

IN BRIEF

- Mean fluoride content of all bottled waters sampled was below the accepted standard for optimally fluoridated water.
- A lack of agreement between the measured fluoride concentration and that displayed on the labels was observed in three-quarters of the samples.
- When advising children and parent/carers on fluoride therapy, the source of their drinking water (ie tap or boiled) should be taken into consideration.
- The dental health of a child who drinks bottled waters containing a low level of fluoride, as the main source of drinking water, might be affected as a result of receiving a sub-optimal level of fluoride.

Fluoride content of still bottled waters available in the North-East of England, UK

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Objective The aims of this study were to measure the fluoride content of still bottled waters on sale in the UK and to estimate and compare the fluoride intake from tap and bottled water for British children.

Methods Three bottles of 25 commercial brands of bottled water were purchased from supermarkets, grocery stores and health shops in the North-East of England. All samples were still spring, mineral or distilled waters, sold in plastic bottles. The fluoride content of all samples was determined, in duplicate, using a Fluoride Ion Selective Electrode.

Results The mean (\pm SD) fluoride content of the bottled waters was 0.08 (\pm 0.08) mg L⁻¹ with a range from 0.01–0.37 mg L⁻¹ which is below the accepted standard for optimally fluoridated water. The mean fluoride intake for 4–18-year-olds when the source of water intake is solely fluoridated tap water was estimated to be 0.26 mg F per day; compared with 0.16 mg F per day, when a combination of tap and bottled water is consumed.

Conclusions Bottled water, from those sampled, is unlikely to make an important contribution to total fluoride intake in British diets.

Consumption of bottled water containing a negligible amount of fluoride in preference to fluoridated tap water might result in less than optimal fluoride ingestion in young people.

An adequate intake of fluoride during the pre-eruptive stage of enamel formation has a protective effect against dental caries in later life. However, the predominant beneficial effect of fluoride occurs locally in the mouth, at the tooth surface.¹ To reduce the prevalence of dental caries, therefore, fluoride should be taken at intervals throughout the day to maintain adequate levels of fluoride at the tooth surface.

Water, used directly as a drink or indirectly as an addition to beverages and foods, is an important source of ingested fluoride. The results of 120 fluoridation studies from different countries have shown ranges of reductions in dental caries of between 40–60% for permanent teeth and 50–60% for primary teeth in

children aged 5 to 15 years who consumed fluoridated water for long periods.² Although water fluoridation is generally accepted as a means to reduce dental caries in children, adults also benefit from fluoride in their drinking water. Reduction in dental caries has been reported for all age groups up to 65 years when fluoridated water is consumed.³

Traditionally, tap water has made an important contribution to total water intake with between 40–50% of daily water intake coming from this source when the air temperature is less than 21°C.^{4–10} However, more recently, there has been a trend to use more natural beverages,¹¹ a developing passion with fitness, greater travel and access to refreshments, as well as moves towards a greater consumption of food outside the home. These changes, as well as the concern about the taste and quality of public water supplies and the potential for contamination of water, has resulted in many people turning to bottled water.¹² According to a commercial report in 1995, 800 million litres of bottled water were consumed in the UK and this figure had increased to 1,390 million litres in 2000.¹³ A further 70% increase in the consumption of bottled water is predicted in the next 5 years.¹²

The concentration of some elements, such as calcium, sodium, iron, silver and aluminium, in bottled waters is regulated in some countries,¹⁴ however there is no regulation regarding the fluoride content of bottled water in the UK or other European countries. Manufacturers are encouraged to list the nutritional contents of their products, but labels stating the fluoride levels of bottled water are not legally required. The fluoride content of bottled waters can be highly variable and this may have oral health implications for those individuals, and especially children, who drink bottled water as their primary source of drinking water.¹⁵ A first step toward evaluating how bottled water consumption might affect fluoride exposure is to determine the fluoride content of bottled waters. Some US studies^{16–19} have reported the levels of fluoride in bottled waters, most recently in 2000. In addition, there are some data on the fluoride content of bottled waters in the UK^{20,21} and Europe^{22,23} but the data from the UK are no longer current. In the 1982 UK study by McFadyen *et al.*,²⁰ 14 still bottled water samples were examined and fluoride levels ranged from 0.10–0.31 mg L⁻¹. Toumba *et al.*²¹ in 1994 reported values ranging from 0.10–0.80 mg L⁻¹ for 12 samples. In view of the expanding range of bottled waters available for purchase in the UK and since the most recent analysis of the fluoride levels of bottled water sold in the UK was

