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Investigation and analysis on the fluorine source and fluorotic teeth epidemic factors in Wumeng mountain coal-burning contaminated area.

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Abstract

Objectives: To investigate the main fluorine sources of Wumeng Mountain coal-burning contaminated area; to screen the factors that affect the prevalence of fluorotic teeth, and to provide theoretical support for the prevention and treatment of Fluorosis disease.

Methods: Questionnaire survey and laboratory tests are conducted for 1200 households from 8 endemic villages; environmental media, fluorine content in food, basic information of the respondents, lifestyle and dietary habits, cognitive level, stove rebuilding status are investigated.

Results: The laboratory tests reveal that the fluorine content in drinking water (0.15 ± 0.04 mg/L) and rice (0.27 ± 0.06 mg/kg) are lower than the national standard; however, the fluorine content in raw coal (115.07 ± 48.67 mg/kg), clay for coal blending (685.72 ± 261.54 mg/kg), corn (18.46 ± 6.08 mg/kg), and pepper (87.85 ± 36.14 mg/kg) are much higher than national standards. According to Logistic multi-factor regression analysis, the main risk factors of the endemic area are: "cooking with coal" (OR=2.47995CI1.634~3.762) and "didn't reconstruct the stove before age 12" (OR=1.58495CI1.135~2.210); main protective factors are: "high scores in cognitive level" (OR=0.548, 95CI: 0.422~0.711) and "don't like pepper" (OR=0.583, 95CI: 0.475~0.717).

Conclusions: High fluorine coal and coal-blending clay are the main fluorine source of Wumeng Mountain coal-burning contaminated area. At this stage, the local government should enhance the promotion and education of fluorotic teeth and the stove reconstruction program, thus achieving better prevention effects.

Keywords: Fluorotic teeth, Epidemicfactors, Wumeng mountain.

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Introduction

Fluorine spreads widely in the nature; absorbed by human beings mainly through intestinal tract, fluorine is one of the necessary elements for the normal development of bones and teeth. If human body takes in excessive fluorine during the mineralization of teeth, the excessive fluorine will be toxic to the ameloblast, leading to the disorder of ameloblast development and poor formation of dentinal tubule, which eventually results in dental malformation and fluorotic teeth. For fluorotic teeth, the ameloblast lacks of normal gloss; the teeth are in chalky white or present brown patches. Serious fluorotic teeth are complicated by substantive defect of ameloblast; in this case, the teeth are more vulnerable and quick-wearing. Fluorotic teeth not only exert bad influence on patients' health, but also do harm to their appearances, resulting in heavy psychological impacts on the patients. Fluorotic Teeth is a high-incidence endemic disease all around the world, and it is most severe in China. For preventing dental caries, fluoridation of the community potable water is regarded as one amongst the top ten public health achievements in the twentieth century. The failure of dental caries is on the rise along with the popularity of dental fluorosis concurrently, a side-effect of fluoride exposure. Amongst worldwide, dental fluorosis is extremely prevalent. Fluoride has devastating effect on cells, on the basis of concentration, exposure time, as well as cell types [1-8].

According to etiology, fluorotic teeth can be classified into drinking water type, tea-drinking type, and coal-burning type fluorosis. Scholars of home and abroad are mainly focusing on the investigation and study of drinking water and tea-drinking fluorosis due to the limitations on geographic and research conditions. Researches into coal-burning fluorosis are very rare. Previous researches suggest that coal-burning fluorosis is mainly caused by burning high-fluorine coal with open stove in indoor conditions, which will contaminate the food and further lead to excessive intake of fluorine, causing damage to the ameloblast. However, the latest researches have questioned about the main fluorine source of fluorotic teeth. Located in the joint part of Sichuan, Yunnan and Guizhou province of China, Wumeng Mountain is of a total area of 110, 000 km^2, with a population of more than 20 million people. This is a mountainous and hilly area of rich coal resources, mostly inhabited by Chinese minorities and in relatively poor economic conditions. Wumeng mountain area is the key cal-burning contaminated area. In order to find out the main fluorine sources and the endemic factors of fluorotic teeth in

this area, and to provide theoretical reference and proof for the prevention of coal-burning fluorotic teeth, this research conducted investigation and analysis into the endemic etiological cause of coal-burning fluorotic teeth. The research findings are listed below [9-15].

