# SKELETAL FLUOROSIS FROM INDOOR BURNING OF COAL IN SOUTHWESTERN CHINA

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**SUMMARY: The effects of airborne fluoride from unvented indoor burning of fluoride-rich coal on the bones and teeth of residents of two rural villages in SW China were investigated and compared. In the highly polluted village of Xaochang in Sichuan Province, stage III skeletal fluorosis was found in 43 (84%) of 51 examinees. In the moderately polluted village of Minzhu in Guizhu Province, this stage was seen in 25 (51%) of 49 examinees. In the nonpolluted control village of Shucai in Jiangxi Province in SE China, none of 47 examinees showed any evidence of skeletal fluorosis. In Minzhu, but not in Xaochang, significantly more males than females were afflicted with stage III skeletal fluorosis. In contrast with Xaochang, some examinees in Minzhu had serious skeletal effects but normal teeth or minor dental fluorosis. A high frequency of extremital transverse bone growth lines was observed in Xaochang but not in Minzhu. These findings suggest that greater exposure to fluoride occurred during infancy and early childhood in Xaochang than in Minzhu.**

Keywords: Coal burning, Minzhu, Skeletal fluorosis, Southwestern China, Xaochang.

## INTRODUCTION

Ordinarily, fluoride in drinking water is the primary cause of dental and skeletal fluorosis. However, even with very little fluoride in the drinking water, fluoride-rich coal burned indoors without adequate venting is now known to be responsible for many cases of endemic fluorosis in various parts of China. In this report we present some of our findings of fluorosis from coal-burning among residents of two villages in southwestern China. These studies were conducted as part of a joint research project with the Institute of Environmental Health and Engineering in the Chinese Academy of Preventive Medicine.

## SUBJECTS AND METHODS

In 1995 we examined 51 adults who were life-long residents of the severely fluoride-polluted village of Xaochang in Sichuan Province. In 1997 we examined 49 adults (also life-long residents) in the moderately-polluted village of Minzhu in Guizhu Province, and, in 1996, 47 residents of the unpolluted village of Shucai in Jiangxi Province were examined as controls. The two polluted villages are located in mountainous regions about 1,500 meters above sea level. The subjects in these two villages were individuals that local health workers suspected were suffering from debilitating skeletal fluorosis.

Skeletal radiography was performed on the forearms and lower legs (frontal) of all subjects. In subjects residing in the polluted villages, pelvic bones (fron-

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tal) and lumbar vertebrae were also x-rayed. In some cases, because of technical problems, radiography of the lumbar vertebrae could not be conducted. Two examinees of Xaochang were excluded because of poor-quality x-rays.

## RESULTS

Table 1 shows the distribution of the examinees by age and sex. Initially, we hoped to have a combined total of 50 males and females from each village in the 40-59 year age bracket, but that did not prove feasible. As can be seen in Table 1, 80% of the examinees in Xaochang were in this age group, 69% in Minzhu, and 91% in Shucai. Although males accounted for only 21% of the examinees in Shucai, their percentages in Xaochang (65%) and in Minzhu (59%) were not significantly different.

**Table 1.** Characteristics of individuals examined

| Age distribution | Xaochang (n=51)[a] | Minzhu (n=49)[b] | Shucai (n=47)[c] |
|---|---|---|---|
| ≤ 39 yrs | 9 (18%) | 10 (20%) | 3 (6%) |
| 40~49 yrs | 27 (53%) | 11 (22%) | 25 (53%) |
| 50~59 yrs | 14 (27%) | 23 (47%) | 18 (38%) |
| 60 yrs or older | 1 (2%) | 5 (10%) | 1 (2%) |
| *Sex distribution* | | | |
| Male | 33 (65%) | 29 (59%) | 10 (21%) |
| Female | 18 (35%) | 20 (41%) | 37 (79%) |

[a]Severely polluted area. [b]Moderately polluted area. [c]Control area.

Table 2 summarizes the results of our x-ray findings showing the much greater effects of fluoride in Xaochang than in Minzhu. In severely-polluted

**Table 2.** Results of x-ray findings

| Marble bone disease-like appearance | Xaochang | Minzhu | Shucai |
|---|---|---|---|
| Pelvic bone | 14/49 (29%) | 7/47 (15%) | 0/47 |
| Lumbar spine | 3/30 (10%) | 1/12 (8%) | 0/47 |
| *Periosteal neostosis* | | | |
| Forearm | 11/49 (22%) | 6/47 (13%) | 0/47 |
| Lower leg | 32/49 (65%) | 12/47 (26%) | 0/47 |
| *Ossification of inter-osseous membrane* | | | |
| Forearm | 40/49 (82%) | 20/47 (43%) | 0/47 |
| Lower leg | 28/49 (57%) | 10/47 (21%) | 0/47 |
| *Ossification of tendon and ligament* | | | |
| Forearm | 13/49 (27%) | 8/47 (17%) | 0/47 |
| Lower leg | 10/49 (20%) | 6/47 (13%) | 0/47 |
| Pelvic bone | 27/49 (55%) | 11/47 (23%) | 0/47 |
| *Transverse line* | | | |
| Forearm | 7/49 (14%) | 0/47 (0%) | 0/47 |
| Lower leg | 32/49 (65%) | 2/47 (4%) | 0/47 |

Xaochang, 84% of the examinees (43/51) had stage III skeletal fluorosis by Singh and Jolly's classification.[1] In moderately-polluted Minzhu, the figure was 51% (25/49) ($p<0.001$). No examinees in the control village of Shucai appeared to have skeletal fluorosis.

