LEVEL OF FLUORIDE AND ARSENIC IN HOUSEHOLD SHALLOW WELL WATER IN WAMIAO AND XINHUAI VILLAGES IN JIANGSU PROVINCE, CHINA

Quanyong Xiang,[a] Yijun Wang,[b] Mingli Yang,[c] Mingfang Zhang,[c] Yan Xu[a]

Nanjing, PR China

SUMMARY: After previously excluding iodine and lead as confounding factors, the aim of the present study, conducted in June 2013, was to consider whether arsenic was a confounding factor in the studies of children's intelligence in Wamiao and Xinhuai. Fluoride and arsenic levels were measured in water samples from the 37 household shallow wells still in use for providing water for washing but not drinking, 17 in Wamiao and 20 in Xinhuai. The fluoride levels in the household shallow wells in Wamiao (2.28±0.44 mg/L, range: 1.66–3.18 mg/L) were significantly higher than those in Xinhuai (0.38±0.21 mg/L, range: 0.15–0.77 mg/L) (t=17.08, p=0.000). In contrast, the levels of arsenic in Xinhuai (16.40±19.11 µg/L, range: 0–48.50 µg/L) were significantly higher than those in Wamiao (0.24±0.26 µg/L, range: 0–0.50 µg/L) (t=3.48, p=0.001). In our 2003 study, in high-fluoride Wamiao (mean drinking water F=2.47 mg/L) the average IQ was 8.4 points lower (92.02 vs. 100.41) than in the low-fluoride Xinhuai (mean drinking water F=0.36 mg/L). These results make it very unlikely that the differences in IQ of the children living in Wamiao and Xinhuai are the result of differences in exposure to arsenic rather than to fluoride.

Keywords: Arsenic in water; Children's intelligence; Fluoride in water; Intelligence Quotient; Jiangsu Province; Wamiao; Xinhuai.

INTRODUCTION

Jiangsu Province is one of the severe endemic fluorosis areas in China with fluorosis screening in 1980s showing that there were 2,026 villages with endemic fluorosis and the average prevalence of dental fluorosis was 66.76%. The affected areas are mainly distributed to the north of the Subei irrigation river and along Lake Hongze Lake including Xuzhou, Suqian, Lianyungang and Huaian city[1].

We previously reported, in 2003–2011, an association between children's intelligence and the level of fluoride in both drinking water and serum in two villages, Wamiao and Xinhuai, in Sihong County, Jiangsu Province,[2-4] and found that neither iodine nor lead were confounding factors[2,5] but did not consider possible confounding by arsenic which may also lower intellectual function in children.[6-8]

Water with high arsenic levels was found in Jiangsu Province in 2004–2005 and in 2005 we screened 9,427 household shallow wells for water arsenic and found 271 water samples with arsenic level over 10 µg/L including 220 samples with levels over 50 µg/L. The highest level of water arsenic was 333 µg/L.[9] The areas with higher water arsenic were mainly located along Lake Hongze and Huaihe river, in Sihong county, Suqian City, and Xuyi County, Huaian City.

[a]For correspondence: Dr Xiang Quanyong, Department of Non-communicable Chronic Disease Control and Prevention, Jiangsu Province Center for Disease Control and Prevention, 172 Jiangsu Road, Nanjing 210009, PR China. E-mail: quanyongxiang@vip.sina.com. [b]School of Public Health, Nantong University. [c]Sihong county Center for Disease Control and Prevention, Jiangsu Province, PR China.

The aim of the present study, conducted in June 2013, was to consider whether arsenic was a confounding factor in the studies of children's intelligence in Wamiao and Xinhuai.

MATERIALS AND METHODS

The basic information on Wamiao and Xinhuai villages has been published previously.[2] Since 2004 in Wamiao and 2009 in Xinhuai almost all villagers have used tap water rather than well water. The household shallow wells have been scarcely used with just a few being used for washing but not drinking. We collected water samples from the 37 household shallow wells still in use, 17 in Wamiao and 20 in Xinhuai.

The 50 mL plastic bottles used to collect the shallow well water were cleaned by soaking in 10% nitric acid (HNO3) for 48 hr and being washed three times with tap water and twice with distilled water. The well water samples were analyzed within two weeks. The water arsenic levels were measured by an atomic fluorescence spectrophotometer (AFS-230E, manufactured by Beijing Haiguang Instrument Company, China) with a limit of detection (LOD) of 0.06 μg/L±2.4%.[10] The water fluoride levels were measured with a fluoride ion selective electrode with an LOD of 20 μg/L ± 2%[11].

The data were analyzed using SPSS16.0 Software.

RESULTS

The sample sites covered most of the area of the villages of Wamiao and Xinhuai as shown in the Google Earth maps (Figures 1 and 2).

Figure 1. The map of Wamiao from Google Earth. The stars indicate the sampling sites.

