Risk of Fluorosis Associated With Infant Formulas Prepared With Bottled Water

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ABSTRACT

Purpose: The purpose of this study was to estimate fluoride (F) intake from infant formulas prepared with different brands of bottled water.
Methods: Fluoride concentrations in 4 samples of infant milk and soy-based formulas, commercially available in the United States, prepared with deionized water and 5 brands of bottled water, were determined after Hexamethyldisioxane (HMDS)-facilitated diffusion, in duplicate, using an F ion-specific electrode. Possible fluoride ingestion per killogram body mass was estimated, based on suggested volumes of formula consumption, for infants 1 and 12 months.
Results: Fluoride concentrations ranged from 0.076 to 0.214 ppm and 0.092 to 1.053 ppm for formulas prepared with deionized and bottled water, respectively. When prepared with deionized water, none of the formulas provided an F intake above the suggested threshold for fluorosis (0.07 mg F/kg/day). However, when prepared with some brands of bottled water containing 0.623 and 0.839 ppm, all of them did provide it.
Conclusions: Some brands of bottled water usually marketed for infants and used to dilute infant formulas may increase fluoride concentrations beyond reccommended levels believed to lead to fluorosis. (*J Dent Child.* 2004;71:110-113)

KEYWORDS: FLUORIDE, FLUOROSIS, INFANT FORMULA, WATER FLUORIDATION

The fluoride intake amount associated with an increase of dental fluorosis has been studied all over the world.[1-5]

Fluoride is available in food, beverages, toothpastes, and the public water supply.[2,6-8] Ingestion of these products is highly variable, and some infants and children may ingest amounts considerably higher than average ingestion at an age when they are susceptible to enamel fluorosis.[1]

Infant formulas may be a major risk factor for fluorosis, especially when prepared with fluoridated water.[4,9-19]

A total daily fluoride intake between 0.05 to 0.07 mg per kilogram body weight is generally regarded as optimum.[6] Since a large number of infants consume infant formulas prepared with bottled water, the fluoride content of infant formulas available in the United States when mixed with various bottled waters were compared to recommended daily fluoride intake.

METHODS

Four infant formulas (Enfamil Lacto-Free, Soy infant formula; Enfamil Prosobee; Prosobee RTF) were prepared according to manufacturer instructions using deionized water and 5 brands of bottled water (Dannon, Crystal Geyser, Pure American, Ice Mountain, Nursery Water).

Fluoride determinations were made after overnight Hexamethyldisioxane (HMDS)-facilitated diffusion (Taves)[21] using the ion-specific electrode (model no. 9609, Orion Research, Cambridge, Mass). A set of standards (ranging between 0.025-1.6 ppm F) was prepared in triplicate, using serial dilution from a 100 ppm NaF stock solution (model no. 940907, Orion Research, Cambridge, Mass) and diffused in the same way as the samples. The millivoltage potentials were converted to μg F using a standard curve with a correlation coefficient of $r \geq 0.999$. All samples were analyzed in triplicate. To estimate possible fluoride ingestion for infants and children, a formula administration guide with suggested formula consumption volumes was used (Table 1).

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Table 1. Formula Administration Guide*

Age (mos)	Body mass (kg)	Suggested feedings	Total volume (ml)
0-1	0-4	5 bottles of 120 ml	600
6-12	8-10	4 bottles of 270 ml	1,080

*Data from Mead Johnson, Crows Nest, NSW.

Table 2. Fluoride Content (mg/L) in Formulas Prepared With Different Brands of Bottled Water

Water	Deionized	Dannon	Crystal Geyser	Pure American	Ice Mountain	Nursery Water
Formulas		(0.016)*	(0.035)*	(0.026)*	(0.839)*	(0.623)*
Enfamil lacto free	0.214	0.230	0.249	0.240	1.053	0.837
Soy infant formula	0.076	0.092	0.111	0.102	0.915	0.699
Enfamil Prosobee	0.199	0.215	0.234	0.225	1.038	0.822
Prosobee (RTF)	0.170	0.186	0.205	0.196	1.009	0.793

*Fluoride content of bottled waters in mg/L.

RESULTS

Fluoride concentrations of bottled water ranged from 0.016 to 0.839 mg/L. Two brands exceeded the recommended dosage of 0.7 mg/L (Ice Mountain and Nursery brand water). Table 2 represents concentrations of F in μg/g of milk formulas prepared with deionized and bottled water. Fluoride content ranged from 0.076 to 0.214 μg/g in formulas prepared with deionized water and from 0.092 to 1.053 mg/L in formulas prepared with bottled water.