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Table 1 Fluoride content of 25 still bottled waters (Mean \pm SD values for 6 samples)

Still bottled water brand	Type of water	Country of origin	Fluoride concentration (mg F/L) Mean \pm SD	Labelled content fluoride* (mg F/L)	pH
Activ	Natural [†]	France	0.14 \pm 0.02	NL	7.72
Boots	Natural	Wales	0.04 \pm 0.01	NL	8.15
Brecon Carreg	Natural	Wales	0.04 \pm 0.01	NL	7.95
Buxton	Natural	England	0.14 \pm 0.02	NL	8.33
Caledonian, Sainsbury	Natural	Scotland	0.06 \pm 0.01	< 0.1	7.98
Deeside, ASDA	Spring	Scotland	0.37 \pm 0.14	NL	7.22
Eden Falls, ASDA	Natural	England	0.03 \pm 0.01	NL	8.00
English Mountain Spring	Spring	England	0.02 \pm 0.00	< 0.1	7.93
Evian	Natural	France	0.06 \pm 0.01	NL	8.28
Glenburn, ASDA	Spring	Scotland	0.06 \pm 0.01	NL	8.24
Glencairn, Safeway	Spring	Scotland	0.03 \pm 0.00	NL	8.07
Hadrian	Spring	England	0.10 \pm 0.01	< 0.2	7.98
Highland	Natural	Scotland	0.05 \pm 0.01	< 0.1	7.68
Mirabel, Marks and Spencer	Spring	Canada	0.12 \pm 0.01	NL	8.47
Naya	Spring	Canada	0.11 \pm 0.01	NL	8.40
Perthshire, Tesco	Spring	Scotland	0.04 \pm 0.01	< 0.2	8.22
Pierval	Spring	France	0.08 \pm 0.01	NL	8.00
Shropshire, Sainsbury	Natural	England	0.05 \pm 0.01	< 0.1	7.61
St. George's Well	Natural	England	0.05 \pm 0.01	4.05	8.22
Strathmore	Spring	Scotland	0.11 \pm 0.00	0.1	7.95
Superdrug	Spring	Ireland	0.04 \pm 0.04	NL	8.12
Table water, Sainsbury	Distilled	England	0.01 \pm 0.01	NL	7.68
Val Blanc	Natural	France	0.03 \pm 0.01	NL	7.64
Vittel	Spring	France	0.12 \pm 0.02	NL	8.16
Volvic	Natural	France	0.20 \pm 0.03	NL	8.08
All	—	—	0.08 \pm 0.08	—	8.00

* NL = Not Labelled
[†]With added calcium

conducted almost 10 years ago, the objective of the present study was to provide up-to-date information on the fluoride content of the range of bottled waters currently on sale in the UK. The second aim of this study was to estimate the effect of consumption of bottled water on the fluoride exposure of children in the UK. These data should be of use to dentists both in clinical practice and dental public health, providing them with current information necessary when advising on fluoride supplementation both on an individual and community basis.

MATERIAL AND METHODS

Twenty-five commercial brands of bottled waters were chosen from those available in the major supermarkets, grocery stores and health shops in North-East England. Three bottles of each brand, each with a different batch number and date of bottling were purchased. The samples were still spring, mineral or distilled waters, and all were sold in plastic bottles.

After shaking the bottle of water, a 1.0 ml sample was taken and mixed with 0.1 ml of Total Ionic Strength Adjusting Buffer III (product 94-09-11, Orion).²⁴ The fluoride concentrations of all 75 samples were determined, in duplicate, using a Fluoride Ion Selective Electrode (model 96-09, ATI Orion) in conjunction with an ISE Meter (Model 720A, ATI Orion). Fluoride standards ranging from 0.01 to 1.00 mg L⁻¹ fluoride were used to calibrate the measurement. The pH of the water samples was also measured using a pH-meter (Model 240, Corning).

