

Investigation and Analysis on Current Situation of Coal-Burning Fluorosis Prevalence

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Abstract

Objective: The purpose of the paper is to provide the result from investigation on the current situation of coal-burning fluorosis prevalence in Chongqing City and make an assessment on the prevention and curing measures.

Method: The Dean's Method is applied to investigate on the fluorotic teeth of locally-born children aged between 8 to 12; investigate how modified cooking stoves are utilized by households and how food maize and hot pepper are being dried; and test the urinary fluorine content and pepper fluorine content.

Result: The investigations show that, in the 661 villages with illness history from the 100 townships of 13 districts in Chongqing City, 11.28% (7464/66,162) of the children aged between 8 and 12 suffer from dental fluorosis; the stoves modified rate, qualified rate of modified stoves, and correct utilization rate of qualified modified stoves are respectively 100%, 98.82%, and 99.45%; and food maize and hot pepper's drying rates are respectively 99.88% and 99.75%. **Conclusion:** The result shows that the coal-burning type fluorosis prevalence in the endemic area of Chongqing City has decreased dramatically, the preventive measure is effectively implemented, and a long-term preventive mechanism has preliminarily been established.

Keywords

Coal-Burning Type Fluorosis, Current Prevalence Conditions

1. Introduction

Regional Fluorosis caused by coal-burning pollution ("coal-burning fluorosis" for short) is a kind of cumulative chronic poisoning suffered by people who live in the area with high content of coal-burning fluorine pollution for a long period of time and take in excessive fluorine through water, air, food, and some other media. There have been many studies about this in China, however, none of them is comprehensive enough to illustrate this issue. This article hence con-

ducts a systematic and comprehensive investigation on the coal type fluorosis in children's dental fluorosis, the residents' usage of stoves, food fluorine, and urinary fluoride in Chongqing, China. In order to evaluate the effect of preventive and curing measures against coal-burning fluorosis in our City, the authors conducted an investigation on the current prevalence conditions of coal-burning fluorosis in our city from June 2013 to June 2015, whose results are analyzed as follows:

2. Research Object and Method

1) Objects:

Children aged between 8 and 12 and the households were chosen from May to August 2015 from the 661 villages that are historically prevalent with fluorosis in the 100 townships in 13 districts of Chongqing City.

2) Method

a) For Children's dental fluorosis:

The Dean's Method [1] was applied to examine the dental fluorosis conditions of all the locally-born children aged between 8 and 12, and calculate the dental fluorosis morbidity rate, dental fluorosis index, fluorotic teeth defect rate.

b) For Investigation in households:

Investigations were carried out on the utilization conditions of modified stoves and the drying conditions of food maize and hot pepper in households in the endemic area; calculations were made on the stoves modified rate, qualified rate of modified stoves, and correct utilization rate of qualified modified stoves, as well as the correctly drying rate of food maize and hot pepper.

c) For children's urinary fluorosis:

Children aged between 8 and 12 from over 3 endemic villages in every endemic county were sampled for test of their urinary fluorosis conditions, with the children selected from each village divided into 5 age groups and each age group assigned with 5 boys and 5 girls, *i.e.* 50 samples altogether from each village. And tests were conducted as per the National Standard (WS/T30-1996) to calculate the geometric mean and standard deviation for obtaining the urinary fluorine content of the sampled children.

d) For maize fluorine content:

10 households from over 3 endemic villages of every county were sampled to test the fluorine content in the maize according to the National Standard (GB/T5009-2003) by calculating the median and standard deviation.

e) For Fluorine content in hot pepper:

10 households from over three endemic villages of every endemic county for testing the food pepper in accordance with the National Standard (GB/T5009-2003) by calculating the median and standard deviation.

3) Statistical analysis was conducted adopting SPSS17.0 software to calculate the morbidity rate of fluorotic teeth and other indicators.

This research has been approved by department of health and family planning commission in Chongqing. We conducted this investigation according to the

ethic guideline about the medical system study for people.

3. Result

1) Basic conditions

The investigations covered 661 endemic villages from 100 townships of 13 districts, where there are 399,314 households with a population of 1,425,705, of which children aged between 8 and 12 are numbered to 91,070 and the examined children are amounted to 66,162, making an examination rate of 72.65%.

2) Children's dental fluorosis conditions

Of the 66,162 examined children, 7464 were diagnosed with dental fluorosis, the detectable rate being 11.28%, the dental fluorosis index being 0.14, and the defect rate being 0.29%. Of the villages surveyed, 426 have a dental fluorosis rate of $\leq 15\%$, and 642 have a dental fluorosis rate of $\leq 30\%$ (as detailed in **Table 1**).

