The Effect of High Fluoride Exposure on the Level of Intelligence in Children

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Objective: Investigate the effect of high fluoride exposure on the level of intelligence in children.

Method: In May 2006, 42 children from a high endemic fluorosis group and 37 children from the control area (who have been consuming low-fluoride water after water improvement schemes) were chosen for the test. They are all from a primary school in Pucheng county, Shaanxi province. Their level of intelligence was tested, and a test for dental fluorosis was conducted using Dean's method, and the level of fluoride in urine was determined with a fluoride ion selective method.

Results: The average intelligence level of the children in the high fluoride group (96.11 +- 12.00) was lower than that of the control group (98.41 +- 14.75). We have not found any children with an intelligence level exceeding a level deemed as excellent; as for the intelligence distribution in these groups, there is little statistical significance. There was a negative correlation between the urine fluoride concentration and the level of intelligence in children (P>0.05).

Conclusion: Exposure to high levels of fluoride is likely to cause a certain level of harm to a child's level of intelligence.

Keywords: Fluoride, Children, Intelligence Level

Recently, there has been more research material discussing the negative correlation between high fluoride exposure and its detrimental effect on childhood intelligence, both at home and abroad. Although different conclusions have been reached, there is not much material within the field of epidemics. (1-3) For this reason, we have performed a random sampled study in a primary school in Pucheng county, Shaanxi province.

1. Content and Methodology

1.1 Basic Information about the Area of Research

The village that we studied in Pucheng county is a region severely impacted by endemic fluorosis. There are 9 groups in the village. From 1988 to 1992, groups 1, 2, 8 and 9 were switched over to low-fluoride water, with a fluoride content of 1.03 mg/L. Groups 3, 4, 5, 6 and 7 have yet to have water improvement schemes put in place at their locations, and the fluoride contained in their water source remains at 3.15 mg/L. The entire village shares common habits and lifestyles in terms of cuisine, economy (source of income), living environment, culture and education, agricultural goods etc. There are no chemical factories around the area, and the village is considered an area covered by iodine salt, with the consumerable iodine salt deemed satisfactory in terms of the national qualification standards.

1.2 Choosing the Endemic Fluorosis Group

Amongst groups 3, 4, 5, 6 and 7 (who have yet to have water improvement schemes put in place), we randomly selected 42 school children between the ages of 7 to 14 as the high/endemic fluorosis group's subjects. From groups 1, 2, 8 and 9 (who have had water improvement schemes put in place and are now consuming low-fluoride water), we have randomly selected 37 school children between the ages of 7 to 14 as subjects of the control group.

1.3 Methodology

To determine the rate of dental fluorosis among the children, we have used Dean's method. We have used plastic polyethylene bottles to collect urine samples from the children. The level of fluoride in the urine samples was determined by the fluoride ion electrode selection method. To test the intelligence level of these children, we used the CRT-C2 image book; with the CRT-C2 intelligence module used to calculate the IQ values. Different levels of intelligence were determined as per the following standard: IQ greater or equal to 130: outstanding; 120-129: excellent;110-119: higher than average; 90-109: average; 80-89: lower than average; 70-79: subsistent intelligence; lower or equal to 69: low intelligence.

1.4 Statistical Analysis

We have used the Epi info 2002 software to analyze the data. The data are shown in -X +S. The correlation between fluoride levels in urine and the intelligence level has been evaluated and performed with single element related analysis. Inspection of the mean figure has been determined with the T-value; as for the comparison between the different rates gathered from the two groups, the χ^2-value has been used to perform the comparison.

2. Results

2.1 Fluoride in the Urine Samples

11 urine samples from the endemic group were found to contain fluoride measuring at 1.14-6.09 mg/L, with an average of 2.89 +/- 1.97 mg/L. 7 urine samples from the control group were found to contain fluoride measuring at 1.33-2.35 mg/L, with an average of 1.78 +/- 0.46 mg/L. This difference between the two was not statistically significant (t =1.48, P>0.05).

2.2 Dental Fluorosis in Children

We investigated a total of 42 school children from the endemic group and found a total of 35 cases of dental fluorosis. The rate of detection was 83.3%. Among the 37 school children from the control group, 11 cases of dental fluorosis were found, for a detection rate of 29.7%. The difference between the rate of disease between the two groups of children bears statistical significance (X = 23.24, P<0.01).