The fluoride levels in the household shallow wells in Wamiao (2.28±0.44 mg/L, range: 1.66–3.18 mg/L) were significantly higher than those in Xinhuai (0.38±0.21 mg/L, range: 0.15–0.77 mg/L) (t=17.08, p=0.000) (Figures 3 and 4). In contrast, the levels of arsenic in Xinhuai (16.40±19.11 μg/L, range: 0–48.50 μg/L; levels of arsenic in 7 water samples were lower than the limitation of arsenic detection) were significantly higher than those in Wamiao (0.24±0.26 μg/L, range:

0–0.50 μg/L; levels of arsenic in 9 water samples were lower than the limitation of arsenic detection) (t=3.48, p=0.001) (Figures 3 and 4).

Figure 2. The map of Xinhuai from Google Earth. The stars indicate the sampling sites.

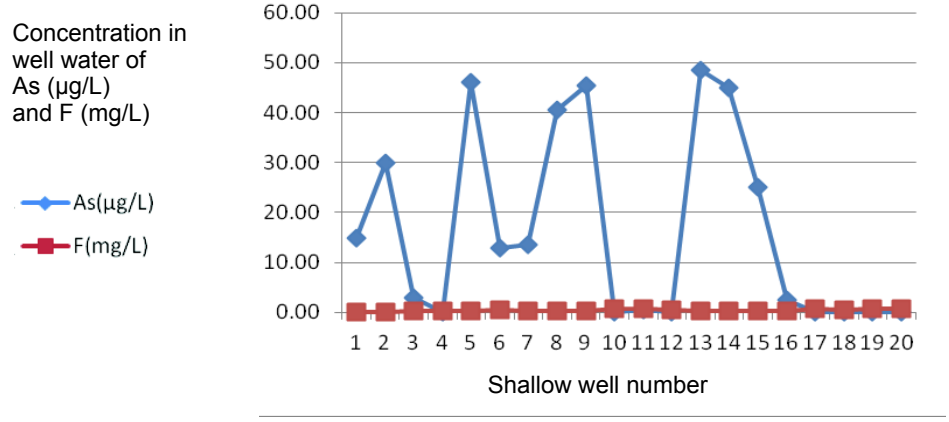

Figure 3. Fluoride and arsenic levels in household shallow wells in Xinhuai village.

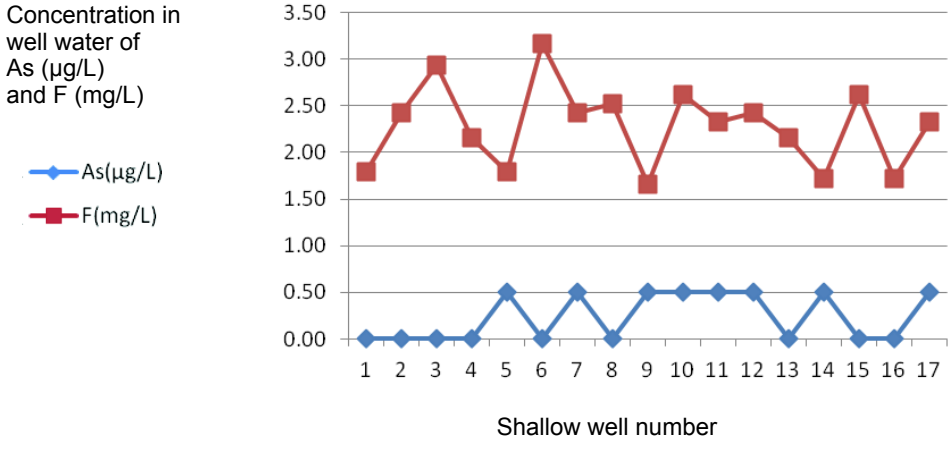

Figure 4. Fluoride and arsenic levels in household shallow wells in Wamiao village.

The results of correlation analysis indicated that a significant inverse relationship was present between the levels of arsenic and fluoride in Xinhuai village with the level of fluoride increasing as the level of arsenic decreased (correlation coefficient= –0.765, p=0.000) (Figure 5). This relationship was not present in Wamiao village (correlation coefficient= –0.264, p=0.305) (Figure 6).