Literature Review

Marya et al. [16] focused on determining the prevalence of as well as relation between dental caries as well as dental fluorosis in potable water at various levels of fluoride. Among 3007 school students between the ages of twelve and sixteen in two districts of Haryana possessing various fluoride levels in the potable water. On the basis of the WHO index as well as dental fluorosis estimations, Type III examination for dental caries is performed with Dean's Index. The presence of dental caries reduced from 48.02% to 28.07% as fluoride levels rose from 0.5 to 1.13 ppm, however as the fluoride level rose more to 1.51 ppm, there was no more decrease in caries, however, there was a considerable rise in fluorosis. The optimal level of fluoride in potable water is 1.13 ppm, at which point there was greatest caries reductions with minimal quantity of aesthetically objectionable fluorosis.

Medjedovic et al. [17] focuses on determining the impacts of improving the health status of teeth after 6 months of treatment with the usage of topical fluoridation 0.5% NaF, as well as the level as well as quality of the effect of treatments with chemical 0.5% NaF on the dental health of children aged between eight and fifteen, with respect to gender as well as chronological age. Students of this age visited health as well as dental services dependent in Mostar. It is clear that after the treatment with 5% NaF by the technique of topical fluoridation, health status of the children in the experimental group considerably enhanced, such that at the final review 89.71% or 61 subjects of the experiment group had healthy (cured teeth), tooth with dental caries only 5.88% or four subjects teeth with dental caries as well as filling 4.41% or three subjects, extracted baby teeth 14.71% or ten subjects, whereas for 13.24% of subjects was identified state with still unerupted teeth. The results indirectly proved that the 6-month treatment of fluoridation with 5% NaF, led to considerable enhancement in total oral health of the experimental group than the control one that was not treated by any dental treatment through the conclusion that there is a statistically considerable difference in the assessed variables of oral health of children in the control group in contrast to the examined variables of oral health the experimental set of children at the final dental exam.

Materials and Methods

Based on the historical researches and the classification standards of endemic fluorosis disease, multistage sampling is adopted and the following 8 villages of Wumeng Mountain area are selected as the investigation fileds: Village Fulai and Fengyuan from Deyao Twon, Gulin County; Village Hongxing and Liugou from Miao nationality township troops; Village Lihong and Jinbang from Moni Town, Xuyong County; Village Nanshan and Xiaba from Guanxing County. In each village, 150 households are randomly chosen; residents of 8 and elder without relocation records are chosen as respondents and signed consent forms with the approval of local ethics committee. Finally, the qualified sample is 2500 people (1220 females and 1280 males).

The research methods are questionnaire, local sampling and laboratory testing. The questionnaire includes a unified survey form about current status (personal information, lifestyle and dietary habits, stove reconstruction status) and a rating form of cognitive level (causes, descriptions, prevention methods, and related knowledge of fluorotic teeth). The questionnaire survey is conducted by two professional doctors (Hospital of Stomatology, Southwest Medical University). The researchers of this program are well trained before this investigation and have passed the consistency test (Kappa values are higher than 0.8). Samples are randomly collected in each village, including 6 types: drinking water, rice, pepper, corn, raw coal, and coal-blending clay; 5 samples are taken for each type. A drinking water sample is 100 ml; before sampling, the graduated polyethylene bottle for sampling will be washed by the sampling water for 3 times, and then the water will be collected and sealed in the bottle. A rice sample is made up of 200 g rice collected from the local rice field.

Table 1. *Fluorine content in environmental medium and food.*

Samples	Number of samples	$\bar{x} \pm S$
Drinking Water (mg/L)	24	0.15 ± 0.04
Raw coal (mg/kg)	24	115.07 ± 38.67
Clay mixed with coal (mg/kg)	24	685.72 ± 261.54
Rice (mg/kg)	40	0.27 ± 0.06
Corn (mg/kg)	40	18.46 ± 6.08
Chili (mg/kg)	40	87.85 ± 36.14

The corn and pepper are collected from dried corn and pepper; each sample weighs 200 g. A raw coal sample and a coal-blending clay sample are both 1000 g in weight. In the sample collection, the weights of all the samples were measured with the same electronic scale (FX-120, AAD, China), and then packed into plastic bags or bottles for sealed preservation. After sample collection, the fluorine content in drinking water was measured under PRC National Standard (GB/T5750.2-2006). The fluorine content in food was tested by the Method of fluorine content measurement in food-fluorine electrode method under PRC National Standard (GB/T5009.18-2003). The fluorine content in raw coal was tested under PRC National Standard (GB/T4633-1997), and the fluorine content in coal-blending clay was tested under PRC National Standard (JXDKCS/C002). A data base was established on the basis of the investigation data through the method of Epidata3.0 software double entry. Then the data was conducted with χ^2 inspection, variance analysis and ordinal logistics regression analysis through SPSS13.0 statistical software.