4. Household Investigation

4.1. Stove Modification

Of the 399,314 households surveyed, 399,314 modified their stoves, reaching a modified rate of 100%; 394,613 modified their stoves up to the qualification level, a qualified modification rate of 98.82%; and 392,441 of the qualified households utilized the modified stoves correctly, representing a correct utilization rate of 99.45%, benefiting a population of 1,425,705 (as detailed in **Table 2**).

4.2. Drying Conditions of Food Maize and Hot Pepper

Of the 661 villages surveyed from 100 townships of 13 districts, 344 have food

Table 1. Dental fluorosis examination result for children aged between 8 and 12 in the endemic counties of Chongqing City prevalent with coal-burning fluorosis in Chongqing City.

County Name	Township No.	Village No.	Children Sampled	Detected No.	Morbidity (%)	Dental Fluorosis Index	Defect rate (%)	Villages $\leq 15\%$	Villages $\leq 30\%$
Fengjie	18	179	14,978	2309	15.42	0.18	0.50	93	179
Pengshui	16	86	10,953	346	3.16	0.04	0.22	85	86
Qijiang	3	19	1503	140	9.31	0.13	0.47	16	19
Qianjiang	16	74	11,410	471	4.13	0.05	0.16	68	73
Wansheng	2	14	1877	101	5.38	0.07	0.21	14	14
Wushan	19	177	17,410	3086	17.73	0.22	0.21	69	163
Wuxi	8	44	3182	532	16.72	0.25	0.69	22	41
Yunyang	5	31	1226	52	4.24	0.06	0.08	31	31
Nanchuan	2	3	330	38	11.52	0.12	0.00	2	3
Xiushan	3	8	399	49	12.28	0.15	0.25	4	7
Shizhu	3	7	614	48	7.82	0.12	0.16	7	7
Kaixian	2	12	1731	250	14.44	0.15	0.00	8	12
Wulong	3	7	549	42	7.65	0.09	0.00	7	7
Sum	100	661	66,162	7464	11.28	0.14	0.29	426	642

Table 2. Modified stoves' examination result for endemic counties prevalent with coal-burning fluorosis in Chongqing City.

County Name	Household No.	Village population	No. of Households modifying stoves	Stove modified rate %	No. of Households with qualified modified stoves	Qualified rate Modified stoves %	No. of households correctly utilizing modified stoves	Correct utilization rate for stoves qualifiedly modified %	Actual beneficiary population
Fengjie	107,314	392,868	107,314	100	104,843	97.70	104,712	99.88	392,868
Pengshui	48,621	204,844	48,621	100	48,474	99.70	48,454	99.96	204,844
Qijiang	11,731	40,017	11,731	100	11,402	97.20	11,354	99.58	40,017
Qianjiang	57,042	200,304	57,042	100	56,563	99.16	56,451	99.80	200,304
Wansheng	12,697	44,472	12,697	100	12,639	99.54	12,620	99.85	44,472
Wushan	102,280	336,299	102,280	100	101,614	99.35	99,849	98.26	336,299
Wuxi	22,537	81,076	22,537	100	22,069	97.92	22,067	99.99	81,076
Yunyang	15,382	49,355	15,382	100	15,374	99.95	15,341	99.79	49,355
Nanchuan	2328	8875	2328	100	2313	99.36	2303	99.57	8875
Xiushan	2190	8409	2190	100	2188	99.91	2188	100	8409
Shizhu	3141	10,198	3141	100	3114	99.14	3083	99.00	10,198
Kaixian	10,851	38,867	10,851	100	10,823	99.74	10,823	100	38,867
Wulong	3200	10,121	3200	100	3197	99.91	3196	99.97	10,121
Sum	399,314	1,425,705	399,314	100	394,613	98.82	392,441	99.45	1,425,705

maize, and 99.88% of them correctly dried up the maize, 342 have a correct drying rate of $\geq 90\%$, making up 99.42% of the villages with food maize, and 341 have a drying rate of $\geq 95\%$, comprising 99.13% of the villages consuming maize. Of the villages surveyed, 657 consume edible hot pepper and 99.75% of them correctly dried the hot pepper; 655 have a correct drying rate of $\geq 90\%$, amounting to 99.70% of the consuming villages, 655 have a correct drying of $\geq 95\%$, amounting to 99.70% of all the consuming villages (as detailed in **Table 3**).

5. Children's Urinary Fluorine Content

The survey altogether examined 2471 urine samples from children of 52 endemic villages of 38 townships, and the result shows that the urinary fluorine's geometric mean is 0.42 mg/L, standard deviation is 0.31, the minimum value is 0.02 mg/L, and the maximum value is 2.550.42 mg/L (as detailed in **Table 4**).