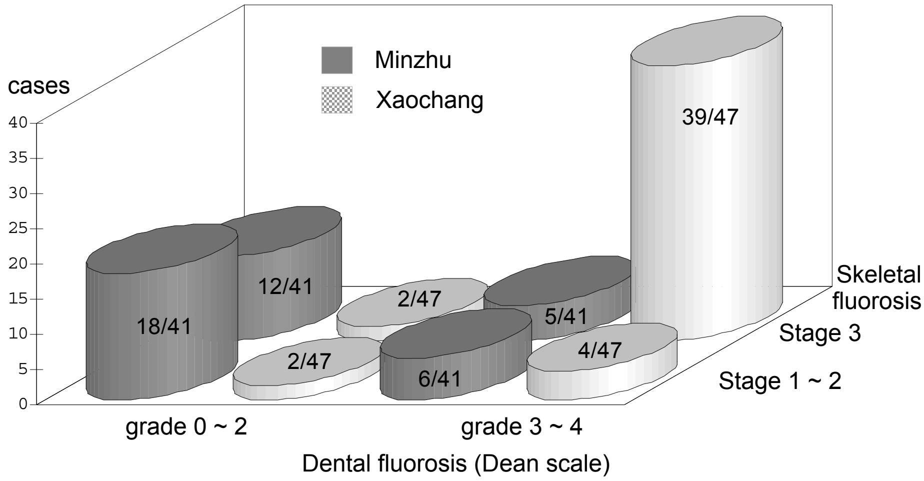
With respect to sex-specific stage III skeletal fluorosis, there was no significant difference in Xaochang, with 88% among males and 78% among females. In Minzhu, however, it was significantly different, with 66% among males but only 30% among females ($p<0.01$).

Figure 1 illustrates the interesting "transverse" or "growth" lines observed in the bones of many of our examinees with skeletal fluorosis. As recorded in Table 2, there were large differences in their occurrence between Xaochang and Minzhu.

In Figure 2, we show the same relationship between the same individual examinees with different stages of skeletal and dental fluorosis. In Xaochang, those with stage III skeletal fluorosis who had grade 3 (moderate) or grade 4 (severe) dental fluorosis on the Dean scale, represented 83% (39/47) of all skeletal fluorosis cases, whereas in Minzhu this percentage was only 12% (5/41) ($p<0.001$). In contrast, 29% (12/41) of examinees in Minzhu had stage III skeletal fluorosis with grade 0 (noma1) to grade 2 (mild) dental fluorosis compared to only 4% (2/47) in Xaochang ($p<0.001$).

**Figure 1.** Example of transverse bone growth lines (proximal end of left tibia)

**Figure 2.** Skeletal fluorosis and dental fluorosis




**DISCUSSION**

Like India, China has a serious public health fluoride problem. A 1990 survey revealed that 300 million people in China were living in fluoride-polluted areas, with 3 million of them suffering from debilitating dental and skeletal fluorosis. Drinking water is considered responsible for fluorosis in 26 provinces and coal in 14 provinces.[2]

A vital source of energy in China is coal which can be gathered readily in coal mines near poor villages in the mountains. Coal containing appreciable amounts of fluoride is used for cooking, heating, and drying grain. People develop fluorosis when they are exposed to fluoride by way of air passages and the alimentary canal.[3] The report by Huo *et al*[4] in 198l appears to be the first connecting health hazards with fluoride in food. It is regrettable that these authors did not mention coal as a causative factor. In the 1990s, reports appeared indicating coal as the cause. Zhang and Cao[5] reported in a survey in Pengsui, Sichuan Province, that there was contamination of grains with coal soot, and that residents ingested as much as 10 mg/day of fluoride by way of air passages and the alimentary canal. They also pointed out that an average of 8.86 mg/day came by way of food.

It has also been found that the rate of skeletal fluorosis is generally higher for males with significant changes for females aged sixty and over.[6] Our surveys indicate that the prevalence of skeletal fluorosis was significantly higher for males in moderately-polluted Minzhu, but not in severely-polluted Xaochang, despite the fact that the majority of examinees were below age 60.

One interesting feature about the x-ray findings is that there was a significant difference between Xaochang and Minzhu in the frequency of “transverse" or "growth” lines in the extremities of bones. Various factors may be responsible for this difference, but published reports indicate that fluoride is also a causative factor. In China, the frequency differs to a significant extent, depending on the survey area. Even in the same province, in Hepei for example, Wang *et al*[7] observed these lines in 70% of cases with fluorosis, whereas Liang and Wu[8] reported 0/60 in the forearm and 3/5l in the lower leg. The percentage in the former cases is close to ours for Xaochang, and the rate in the latter is almost the same as ours for Minzhu.

On the significance of these findings, neither Wang *et al* nor Liang and Wu offered any comment. Nevertheless, it should be noted that this "transverse" or "growth" line phenomenon is far more prevalent in Xaochang, where co-existing wide-spread dental fluorosis occurs, than in Minzhu where there is much less dental fluorosis among adults with overt skeletal fluorosis. For dental fluorosis to occur, excessive fluoride intake must take place before the teeth erupt, in contrast to skeletal fluorosis, which can develop at any age.

In Xaochang, coal-fluoride pollution has existed for many years and has caused extensive dental as well as skeletal fluorosis. In Minzhu, on the other hand, coal-fluoride pollution is more recent and has resulted from a greatly increased domestic use of fluoride-rich coal throughout much of the central Guizhou Province where Minzhu is located. Dental fluorosis is therefore much less prevalent among adults in Minzhu. The very low incidence of "transverse" or "growth" lines among cases of skeletal fluorosis in Minzhu may therefore be related to a low level of fluoride intake during early childhood. Further investigation to verify this interpretation is needed.

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