One batch number (out of three) for each of the 25 waters was randomly selected and the samples re-analysed to assess the reliability of the method.

The water intake data from the UK National Diet and Nutrition Survey (NDNS),¹⁰ 2000 was used to estimate daily fluoride intakes based on the results of this study.

Data management

Final calculation of the fluoride content of water samples from the ISE meter readings (in mV) was carried out in *Microsoft Excel 97* using logarithmic regression. *SPSS* (Statistical Package for Social Sciences, version 8) was used to derive descriptive data.

RESULTS

Of the 25 bottled waters tested, 84% had their source or production site in England, Scotland or France (Table 1). Table 1 also lists the most common brands of bottled water according to type of source (ie natural, spring or distilled), fluoride concentration (mg F L⁻¹) the labelled content fluoride (if labelled) and pH. The reliability of the method of fluoride analysis was determined to be 99%. The mean (\pm SD) fluoride content of the 25 still bottled waters was 0.08 (\pm 0.08) mg F L⁻¹ with a range from 0.01–0.37 mg F L⁻¹. The highest mean concentration was found in bottled water from Scotland, Deeside (ASDA) which had a mean fluoride content of 0.37 mg F L⁻¹ (\pm 0.14). No substantial difference in fluoride concentration was found between samples from differing countries of origin. The mean fluoride concentrations of samples from Wales, Ireland, England, Scotland, Canada and France were 0.04, 0.04, 0.06, 0.10, 0.10, and 0.11 mg F L⁻¹ respectively.

Regarding the quality of the labelling of bottled waters, 17 of the water samples (68%) did not state the fluoride concen-

Table 2 Fluoride content (mg F/L) of three different batch numbers of each bottled water, measured in duplicate

Still bottled water brand	Fluoride content (mg F/L)		
	Batch 1	Batch 2	Batch 3
Activ	0.15	0.12	0.13
Boots	0.04	0.04	0.05
Brecon Carreg	0.05	0.02	0.04
Buxton	0.12	0.16	0.14
Caledonian, Sainsbury	0.05	0.06	0.07
Deeside, ASDA	0.42	0.50	0.20
Eden Falls, ASDA	0.03	0.03	0.02
English Mountain Spring	0.02	0.02	0.02
Evian	0.06	0.05	0.06
Glenburn, ASDA	0.05	0.05	0.06
Glencairn, Safeway	0.04	0.04	0.03
Hadrian	0.09	0.11	0.11
Highland	0.05	0.03	0.06
Mirabel, Marks and Spencer	0.13	0.11	0.12
Naya	0.09	0.11	0.12
Perthshire, Tesco	0.04	0.05	0.03
Pierval	0.09	0.06	0.08
Shropshire, Sainsbury	0.06	0.05	0.04
St. George's Well	0.05	0.06	0.05
Strathmore	0.11	0.11	0.11
Superdrug	0.10	0.02	0.01
Table water, Sainsbury	0.02	0.01	0.01
Val Blanc	0.03	0.03	0.04
Vittel	0.09	0.13	0.13
Volvic	0.20	0.17	0.22

tration on the label (Table 1), while of the eight labelled samples, six did not display precise values for fluoride content. For one sample (St. George's Well) the displayed fluoride concentration on the label was far above the level measured in this study – it was labelled 4.05 mg F L⁻¹ compared with a measured fluoride content of 0.05 mg F L⁻¹ (Table 1).

There were no considerable differences between three batch numbers for each brand (Table 2), except for the bottled water sam-

ples from Superdrug which contained 0.10, 0.01 and 0.02 mg F L⁻¹. The mean pH of the water samples tested was 8.00 with a range from 7.22–8.47 (Table 1).

Based on the data from the NDNS¹⁰ for young people aged 4 to 18 years in the UK, the mean total daily fluoride intake, when the source of water intake is solely tap water and when it is a combination of tap and bottled water were estimated to be 0.264 and 0.164 mg L⁻¹, respectively (Table 3).