Results

The test on the lab samples showed that the average fluorine content in local drinking water is 0.15 ± 0.04 mg/L, which is lower than the current national "Sanitary standard for drinking water" (GB 5749-2006). The average fluorine content in raw coal is 115.07 ± 48.67 mg/kg, which is higher than the average fluorine content of 82 mg/kg of coal in China. So the coal in the coal-burning contaminated area belongs to high fluorine coal. The average fluorine content of coal-blending clay is 685.72 ± 261.54 mg/kg, which is higher than the average content of 478.0 ± 197.7 mg/kg of coal in China. So the coal-blending clay is also high fluorine coal-blending clay. In the endemic area, 40 samples of each corn, chili and rice were collected, with the average fluorine content of 18.46 ± 6.08 mg/kg, 87.85 ± 36.14 mg/kg and 0.27 ± 0.06 mg/kg respectively. Among them, the fluorine contents of corn and chili are much higher than the up limit of our food fluorine limit sanitary standard (GB4809-84), while the rice fluorine content is slightly lower than the up limit of our food fluorine limit sanitary standard, as shown in Table 1.

Personal situation in questionnaire: female has a higher morbidity rate than male; rural area has a higher morbidity rate than urban area. But the differences have no statistical significance (P>0.05). Different education levels, careers, nationalities, annual income and whether the stove has been reconstructed before the resident is younger than 12 years old, the morbidity rate of fluorotic teeth has no significant differences (P<0.05). In the aspect of lifestyle and dietary habits: different family staple food, chili references, drying and cooking ways, people accustomed to use coal also have different morbidity rate. But the difference has no statistical significance (P<0.05). The morbidity rate of fluorotic teeth of high recognition level population is much lower than low recognition level population (P<0.001), as shown in Table 2.

Table 2. *Influencing factors of fluorotic teeth.*

Variables	Gender	Number of respondents	Number of patients	Prevalence rate (%)	Chi-Square	P value	CFI	u/F value/ Chi-Square	P value
Gender	male	1280	594	46.4	0.058	0.810	1.345 ± 1.5634	0.235	0.628
	female	1220	572	46.9			1.375 ± 1.5836		
Residence	Urban	1227	562	45.8	0.679	0.410	1.363 ± 1.5924	0.013	0.908
	Rural	1273	604	47.4			1.356 ± 1.5547		
Educational attainment	Illiterate	155	112	72.3	68.785	P<0.001	2.274 ± 1.6128	26.865	P<0.001
	Primary school	972	437	45.0			1.3 ± 1.5552		
	Junior high school	972	479	49.3			1.427 ± 1.566		
	Beyond junior high school	401	138	34.4			0.986 ± 1.4745		
Occupation	Worker	1375	767	55.8	330.701	P<0.001	1.641 ± 1.6079	217.414	P<0.001
	Farmer	454	285	62.8			1.957 ± 1.6363		
	Student	671	114	17			0.379 ± 0.865		
Nationality	The Han nationality	2267	1042	46.0	4.469	0.035	1.352 ± 1.5801	0.531	0.466
	The Miao nationality	233	124	53.2			1.431 ± 1.5042		
Annual income	<5000	1840	960	52.2	88.722	P<0.001	1.539 ± 1.5994	47.836	P<0.001
	5000-10000	434	125	28.8			0.808 ± 1.3721		
	>10000	226	81	35.8			0.958 ± 1.3918		
Staple food	Rice	2157	975	45.2	17.189	P<0.001	1.317 ± 1.5659	11.885	0.001
	corn	343	191	55.7			1.631 ± 1.5927		
Chili	Dislike	496	193	38.9	14.851	P<0.0001	1.085 ± 1.4685	19.065	P<0.001
	like	2004	973	48.6			1.428 ± 1.5909		
Drying mode	Coal fire drying	1647	837	50.8	33.884	P<0.001	1.494 ± 1.5956	35.418	P<0.001
	Natural drying	853	329	38.6			1.101 ± 1.4959		

