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Endemic Fluorosis in China from Ingestion of Food Immersed in Hot Spring Water

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Fengliang was identified as a town with endemic dental fluorosis during an overall screening to identify areas with endemic fluorosis in Guangdong Province. Fengliang is situated in a hot spring area in the eastern part of Guangdong. Among a population of 8000, the prevalence of dental fluorosis inchildren aged 8 to 15 years (total 837) reached 50%, but the fluoride content of drinking water was less than 0.4ppm. In comparison, the United States federal standard for fluoride in drinking water is 4 ppm (Federal Register, 1985). The California drinking water standard is 1.4 to 2.4 ppm, depending on ambient temperature (California Administrative Code Title 22). In order to determine the cause of the dental fluorosis in Fengliang, a systemic study was conducted to investigate dietary intake of fluoride as a possible source of exposure. Researchers examined hot spring water and foods for fluoride content on the basis that the local population routinely immersed their vegetables in hot spring water.

MATERIALS AND METHODS

Figure 1 shows the locations of the fluorosis area and control area and their geographical relationship to two hot springs. There are four villages in Fengliang, the endemic area, near the hot springs: Jieshang, Beixiang, Donglian and Xixiang. The hot springs are located at the river beach. They contained fluoride at 20.33 ppm and 19.26 ppm, with water temperatures of 98°C and 95°C , respectively. The control area, Fuxing village, is 3 kilometers away from the hot springs.

Residents in the fluorosis villages habitually immerse vegetables and beans in water from the hot springs as soon as produce has been picked. They then fry these foods or make dried vegetables, saving fuel by using hot spring water to treat the food. Residents in the control village do not immerse vegetables in hot spring water.

For dental fluorosis assessments, all local born children aged 8 to 15 years in five villages (67-499 per village) were examined; the results were recorded using Dean's classification system and Russell's differential diagnostic criteria (Horowitz, 1986).

Ten families in each endemic fluorosis village, and 20 families in the control village, were randomly selected for the collection of samples of water, food , and urine. Morning urine samples of selected family members were collected to examine the fluoride content. Water samples from public and family wells and home water containers were collected. Rice, tea, and dried vegetable samples were taken from 60 families. Fresh vegetables(I, Lactuca Sativa Var. angustana; II, Brassica Chinensis L; and III, Brassica

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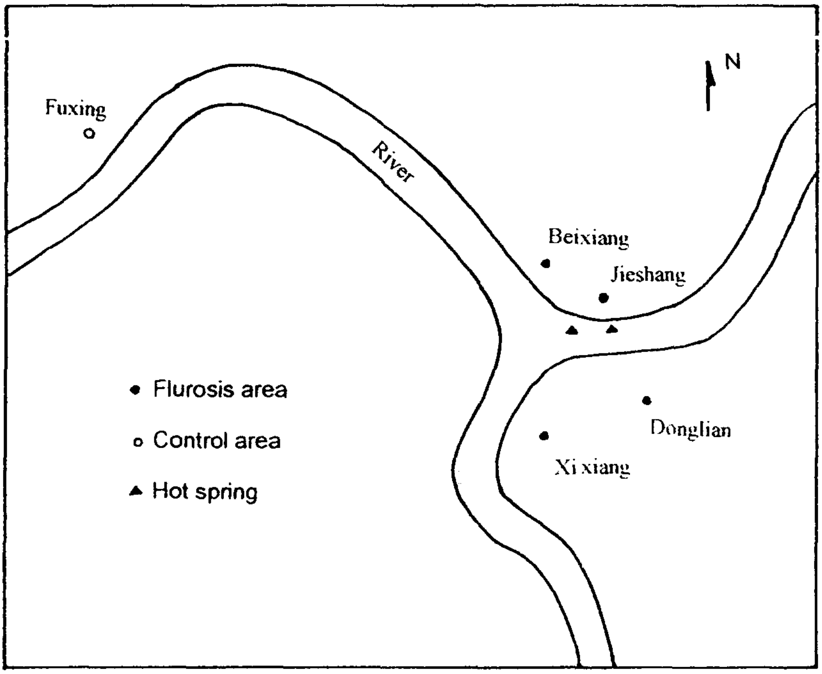

Figure 1. Map showing the geographical location of fluorosis area, control area and two hot springs

Juncea Var. rugosa Bailey) were taken from each village's field; pork and bean curd were taken from local sellers.

To determine the changes in fluoride content in vegetbles following immersion in hot spring water, three kinds of vegetables were immersed for 20 minutes in either hot spring water containing 20.33 ppm fluoride (98°C) or well water containing 0.12 ppm fluoride (100° C). Samples were then dried.

The fluoride content of water and urine was determined with a specific fluoride electrode (model CSB-F-1,Spring Bloom, China) combined with a reference electrode (model 233, Double Ring, Shanghai, China),both connected to an ionometer (model DF-801, Guangzhou, China). The fluoride content of each kind of food, except pork, was determined from its powder product by acid extraction(1N HCl). Pork was determined by alkali fusion (Liu, 1988).