6. Food Maize's Fluorine Content

The investigation surveyed 679 food maize samples from 67 endemic villages of 46 townships, and obtained a median of 0.64 mg/kg, standard deviation of 1.73 mg/kg, minimum value of 0.02 mg/kg, and maximum value of 28.09 mg/kg (as detailed in **Table 5**).

7. Hot Pepper's Fluorine Content

The investigation surveyed totally 679 samples of food hot pepper from 67 en-

Table 3. Drying conditions self-inspection result for maize and hot pepper consumed by people in the endemic counties prevalent with coal-burning fluorosis in Chongqing City.

County name	Township NO.	Village No.	Drying condition of food maize				Drying condition of food hot pepper			
			Consuming village No.	Correct drying rate	No. of villages whose drying rate is $\geq 90\%$	No. of villages whose drying rate is $\geq 95\%$	Consuming village No.	Correct drying rate	No. of villages whose drying rate is $\geq 90\%$	No. of villages whose drying rate is $\geq 95\%$
Fengjie	18	179	44	100	44	44	179	100	179	179
Pengshui	16	86	56	99.95	56	56	84	100	84	84
Qijiang	3	19	10	99.57	10	10	19	98.53	19	19
Qianjiang	16	74	38	99.00	36	35	72	98.64	70	70
Wansheng	2	14	12	99.93	12	12	14	99.44	14	14
Wushan	19	177	108	100	108	108	177	100	177	177
Wuxi	8	44	40	100	40	40	44	100	44	44
Yunyang	5	31	19	100	19	19	31	100	31	31
Nanchuan	2	3	1	100	1	1	3	100	3	3
Xiushan	3	8	4	100	4	4	8	100	8	8
Shizhu	3	7	1	100	1	1	7	100	7	7
Kaixian	2	12	9	100	9	9	12	100	12	12
Wulong	3	7	2	100	2	2	7	100	7	7
Sum	100	661	344	99.88	342	341	657	99.75	655	655

Table 4. Children's urinary fluorine inspection result for the coal-burning endemic counties of Chongqing City.

County Name	Township No.	Village No.	Sample No.	Geometric mean	Minimum value	Maximum value	Standard deviation
Fengjie	2	3	153	0.37	0.12	1.12	0.16
Pengshui	6	6	300	0.40	0.10	1.34	0.17
Qijiang	3	3	150	0.47	0.10	1.41	0.23
Qianjiang	3	3	150	0.55	0.02	2.55	0.61
Wansheng	2	3	150	0.43	0.10	1.29	0.18
Wushan	3	3	150	0.54	0.11	2.20	0.32
Wuxi	3	3	150	0.36	0.10	2.00	0.25
Yunyang	3	3	150	0.48	0.08	2.18	0.36
Nanchuan	2	3	154	0.79	0.26	1.18	0.24
Xiushan	3	5	150	0.62	0.31	1.14	0.23
Shizhu	3	7	350	0.37	0.04	1.94	0.26
Kaixian	2	3	150	0.41	0.14	1.19	0.17
Wulong	3	7	314	0.25	0.06	1.05	0.14
Sum	38	52	2471	0.42	0.02	2.55	0.31

Table 5. Maize fluorine content inspection result for the households in endemic counties prevalent with coal-burning fluorosis in Chongqing City.

County Name	Township No.	Village No.	Sample No.	Median	Minimum value	Maximum value	Standard deviation
Fengjie	3	6	60	0.80	0.45	2.90	0.45
Pengshui	6	6	60	0.86	0.54	6.97	0.80
Qijiang	3	3	30	0.46	0.31	0.59	0.08
Qianjiang	3	3	30	1.96	1.27	2.62	0.29
Wansheng	2	3	30	0.64	0.12	1.10	0.20
Wushan	10	10	100	0.68	0.02	14.37	1.72
Wuxi	3	3	31	0.73	0.58	1.10	0.11
Yunyang	3	9	100	0.60	0.23	0.94	0.11
Nanchuan	2	3	30	0.51	0.13	0.67	0.14
Xiushan	3	5	50	0.41	0.32	0.80	0.11
Shizhu	3	7	70	0.56	0.38	28.09	3.54
Kaixian	2	3	30	0.55	0.47	0.74	0.06
Wulong	3	6	58	0.71	0.27	27.84	3.57
Sum	46	67	679	0.64	0.02	28.09	1.73

Table 6. Hot pepper fluorine inspection result for households in the endemic counties prevalent with coal-burning fluorosis in Chongqing City.