Cooking mode	Electric cooking	624	255	40.9	35.349	P<0.001	1.211 ± 1.5468	24.436	P<0.001
	Coal burning	1254	659	52.6			1.572 ± 1.6244		
	Natural gas	622	252	40.5			1.081 ± 1.429		
Coal using habit	Not using coal	555	230	41.4	5.023	0.025	1.215 ± 1.4997	3.579	0.028*
	Often	1387	682	49.2			1.425 ± 1.6002		
	Occasionally	558	254	45.5			1.341 ± 1.5687		
Cognition	High score	410	131	32.0	42.518	P<0.001	0.835 ± 1.3098	55.704	P<0.001
	Local score	2090	1035	49.5			1.463 ± 1.5999		
Whether cooking stoves were improved before 12	No	1330	869	65.3	399.243	P<0.001	2.008 ± 1.6076	597.557	P<0.001
	Yes	1170	297	25.4			0.623 ± 1.1534		

Table 3. *Variable assignment table.*

Variables	Assignment
Staple food	1=Rice, 2=Corn
Chili	1=Dislike, 2=Like
Cook rice	1=Electricity, 2=Coal, 3=Natural gas
Drying method	1=Coal drying, 2=Natural drying
Coal using habit	1=Often, 2=no, 3=Sometimes
Recognition	1=High, 2=Low
Whether reconstructed before 12 years old	0=No, 1=Yes

Logistics regression analysis on the possible prevailing factors of fluorotic teeth was conducted. The test results are shown as below. The main protective factors of fluorotic teeth include: rice as staple food (OR=0.669, 95% CI is from0.534~0.839), dislike chili (OR=0.583, 95% CI is 0.475~0.717), no coal (OR=0.648, 95% CI is 0.431~0.973) and high recognition level (OR=0.548, 95% CI is 0.422~0.711). However, drying food with coal (OR=1.436, 95% CI is 1.131~1.822), cook rice with coal (OR=2.479, 95% CI is 1.634~3.762), stove unconstructed before 12 years old (OR=1.584, 95% CI is 1.135~2.210) are dangerous factors of the fluorotic teeth prevalence in local coal-burning contaminated area, as shown in Tables 3 and 4.

Table 4. *Logistics regression.*

Variables	Estimated value	Wald value	P value	OR value	95% CI
Staple food	-0.402	12.128	0.000	0.669	0.534~0.839
Chili	-0.539	26.276	0.000	0.583	0.475~0.717
Drying method	0.362	8.837	0.003	1.436	1.131~1.822
Rice cooking=1	0.120	0.920	0.337	1.127	0.882~1.441
Rice cooking=2	0.908	18.225	0.000	2.479	1.634~3.762
Coal using habit=1	0.275	3.118	0.077	1.317	0.741~1.788
Coal using habit=2	-0.434	4.359	0.037	0.648	0.431~0.973
Recognition	-0.601	20.450	0.000	0.548	0.422~0.711
Whether reconstructed before 12 years old	0.460	7.320	0.007	1.584	1.135~2.210

Discussion

Based on pathogenesis, fluorosis mainly includes drinking-water type, drinking-tea type and coal-burning type. The investigation shows that, the water fluorine content in the Wumeng Mountain coal-burning contaminated area is 0.150.27 ± 0.060.04 mg/L, which is lower than the national sanitary standard for drinking water of 1 mg/L. The residents also have no wide-range habit of drinking tea. So, the main fluorine