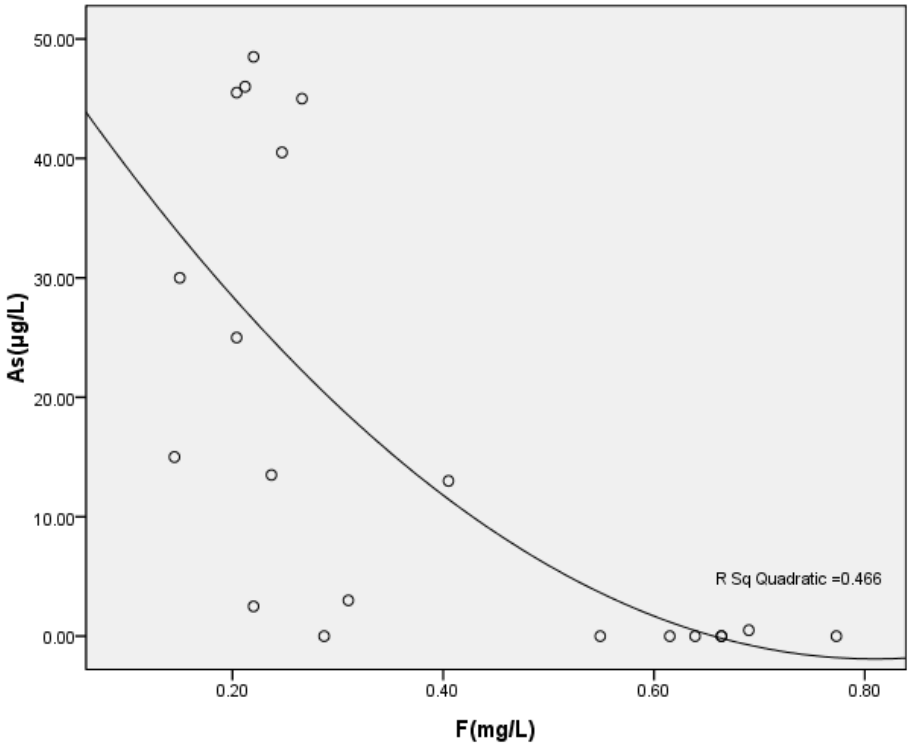

Figure 5. Relationship of F and As in household shallow well water in Xinhuai.

DISCUSSION

In this follow-up study, on fluoride exposure and children's IQ, we found that the arsenic levels in the household shallow well water in the high-fluoride Wamiao village were very low, with the highest level of arsenic being only 0.50 μg/L. In low-fluoride Xinhuai village, the average level of arsenic was significant higher (16.40±19.11 μg/L) than that in Wamiao (0.24±0.26 μg/L). The highest level of arsenic in Xinhuai was 48.50 μg/L, which was lower than the former national standard of China of 50.00 μg/L. In our 2003 study, in high-fluoride Wamiao (mean drinking water F=2.47 mg/L) the average IQ was 8.4 points lower (92.02 vs. 100.41) than in the low-fluoride Xinhuai (mean drinking water F=0.36 mg/L). These results make it very unlikely that the differences in IQ of the children living in Wamiao and Xinhuai are the result of differences in exposure to arsenic rather than to fluoride.

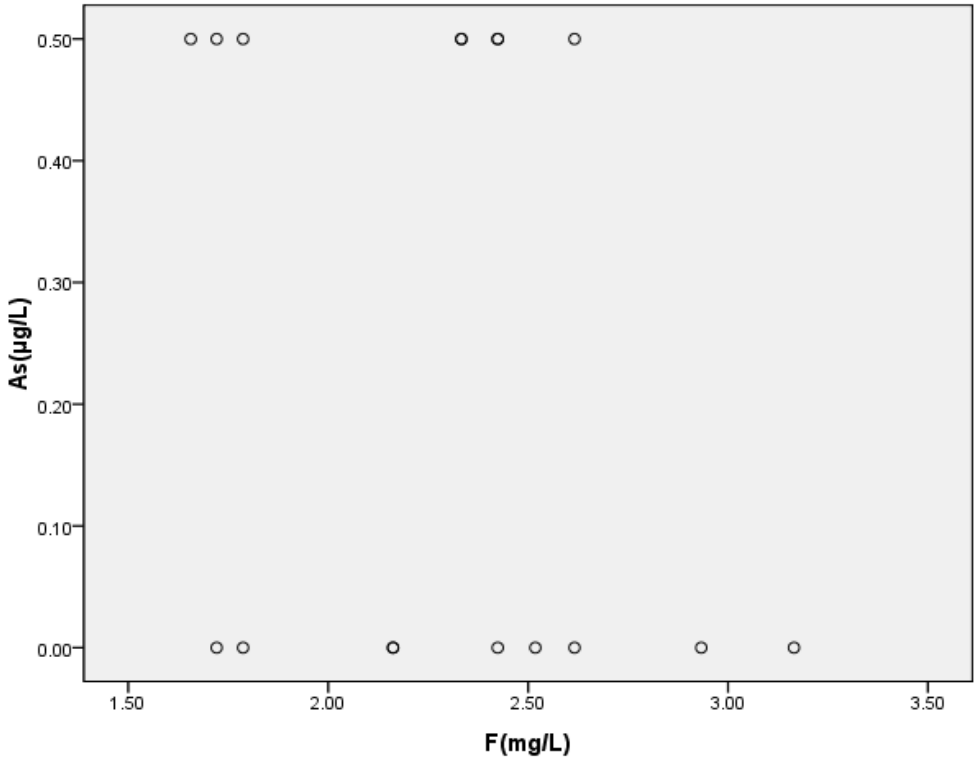

Figure 6. Relationship of F and As in household shallow well water in Wamiao.