2.3 Results of Intelligence Tests

From Table 1 below it can be seen that no school children having an "excellent" (or above) level of IQ have been found in the group impacted by endemic fluorosis, whereas 3 school children with such level of IQ were found in the control group. 4 school children with an IQ level which is deemed to be higher than average were found in the endemic group, which takes up 9.5% of the whole group. 8 such school children were found in the control group, taking up 21.6% of the whole group. This difference was not statistically significant (X2 =2.24, P>0.05). The average IQ of the endemic group is 96.11, which is lower by 2 points than the control group's score of 98.41. This difference did not reach statistical significance (t = 0.76, P>0.05).

2.4 Relevant Analysis of the Correlation Between Fluoride Content in Urine and the Level of Intelligence

With the single element analysis method, we investigated the correlation of the fluoride content in the children's urine and the level of intelligence. A negative correlation was found between the two measures, but the difference was not statistically significant (the endemic group: r = 0.390, P>0.05; comparative group: r= -0.220, P>0.05).

3. Discussion

Fluoride can enter the brain tissue via the blood-brain barrier (4), and as doses of fluoride-contaminated matter increases, the amount of fluoride contained in the brain tissue likewise increases (5). The hippocampus, nerve

Table 1. The distribution of the different levels of intelligence in the children amongst the endemic and control groups

Group	People	IQ rate (-X +S)	Outstanding	Excellent	Higher than average	Average	Lower than average	Subsistent	Low
			No. of Children (%)	No. of Children (%)	No. of Children (%)	No. of Children (%)	No. of Children (%)	No. of Children (%)	No. of Children (%)
Endemic group	42	96.11 +/- 12.00	0 (0)	0 (0)	4 (9.5)	28 (66.7)	7 (16.7)	2 (4.8)	1 (2.3)
Control group	37	98.41 +/- 14.75	1 (2.7)	2 (5.4)	5 (13.5)	18 (48.0)	8 (21.6)	2 (5.4)	1 (2.7)

fibers, nerve synapses and blood-brain barrier of a lab rat that has consumed high-fluoride water over a long period of time are all seen to be harmed by such consumption (6). This research in particular has shown that no children with a level of IQ deemed as "excellent" or above have been found in the group consuming water containing fluoride at 3.50 mg/L over an extended period of time. Additionally, the average IQ level of the endemic group was found to measure 2 points lower than that of the control group. This difference bears no statistical significance ($P>0.05$), which is in accordance with the conclusion of the research team led by Yuanshen Hu, who performed similar research in a village whose drinking water contained fluoride measuring at 7.00 mg/L (3). These are all indicative of the importance and necessity of rolling out the water improvement schemes in these affected areas. There is a significant need to carry out improvement schemes to lower the level of fluoride in drinking water. Doing so may subsequently protect and allow children in these areas to have a normal development of intelligence.

As the level of fluoride in this area is far too high, subjects consumed fluoride from a variety of sources. Other than water, subjects were exposed to fluoride in food items, vegetables and other items in the food chain. This could be a factor contributing to the statistically nonsignificant difference between the average fluoride level in the urine samples and the IQ levels of the subjects from the control and endemic areas. We therefore recommend that more extensive research be done on the degree of exposure and source of fluoride intake in the affected endemic regions. As well, we recommend lowering the health standard for fluoride in drinking water in endemic regions where the overall intake of fluoride has exceeded the national health standard. We believe that it is realistic and important as a measure for endemic regions to proceed with a particular, regional fluoride standard in drinking water; as well, the method of food relocation (having food items produced in the south to be brought up north) would be affective in lowering the overall amount of fluoride consumption. As for the correlation between the level of fluoride in urine and the level of intelligence in children, the results are shown to be negative. It has been observed that as the level of fluoride content in urine increases, the level of intelligence in a child decreases. Therefore, focusing and expanding efforts to reduce the level of fluoride in drinking water has a far-reaching impact on the quality of our country's citizens.

The present research has also shown that while fluoride consumption has a certain level of impact on the level of intelligence in children, the difference is not statistically apparent. Whether this is because of the relatively low number of samples collected, the overall level of fluoride consumption, or whether dental fluorosis is (or is not) under control (30%) remains to be determined. As the amount of fluoride in drinking water increases and continues to be consumed over an extended period of time, the negative impact - and the scope of said impact - on the development of intelligence in children is very much worthy of further research and investigation.

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