source from water or tea can be excluded. The average fluorine content of the local raw coal is 115.070.27 ± 0.0648.67 mg/kg, which exceeded the average value of Chinese coal of 82 mg/kg and belongs to high fluorine coal. The average fluorine content of coal-blending clay is 685.720.27 ± 0.06261.54 mg/kg, which exceeded the normal range greatly, almost 6 times of the raw coal fluorine content. At present, most of the scholars only study the fluorine content in raw coal, holding that fluorine pollution is caused by the coal-burning type fluorosis which burns high-content fluorine coal. Some scholars considered coal-blending clay to the main fluorine source on the basis of the fluorine content. We believe the above two opinions are not complete. The results of this study showed that the fluorine contents in both raw coal and coal-blending clay in Wumeng Mountain area are higher than normal value. As proven by related researches, although the fluorine content in coal-blending clay is much higher than raw coal, food's absorption of rich fluorine from the clay is limited. No excess fluorine will be accumulated in food through this way. The test on the rice also proved this viewpoint. The fluorine content of rice is 0.27 ± 0.06 mg/kg, which is lower than the national sanitary standard. In the coal burning process, coal-blending clay is usually used as adhesive which doesn't take part in the burning directly. Coal and coal-blending clay have different release proportion of fluorine when burning. There are also researches showed that the mixture of coal and coal-blending clay release more fluorine than the two matters burning separately. Hence, in Wumeng Mountain area, both high fluorine coal and coal-blending clay are key fluorine sources. The joint action of the two matters leads to the fluorine pollution and result in the prevalence of the coal-burning type fluorosis.

1) Personal situation: According to the questionnaires in this study, people with higher education background and economic conditions have lower morbidity rate of fluorotic teeth. This finding is in accordance with the results of previous investigations. This is because these people can easily accept the view of fluorotic teeth control, change their unhealthy habits and they also have better nutritional conditions. The morbidity rate of students was greatly reduced compared with workers and peasants. This is because the local government carried out stove reconstructions more than 10 years ago, which effectively prevented the indoor fluorine pollution. Students are young. Most of them already enjoyed the policy before 12 years old. Moreover, they have more chances of accepting fluorosis education and better acceptability than other populations. Compared with Han nationality, Miao nationality mainly live in mountainous area. The social and economic development of them is relatively backward. Due to the language problem and the low acceptability of the residents, it is hard for the local government to conduct health education for the residents and the effect is unsatisfactory. Hence, the prevalence of fluorosis in Miao nationality is worse than Han nationality.

2) Dietary habits: Local people prefer corn and chili. But due to the relatively high terrain, cold weather and insufficient sunlight, it is hard to get the corns and chilies naturally dried in the sun. So people used indoor open stove to burn high fluorine coal and coal-blending clay to dry corn, chili or for warmth in winter, which result in the fluorine pollution of indoor air and food as well as the prevalence of coal-burning fluorosis. The testing results from laboratory showed that the average fluorine content in local corns and chilies is much higher than the national sanitary standard. As shown in logistics regression analysis, staple food of rice, less chili, dry food naturally, cook rice with natural gas and electricity and less coal are all protective factors of fluorotic teeth , and can effectively control the ingestion of fluorine.

3) Recognition level on fluorotic teeth: Researches have shown that people with high recognition levels can effectively reduce the occurrence of fluorotic teeth (OR=0.548, 95CI: 0.422~0.711). The main reason is that they can master proper sanitary and health care knowledge, and consciously adopt healthy behaviors and life styles. However, there are only 410 people with high recognition level, occupying only 16.4% of the total population. This means that most of people lack enough knowledge of fluorotic teeth. It also represented that the local government made insufficient publicity to prevent fluorotic teeth, which needs to be noticed.

Conclusion

This research showed that the main fluorine sources in Wumeng Mountain coal-burning contaminated area are high fluorine coal and coal-blending clay. The joint action of the two matters leads to the occurrence of coal-burning type fluorosis. In addition, personal situation, dietary habit, recognition level on fluorosis also influence the prevalence of coal-burning type fluorosis. Based on the prevalence of coal-burning fluorosis in Wumeng Mountain area, this study proposed following suggestions: 1) Strengthen behavior intervention. Encourage local people to change fuel types such as electricity, natural gas and biogas, etc.; change dietary patterns; choose rice and vitamin, and use natural drying method to dry corns and chilies. 2) Continue the stove reconstruction program. At the current stage, the program has achieved good fluorosis preventing effect and should be continued. 3) Enhance the sanitary publicity of fluorotic teeth. Due to the restriction of geographical conditions, verbal communication and social economy, the publicity of sanitary and health care knowledge of fluorotic teeth is less effective and related publicity strategy needs to be formulated. 4) Increase the poverty alleviation support on Wumeng Mountain area. 5) The prevalence of coal-burning fluorosis in the area is still very serious, and local people are suffering a lot from the disease. Hence, the government should increase the fund in treating the disease specifically.

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