RESULTS AND DISCUSSION

We identified an endemic fluorosis area in which drinking water contained very low fluoride levels. This region has two hot springs with high fluoride content. Inhabitants of the fluorosis and control areas displayed similar socioeconomic status and living habits, excluding use of the hot springs. On the basis that residents in thd endemic area routinely immersed their vegetables in hot spring water, we compared their dietary intakes of fluoride with the intakes of residents from a control area. Though residents in the fluorosis area do not drink hot spring water directly, they frequently immerse vegetables and beans in this water, consuming foods after immersion. The fluoride content of natural foods in the fluorosis area was similar to that of the control area.

We found the fluoride level in vegetable was increased significantly after immersion in hot spring water (Xu,1990).

The prevalence of dental fluorosis and the average urine fluoride content in five sites, as well as the relative distance between each site and the hot springs, are shown in Table 1 Dental fluorosis prevalence and urine fluoride content in the four fluorosis villages were significantly higher than those levels found in the control village. An inverse relationship existed between distance from village to hot springs and fluorosis prevalence, index and urine fluoride content; the coefficients of correlation (Spearman) (Yang,1988) were -1, -0. 94, -1 (P<0.01), respectively.

Table 1. Detal fluorosis prevalence and urine fluoride content in five sites and distance between sites and hot spring

Residential sites	Distance Between Site and Hot Spring(M)	Dental Fluorosis				Urine		
		No. of Children	Positive	%	Index	No. of Samples	Mean (ppm)	S.D.
Fluorosis Area								
Jieshang	50	499	270	54.11	1.35	32	2.98	1.55
Beixiang	500	67	33	49.25	1.19	35	2.17	1.20
Donglian	600	198	90	45.45	0.90	30	2.03	0.95
Xixiang	800	73	30	41.10	1.00	32	1.31	0.82
Control								
Fuxing	3000	283	3	0.01	0.02	58	0.67	0.42

The results obtained regarding the fluoride content of water and foods from the fluorosis and control areas are shown in Table 2. Water obtained from all five residential sites revealed relatively low fluoride content, from 0. 07 to 0.23 ppm; natural foods selected from different sites contained similarly low fluoride levels. The average fluoride content of homemade dried vegetables in the fluorosis villages, however, ranged from 24.7 to 36. 3 ppm, displaying levels 2.49 to 3.36 times higher than those levels found in the control village. Bean curd from fluorosis villages showed significantly higher fluoride content than bean curd from the control area: 113. 3 ppm compared to 4.69 ppm, respectively. Table 3 reveals the results of this comparison test. Vegetables immersed in hot spring water showed greatly elevated fluoride levels.

The fluoride content of homemad dried vegetables from the fluorosis ivllages was 2.49 to 3.36 times than levels obtained from the control village. The difference was shown to be much greater, from 14.1 to 58.1 times, in the comparison test. The increase in fluoride content in vegetables immersed in hot spring water seems to be dependent upon the kind of vegetable and the duration of immersion. This finding is consitent with previous reports that the fluoride content of water used in industrial food production and home cooking affects the fluorde content of ready-to-eat products (WHO, 1984).

A significant negative correlation between the distance from residential site to hot spring and dental fluorosis prevalence, index and urine fluoride content was found. It may be assumed that residents living in the vicinity of the hot spring site were exposed

Table 2. Average fluoride content (ppm) of water and foods from fluorosis and control areas

Sampling Sites	Water				Food (dry weight)								
	Well	N	Home Container	N	Rice	Vegetable I	Vegetable II	Vegetable III	Tea	Pork*	Dired Vegetable	N	Bean Curd**
Fluorosis Area													
Jieshang	0.23	8	0.11	10	0.59	3.79	8.40	10.1	127	0.88	31.6	18	113
Beixiang	0.20	3	0.13	10	0.50	2.09	7.99	9.58	135	0.56	32.7	18	
Donglian	0.19	8	0.17	10	0.54	2.14	9.58	10.9	156	0.66	36.3	14	
Xixiang	0.11	1	0.12	10	0.52	2.32	6.57	6.40	163	0.42	24.7	16	
Control													
Fuxing	0.07	5	0.07	20	0.51	2.58	10.7	9.90	141	0.66	9.98	13	4.69

* Fresh Weight
** Bean immersed in hot spring water over night in fluorosis area
N = No. of samples. Values represent composite samples where N is not specified.

Table 3. Fluoride content (ppm) in vegetables immersed in hot spring water and well water

Vegetable	Immersion		H / W
	Hot spring water(H) (F^-, 20.33 ppm)	Well water(W) (F^-, 0.12 ppm)	
I	147	2.53	58.1
II	115	8.17	14.1
III	151	9.53	15.8

to fluoride to a greater degree than residents living in a more remote site. In the present study, exposure to elevated levels of fluouide occurred orally through ingestion of vegetbales and bean curd trated with hot spring water.

Daily fluoride intake of residents based on dietary intake interviews and sample analyses. Daily fluoride intake was estimated to be 3. 64 mg in the fluorosis area, and 1.59 mg ing the control area. The difference can be primarily attributed to elevated fluoride content in foods (vegetables and beans) immersed in hot spring water, it accounted for 58.87% and 0.14% of total daily fluoride intake in the fluorosis and control areas, respectively.

The results obtained from the present study lead to the conclusion that food immersed in hot spring water containing high levels of fluoride is a primary cause of endemic dental fluorosis in Fengliang area. Dietary inqestion is an exposure route leading to endemic dental fluorosis not previously recognized.

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