Wasserman et al. found that water arsenic concentrations of 10 and 50 μg/L were associated with decrements in full-scale raw IQ scores of 3.8 and 6.4 points, respectively.[7] These levels are comparable to those found in the shallow well water in Xinhuai village and we regret we did not measure the arsenic levels in our initial 2003 study. Wang et al. found that exposure to fluoride in drinking water was associated with neurotoxic effects in children and that the decline in the intellectual function from exposure to arsenic was more significant than that from fluoride exposure.[8] However, they did not analysis the effect on IQ of the interaction of arsenic and fluoride.

Although the adverse effects of comparatively low intake of fluoride on intelligence and mental acuity continue to be reported, [2,12-17] they are also still being questioned and denied. [16] We do not have a clear explanation for the inverse relationship between fluoride and arsenic in the well water in the low-fluoride village Xinhuai.

In our future research, we plan to study the health effects of the interaction of the fluoride and arsenic and the dose-response relationships, especially their neurotoxicity at comparatively low concentrations.

REFERENCES

1 Wang CH, Bu XH, Gu SD. Epidemiological investigation of the endemic fluorosis in Huanbei areas in Jiangsu Province. Chinese Journal of Endemiology 1997; 12(4): 28-31. [in Chinese].
2 Xiang QY, Liang Y, Chen L, Wang C, Chen B, Chen X, et al. Effect of fluoride in drinking water on children's intelligence. Fluoride 2003;36(2):84-94. Erratum in: Fluoride 2004;37(4):320.
3 Fluoride levels and children's intelligence quotient in two villages in China [abstract]. Fluoride 2005;38(4):326-7. Erratum in: Fluoride 2006;39(1):78.
4 Xiang QY, Liang YX, Chen BH, Chen LS. Analysis of children's serum fluoride levels in relation to intelligence scores in a high and low fluoride water village in China. Fluoride 2011;44(4):191-4.
5 Xiang QY, Liang YX. Blood lead of children in Wamiao-Xinhuai intelligence study [letter to the editor]. Fluoride 2003;36(3): 198-9;
6 Tsai SY, Chou HY, The HW, Chen CM, Chen CJ. The Effects of chronic arsenic exposure from drinking water on the neurobehavioral development in adolescence. Neurotoxicology 2003; 24(4-5): 747-53.
7 Wasserman GA, Liu X, Parvez F, Ahsan H, Factor-Litvak P, van Geen A, et al. Water arsenic exposure and children's intellectual function in Araihazar, Bangladesh. Environ Health Perspect 2004; 112:1329-33.
8 Wang SX, Wang ZH, Cheng XT, Li J, Sang ZP, Zhang XD, et al. Arsenic and fluoride exposure in drinking water: children's IQ and growth in Shanyin County, Shanxi Province, China. Environ Health Perspect 2007;115(4):643-7.
9 Zhang M, Xiang QY, Hu XS. Analysis of the results of screening for high level arsenic in drinking water in Jiangsu province in 2005. Jiangsu J Prev Med 2008;19(4):1-4. [in Chinese]
10 National Standard of PR China. Standard examination method for drinking water GB 5750-85. [in Chinese]
11 National Standard of PR China. Determination of fluoride in urine: ion selective electrode method (WS/T 89 – 1996). [in Chinese]
12 Li XS, Zhi JL, Gao RO. Effect of fluoride exposure on intelligence in children. Fluoride 1995; 28(4):189-92.
13 Zhao LB, Liang GH, Zhang DN, Wu XR. Effect of a high fluoride water supply on children's intelligence. Fluoride 1996; 29(4):190-2.
14 Lu Y, Sun ZR, Wu LN, Wang X, Lu W, Liu SS. Effect of high-fluoride water on intelligence in children. Fluoride 2000;33(2):75-8.
15 Burgstahler AW. Influence of fluoride and lead on children's IQ: U.S. tolerance standards in question [editorial]. Fluoride 2003;36(2):79-81.
16 Spittle B. Fluoride and intelligence [editorial]. Fluoride 2000;33(2):49-52.
17 Ding YP, Gao YH, Sun HX, Han HP, Wang W, Ji XH, et al. The relationships between low levels of urine fluoride on children's intelligence, dental fluorosis in endemic fluorosis areas in Hulunbuir, Inner Mongolia, China. J Hazard Mater 2011. doi:10.1016/j.jhazmat.2010.12.097 [abstract in Fluoride 2011;44(1):50]