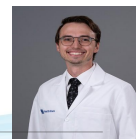


Fluoride Exposure Associated with Bottled Water Consumption

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INTRODUCTION

Fluoride is a naturally occurring mineral present in most water sources, originating from geological processes. Initial observations of a unique brown discoloration found on children's teeth in Colorado in early 20th century linked high fluoride intake to the formation of defective enamel, a condition later named dental fluorosis.¹ Total fluoride exposure is most dependent on drinking water's fluoride concentration, with an average of 57-94% of a person's total fluoride intake coming from this source. In 2022, 62.8% of the U.S. population received fluoridated water.² The prevalence of dental fluorosis has risen markedly, with an estimated 65% of individuals aged 12-15 years affected, and approximately 30.4% of cases categorized as moderate to severe in the U.S.³ With rising concerns regarding the safety of fluoride in water, patients may prefer alternative sources of water, like bottled water.



Figure 1: Patient with mild fluorosis on anterior teeth.



Figure 3: Estimate of Kentucky Clinic patients drinking bottled water.

OBJECTIVE

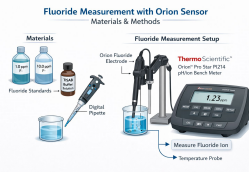
This study aims to quantify bioavailable fluoride concentration and pH found in bottled water brands and estimate fluoride intake with pediatric tolerable upper intake levels (ULs).

MATERIAL AND METHODS

Fluoride concentrations in bottled waters were determined using an ORION fluoride ion-selective electrode (Thermo Fisher Scientific, Waltham, MA, USA). The electrode was calibrated using a series of five standard fluoride solutions (0.125 - 5 ppm) (Thermo Fisher Scientific) in the presence of Total Ionic Strength Adjustment Buffer II, (TISAB II - Thermo Fisher Scientific). Then, 30 mL of thirteen bottled water products were mixed with 30 mL of TISAB II. The mixture was gently stirred, and the fluoride concentration was measured. The pH of each sample was also measured using a pH meter (Thermo Fisher Scientific). All measurements were performed in triplicate. The estimated daily intake (EDI) for patients was calculated assuming a daily consumption volume of 32 oz (950 mL).

The percentage contribution to daily upper limit (%UL) was also calculated. Data was descriptively analyzed.

Figure 4: Schematic image showing the preparation and analysis of the samples.



Age	Male	Female
0-6 months	0.7 mg	0.7 mg
7-12 months	0.9 mg	0.9 mg
1-3 years	1.3 mg	1.3 mg
4-8 years	2.2 mg	2.2 mg

Table 1: Daily tolerable intake levels for fluoride.⁶



Figure 5: Water brands tested

RESULTS

Water pH ranged from 5.4(0.1)-10.2(0.3) while fluoride concentrations ranged from 0.00(0.0)-0.13(0.0) mg/L. EDI ranged from 0.00-0.12 mg/day, corresponding to 0-10% of the UL for children aged 1-3 years and 0-6% for children 4-8 years old.

DISCUSSION

Fluoride intake was calculated based on the average recommended intake of water for children up to 8 years of age.⁴ From all tested bottled water brands was below 10% of the recommended tolerable daily intake across all age groups. Overall, the results suggest that most bottled waters contain little to no fluoride. This is consistent with the fact that many commercially available products are purified through reverse osmosis, a process that removes fluoride. Similarly, spring water samples also showed low fluoride concentrations.

CONCLUSIONS

Fluoride concentrations varied across bottled water brands. All samples had estimated exposure that was minimal or low relative to pediatric ULs.

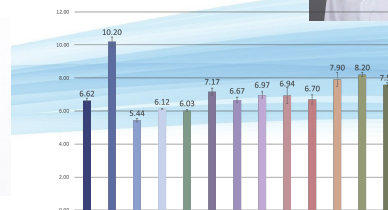


Figure 6: Average pH of different bottled water products.

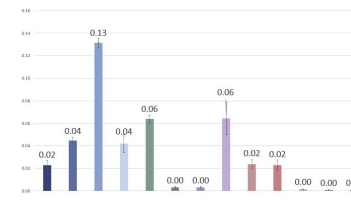


Figure 7: Amount of fluoride in each product (ugF/g).

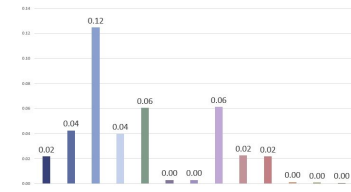


Figure 8: Estimated daily intake of fluoride (mg/day), considering 950 mL of water.

Groups	%UL 0-3 yo	%UL 4-8 yo
Natural Spring Kroger	1.67	0.98
Deer Park	3.27	1.93
Maison Perrier	9.60	5.67
Smart Water	3.07	1.81
Waiakea	4.66	2.76
Purified Kroger	0.23	0.13
Pure Life Kids	0.22	0.13
Skyra Icelandic	4.71	2.78
Pure Life	1.73	1.02
Purified Seven	1.67	0.99
Gatorade Water	0.11	0.06
Seven 7 select Pure	0.06	0.03
BodyArmor Sport Water	0.05	0.03

Figure 9: percentage of upper limit daily intake for fluoride for patients aged 1-8 years of age.