County name	Township No.	Village No.	Sample No.	Median	Minimum value	Maximum	Standard deviation
Fengjie	3	6	60	1.50	0.60	93.00	11.87
Pengshui	6	6	60	3.71	1.04	90.88	13.51
Qijiang	3	3	30	1.77	0.97	2.81	0.35
Qianjiang	3	3	30	2.19	1.49	15.18	2.77
Wansheng	2	3	30	3.70	1.10	100	23.41
Wushan	10	10	100	5.87	2.03	843.48	86.70
Wuxi	3	3	31	1.50	1.00	5.00	1.07
Yunyang	3	9	100	0.89	0.44	146.77	16.13
Nanchuan	2	3	30	0.44	0.11	0.80	0.13
Xiushan	3	5	50	0.76	0.52	0.98	0.12
Shizhu	3	7	70	1.54	0.49	231.21	28.83
Kaixian	2	3	30	0.75	0.59	0.87	0.08
Wulong	3	6	58	2.09	1.02	1292.20	171.16
Sum	46	67	679	1.60	0.11	1292.20	61.82

demic villages of 46 townships, and obtained a median of 1.60 mg/kg, standard deviation of 61.82 mg/kg, minimum value of 0.11 mg/kg, and maximum value of 1292.20 mg/kg (as detailed in **Table 6**).

8. Discussion

Coal-burning type fluorosis is an endemic disease severely impacting the people's health in China, and it is a geochemical disease prevalent in China only. In addition to intake amount of pathogenic factors, the prevalence condition of a disease is also closely related with the natural environment, economic conditions, productivity and life habit [2] [3]. The pathogen of coal-burning type fluorosis in Chongqing City was brought in mainly by intake of food fluorine such as maize and hot pepper, etc. [4] in the 80s of the last century, and gradually by intake of air fluorine [5], and the total intake of fluorine through such way has seen a distinct drop [6].

This survey shows that the dental fluorosis prevalence rate for children aged between 8% and 12% is 11.28%, dental fluorosis index is 0.14, and dental defect rate is 0.29, meaning that such prevalence belongs to a kind of negative prevalence. There are 19 villages whose dental prevalence rate is higher than 30%, taking up 2.87%, respectively distributing in Wushan (14), Wuxi (3), and Qianjiang (1), indicating an obvious decrease of children's dental fluorosis prevalence in our City. The investigations in the households on how they modified their stoves and how they dried up the food maize and hot pepper show that, from 2004 to 2012, with the payment transferred by central government from to local governments for prevention and treatment of endemic fluorosis for the good of public health, 282,755 households completed modifying stoves as required; and up to the end of 2015, 390,000 households of our City had completed modifying their stoves, with stoves modified rate, qualified rate of modified stoves, and correct rate for utilizing qualifiedly modified stoves respectively were 100%, 99.82%, and 99.45%. The survey also found that drying rate of food maize and hot pepper were respectively 99.88% and 99.75%. Such results showed that the prevention and curing measures have been effectively implemented and achieved sound effect. The results are consistent with other similar research results in China [7] [8].

Children's urinary fluorine is one of the important indicators for assessing fluorine content level in the human body, and in this survey, the geometric mean for children's urinary fluorine is 0.42 ± 0.31 mg/L. Of the 661 villages surveyed, 344 villages consume maize for food, accounting for 52.04% of the total villages surveyed, and maize fluorine content median is 0.64 ± 1.73 mg/kg; and 657 villages consume hot pepper for food, holding 99.39%, and the median for hot pepper fluorine content is 1.60 ± 61.82 mg/kg. From these three key indicators for fluorine intake, it can be perceived that maize consuming villages are decreasing in number, and drying up maize correctly, and hot pepper consuming villages are large in number, and can basically dry up hot pepper in the correct way, which further verifies an evident drop of coal-burning type fluorosis prevalence in our City.

Investigation results demonstrate that there is clear drop of coal-burning type fluorosis prevalence in Chongqing City. the prevention and curing measures, such as adopting biomass gasifiers and fluorine-reducing smoke-recycling

stoves, etc. have been effectively implemented and have produced distinct effects, certain achievements have been gained in terms of management of modified stoves in the post-modification period, and that a preliminary mechanism for a long-term prevention and curing of fluorosis has been established. In the future, measures will be taken in the light of the conditions of our City, and instructions will be given according to the types and categories of different endemic areas, *i.e.* in the endemic villages where prevention measures haven't been taken, efforts should be strengthened to implement the stove-modification measures, enhance health education, and improve hygiene behaviors; in the endemic villages where prevention measures have been adopted, work should be done for maintenance and management of modified stoves, and for reinforcing health education and intensifying good hygiene behaviors, so that the standards for eliminating fluorosis can be met; and in the endemic villages where fluorosis prevalence has been controlled, people's awareness in utilizing and purchasing modified stoves should be improved, and efforts should be made to establish such a long-term mechanism "to work on the basis of marketization, under government instruction and departmental cooperation, and with people's voluntary and positive involvement" for prevention of fluorosis prevalence, and thus maintain the status of elimination in the prevalence of fluorosis [9] [10] [11].

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