Opaque white areas covering less than 50% of the tooth surface
<b>Moderate</b>	All tooth surfaces affected; marked wear on biting surfaces; brown stain may be present
<b>Severe</b>	All tooth surfaces affected; discrete or confluent pitting; brown stain present

## 28. Is it safe to use fluoridated water to reconstitute infant formula?

### Answer.

It is safe to use fluoridated water to reconstitute infant formula.

### Fact.

Fluoridated water can be used to prepare infant formula. However, if the child is exclusively consuming infant formula reconstituted with fluoridated water, there could be an increased chance of mild dental fluorosis.<sup>86</sup> To lessen this chance, parents can use low-fluoride bottled water some of the time to mix infant formula. These bottled waters are labeled as de-ionized, purified, demineralized, or distilled. However, parents should be aware that using these types of waters exclusively means an infant does not receive the amount of fluoride the Institute of Medicine indicated is required to prevent tooth decay.<sup>40</sup> On the other hand, the exclusive use of nonfluoridated water to reconstitute infant formula will not guarantee that an infant will not develop dental fluorosis. The chance of development of dental fluorosis exists through approximate eight years of age when the permanent teeth are still forming under the gums. Fluoride intake from other sources during this time such as toothpaste, mouthrinse and dietary fluoride supplements also contributes to the chance of dental fluorosis for children living in nonfluoridated and fluoridated communities.<sup>84</sup>

In response to the report of the National Research Council (NRC) *Fluoride in Drinking Water: A Scientific Review of EPA's Standards*<sup>9</sup> in November 2006, and with an abundance of caution, the ADA issued the *Interim Guidance on Fluoride Intake for Infants and Young Children (Interim Guidance)*. **The Interim Guidance is no longer current and has been replaced.** Unfortunately, those opposed to fluoridation continue to publicize and use the Interim Guidance in efforts to halt fluoridation.

The *Interim Guidance* was replaced in January 2011 by the ADA *Evidence-Based Clinical Recommendations Regarding Fluoride Intake From Reconstituted Infant Formula and Enamel Fluorosis A Report of the American Dental Association Council on Scientific Affairs*.<sup>84</sup> The report encourages clinicians to follow the American Academy of Pediatrics guidelines for infant nutrition which advocates exclusive breastfeeding until the child is aged 6 months and continued breastfeeding until the

child is at least 12 months of age, unless specifically contraindicated. Additionally, the ADA report, designed for use by clinical practitioners, offers the following suggestions to practitioners to use in advising parents and caregivers of infants who consume powdered or liquid concentrate infant formula as the main source of nutrition:<sup>84</sup>

- Suggest the continued use of powdered or liquid concentrate infant formulas reconstituted with optimally fluoridated drinking water while being cognizant of the potential risk of enamel fluorosis development.<sup>89</sup>
- When the potential risk of enamel fluorosis development is a concern, suggest ready-to-feed formula or powdered or liquid concentrate formula reconstituted with water that either is fluoride free or has low concentrations of fluoride.<sup>84</sup>

It should be noted that the Centers for Disease Control and Prevention,<sup>85</sup> as well as other agencies, such as the U.S. Department of Health and Human Services,<sup>86</sup> American Public Health Association,<sup>87</sup> and health departments such as the New York State Health Department<sup>88</sup> provide similar information regarding the use of fluoridated water to reconstitute infant formula.

## 29. What can be done to reduce the occurrence of dental fluorosis in the U.S.?

### Answer.

The vast majority of enamel fluorosis in the United States can be prevented by limiting the ingestion of topical fluoride products (such as toothpaste) and recommending the appropriate use of dietary fluoride supplements — without denying young children the decay prevention benefits of community water fluoridation.

### Fact.

Tooth decay has decreased substantially in the United States because more children today are benefitting from access to fluoride which is available from a wider variety of sources than decades ago. Many of these sources are intended for topical use only; however, when they are used, some fluoride is inadvertently swallowed by children.<sup>42,43,89</sup> Inappropriate ingestion of topical fluoride can be minimized, thus reducing the risk for dental fluorosis without reducing decay prevention benefits.