DISCUSSION

The results of this study were generally consistent with the two previous studies that have analysed the fluoride content of bottled water in the UK.^{20,21} However, the fluoride content of those bottled waters analysed in both the study of Toumba *et al.*²¹ and the present study showed some differences. Caledonian, Evian, Highland Spring, Strathmore and Volvic waters showed mean fluoride contents of 0.13, 0.15, 0.10, 0.16 and 0.23 mg F L⁻¹, respectively in the study by Toumba *et al.*²¹, and 0.06, 0.06, 0.05, 0.11, and 0.20 mg F L⁻¹, respectively in the present study. In a recent analysis in Belgium,²³ the mean fluoride contents of Evian, Pierval, Vittel and Volvic waters were measured as 0.08, 0.08, 0.17 and 0.15 mg F L⁻¹, respectively. These results were close to those recorded in the present study. As the method of fluoride analysis was similar in all studies, the differences between the measured fluoride contents of bottled waters in different studies can be explained by variation of the fluoride content of water over time, depending on the sources of bottled water, as well as seasonal fluctuation.

The range of pH values obtained in the study was in the range of the normal pH found in surface water systems (6.5–8.5) or groundwater systems (6–8.5).²⁵

This study showed that only 32% of products sampled displayed the fluoride content of the water on the labels. Health professionals should be aware that values on labels may not be reliable, as the present study showed a difference between the measured fluoride content and that marked on the labels in 75% of the bottled water samples. It is also important that the consumers have accurate information on the fluoride content of the water that they drink. With this in mind it may be advisable for bottled waters to be assayed at least twice per year for their fluoride content by an independent organisation. There is no strict regulation

Table 3 Daily fluoride intake (mg) from drinking water (ml) by age and gender (M = male, F = female)

	Age group (years)								Mean for all age groups and both genders
	4–6		7–10		11–14		15–18		
	M	F	M	F	M	F	M	F	
Total drinking water intake (ml)*:	219	220	217	197	225	265	487	279	263
– Bottled water (ml)	109	114	63	57	83	101	250	107	108
– Tap water (ml)	110	106	154	140	142	164	237	172	155
Estimate of total fluoride intake from drinking water (mg):									
a) when drinking bottled and tap water in the proportion described above									
– Bottled water at 0.08 mg F L ⁻¹	0.009	0.009	0.005	0.005	0.007	0.008	0.020	0.009	0.008
– Tap water at 1 mg F L ⁻¹	0.110	0.106	0.154	0.140	0.142	0.164	0.237	0.172	0.155
– Total	0.119	0.115	0.159	0.145	0.149	0.172	0.257	0.181	0.164
b) when drinking only tap water at 1 mg F L ⁻¹	0.219	0.220	0.217	0.197	0.225	0.265	0.487	0.279	0.264
Estimated reduction (%) in fluoride intake when drinking bottled water (as figured above)	46%	48%	27%	26%	34%	41%	47%	35%	38%

* Data from the UK National Diet and Nutrition Survey by Gregory *et al.*¹⁰

on the labelling of fluoride contents of bottled waters in Europe, and while products are exported from one European country to another and beyond there is potential for confusion. The need for detailed European Union-based regulation in this regard should be considered.

When the results of the present study are used to estimate daily fluoride intake from drinking water by age and gender (Table 3), it is clear that bottled water consumers receive less than the recommended level of fluoride for optimal oral health. With an average daily intake of between 197 ml and 487 ml of drinking water for 4–18-year-old children in the UK respectively,¹⁰ drinking solely bottled water with a fluoride concentration of 0.08 mg F L⁻¹ would result in a 26% to 48% reduction in fluoride intake compared with the consumption of tap water optimally fluoridated at 1 mg L⁻¹ (Table 3). This is a considerable reduction since 12% of the UK population receive naturally or artificially fluoridated water.²⁶

In view of these estimated differences, it is important that the source of drinking water is identified by the dentist when giving preventive advice and especially when prescribing fluoride therapy in children. In addition, when evaluating the effect of bottled water consumption on total fluoride intake of an individual, three factors should be considered:

1. The quantity of bottled water consumed per day
2. Fluoride intake from other sources such as toothpaste ingestion or high fluoride foods, and
3. Usage of bottled water in meal preparation, baby formula and infant food dilution.

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