Using average infant body masses and suggested volumes of formula consumption for infants 1 month and 12 months (Table 1), possible fluoride ingestion per kilogram body mass can be estimated. (Table 3). When reconstituted with deionized water, none of the formulas provided an intake higher than 0.07 mg/F/kg body mass. At the ages of 1 and 12 months, all formulas prepared with Ice Mountain and Nursery brand water (a fluoridated water specially marketed for infants) provided a daily fluoride intake ranging from 0.09 to 0.158 μg/kg, which is above the suggested threshold for fluorosis.[6]

DISCUSSION

There has been an increase in the prevalence of dental fluorosis in the United States.[22] Four major risk factors have been identified: (1) fluoridated drinking water use; (2) fluoride supplements; (3) fluoride dentifrice; and (4) infant formulas.[23,24]

Giving special attention to infant formulas, it is possible to recognize that infant feeding practices have changed greatly in recent decades. Infant formula feeding has taken place in many countries. Hence, fluoride content in infant formulas became an important factor to be assessed, as well as fluoride present in the diluents needed to prepare the formulas.[25] A number of studies implicate infant formulas as a risk factor for dental fluorosis, particularly in fluoridated areas.[4,9,14,17,19,26,27] but not in nonfluoridated areas.[28] In fact, the most important factor when considering infant formulas as a risk factor for dental fluorosis is the water used to reconstitute them. When infant formulas are reconstituted with optimally fluoridated water, they provide a daily fluoride intake above that which is likely to cause some degree of dental fluorosis.[4,6-9] This was observed in this study when formulas were reconstituted with fluoridated bottled water.

When used to reconstitute infant formulas, Nursery water can provide a total daily fluoride intake above the suggested threshold for dental fluorosis for a 12-month-old child. At this age, there is already risk of dental fluorosis for the permanent dentition. In addition, at this age infants are consuming fluoride from sources other than the formula, which can worsen the situation. Health professionals should be aware of this fact to give parents precise recommendations.

In this study, Table 2 shows fluoride concentration of the formulas prepared with deionized water, or the equivalent fluoride content of plain formula. The soy products did not show

Table 3. Estimated Fluoride Intake (mg/L) From Formulas Prepared With Different Brands of Bottled Water

	1 mo (4 kg)						12 mos (10 kg)					
	Deionized	Dannon	Crystal Geyser	Pure American	Ice Mountain	Nursery Water	Deionized	Dannon	Crystal Geyser	Pure American	Ice Mountain	Nursery Water
Enfamil lacto free	0.032	0.035	0.037	0.036	0.158*	0.126*	0.023	0.025	0.027	0.026	0.114*	0.090*
Soy infant formula	0.011	0.014	0.017	0.015	0.137*	0.105*	0.008	0.010	0.012	0.011	0.099*	0.075*
Enfamil Prosobee	0.030	0.032	0.035	0.034	0.156*	0.123*	0.021	0.023	0.025	0.024	0.112*	0.089*
Prosobee (RTF)	0.026	0.028	0.031	0.029	0.151*	0.119*	0.018	0.020	0.022	0.021	0.109*	0.086*

*Values that exceeded 0.07 mg/kg.

the higher fluoride concentrations usually found in other studies. This can be attributed to higher endogenous levels of fluoride in soy extract.[14,29] Soy infant formula has 0.076 ppm, Enfamil Prosobee formula has 0.199 ppm, and Prosobee ready-to-feed formula has 0.17 ppm.

Silva and Reynolds[9] found a fluoride content of 0.46 ppm for Pregestemil, 0.41 ppm for Prosobee, and 0.158 ppm for Infasoy. Johnson and Bawden[14] found fluoride levels ranging from 0.18 to 0.24 ppm for Prosobee purchased in different American cities. Latifah and Razak[18] found 0.236 ppm for Nursoy. Adair and Wei[12] found 0.27 ppm for Prosobee and 0.92 ppm for Prosobee ready-to-feed. These great differences are common in the literature and are attributed to the fluoride content of the water used in processing the formula.[9,12,14,18]

None of the formulas and mineral waters show the fluoride content on their labels. Because it is artificially fluoridated, Nursery water is the only product showing a fluoride content of 0.6 ppm on its label. Horowitz[1] commented that there should be regulations requiring that fluoride content be identified. However, this can be a problem, as consumers are typically not educated enough to assimilate and interpret this information. The practitioner's role should be to:

1. explain to the manufacturers the implication of excessive concentrations of fluoride in their products;
2. convince manufacturers to produce products with specific upper limits of fluoride.

The use of bottled water to prepare milk formulas is very common, and their fluoride content is variable. The authors found fluoride concentrations ranging from 0.016 to 0.839 ppm. Villena et al[30] found fluoride values ranging from 0 to 4.4 ppm in Brazilian bottled waters. In a study from their research group, the authors found fluoride concentrations from 0.02 to 0.69 ppm for Brazilian bottled waters,[4] while Toumba et al[31] found fluoride concentrations ranging from 0.1 to 0.8 ppm in British bottled waters. Van Winkle et al[19] found fluoride concentrations ranging from 0.34 to 1.36 ppm and among the brands analyzed. Crystal Geyser had 0.52 ppm fluoride, and Nursery water had 1.07 ppm fluoride—differing from the authors' findings.

In the present study, all formulas prepared with Ice Mountain (0.839 ppm) and Nursery water (0.623 ppm) exceeded the total optimal daily intake recommendation for fluoride. These formulas should provide a daily intake above the suggested threshold for fluorosis for a 1and for a 12-month-old infant (Table 3). It is also crucial to emphasize that a 12-month-old child receives fluoride from other feeding sources.

All health professional should understand the risks of preparing infant formulas with optimally fluoridated water and give precise recommendations to their patients. Additionally, this information should be emphasized in public health policies.

CONCLUSIONS

The results of this study suggest that bottled water, when used to reconsititute formula concentrate, can exceed fluoride levels associated with increased liklihood of fluorosis.

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