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EFFECTS OF ENDEMIC FLUORIDE POISONING ON THE INTELLECTUAL DEVELOPMENT OF CHILDREN IN BAOTOU

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SUMMARY: Our goal was to investigate the effects of endemic fluoride poisoning on the intellectual development of children living in Baotou, Inner Mongolia. Our method was to select random child subjects from endemic fluoride areas in Baotou and use the illustrated version of the Chinese Standardized Raven Test for use with children in rural areas to test their IQ. The results showed that the average IQ of 720 children in the endemic area was 92.07 (compared to 93.78 for 236 children in the control area), with 10.38% falling into the "low" IQ category versus 4.24% in the control area. Compared with the theoretical average IQ for the Chinese children from rural areas, the average IQ of the endemic fluoride area subjects was 7.93 points lower, and the rate of underdeveloped intelligence 8% higher than the average, a very significant difference. The average IQ of children with dental fluorosis was 88.67, which was 8.12 points lower than the average for the unaffected children (96.79), and 11.69% were classified as having "low" IQ, a rate 3% higher than the children not exhibiting dental fluorosis. This indicates that children living in areas of endemic fluoride poisoning have development deficits, and that the damage to intellectual ability caused by fluoride is significant.

Keywords: Baotou, Inner Mongolia; Dental Fluorosis; Endemic fluoride poisoning, Intellectual ability; IQ of children.

INTRODUCTION

Populations living permanently in areas whose drinking water has high fluoride content will have an excess body burden of fluoride, leading to endemic fluoride poisoning. The endemic fluoride poisoning in the Baotou region of Inner Mongolia is mostly concentrated on the high plateau north of the Ying Mountain Range, and the alluvial plain of the Yellow River south of Ying Mountain. As part of our endemic disease prevention work, we conducted a study of the effects of fluoride poisoning on intellectual development with the children of this region as our subjects.

SUBJECTS AND METHODS

Subjects: We selected elementary school students from five elementary schools in the fluorosis endemic region, and also drew a control group from two elementary schools outside the region. The region classified as endemic was designated using the 1981 standards for designation of endemic regions laid out in 1981's *Standards for Endemic Fluorosis Prevention and Treatment Work* by the Chinese Geological Office; the diagnoses of dental fluorosis were made according to the standards for diagnosis of dental fluorosis found in the *Endemic Fluorosis Prevention and Treatment Handbook* issued by the Endemic Disease Department of the Ministry of Health.

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IQ testing: Using the Chinese Standardized Raven Test (illustrated version for use with rural children), a sample of children 6-13 years old were selected and collectively tested by class. A base score was calculated by comparison with standard answers, and then the final IQ calculated with reference to the standardized Chinese Raven IQ Test for Rural Children, table of norms #2 (CRT-RC2; as published by the Tianjin Endocrinology Research Center and the Medical Psychology Research and Teaching Section of Tianjin Medical University in August, 1997). General intellectual ability was assessed based on the IQ score, with subjects placed in the following seven categories: outstanding (IQ >130), excellent (120–129), above average (110–119), average (90–109), below average (80–89), borderline (70–79), and low (IQ <69). These data were then entered into Foxpro and SQL databases for statistical analysis.

RESULTS

Incidence of dental fluorosis in children from the endemic fluoride poisoning zone: In addition to the IQ testing, students from the five primary schools in the fluoride-poisoned zone were examined for dental fluorosis; in total, 720 students were examined for the disease, including 381 boys and 339 girls, and 419 cases of dental fluorosis were diagnosed, a disease rate of 58.19%. Students from the two schools in the control area were also examined; of the 236 (114 boys, 118 girls) that were tested, 29 were found to have dental fluorosis, a disease rate of 12.29%. The incidence of dental fluorosis in children from the subject area was clearly higher than the control, and this difference was statistically significant ($p<0.01$).

Distribution of IQ scores of the children from the endemic fluoride poisoning area: The IQ scores of the children from the endemic area showed a clear leftward shift, with the average IQ (92.07) lower than the control; this difference was not significant, however. The rate of children classified as having low IQ is clearly higher than the control group, and this result does have high statistical significance (see Table 1).

Table 1. Distribution of IQ scores of children in the endemic fluorosis and the control areas

Type	n	Mean±SD	Distribution (%)							Significance of average IQ
			<69	70-79	80-89	90-109	110-119	120-129	>130	
Endemic	720	92.07±17.12	10.38	11.67	17.78	42.50	11.94	4.72	0.56	
Control	236	93.78±14.30	4.24	12.29	17.37	51.27	12.29	2.12	0.42	p>0.05

Comparison of IQ distributions between the children from the area of endemic fluoride poisoning and the theoretical standard distribution (Table 2):

Table 2. Comparison of IQ distribution between the fluoride endemic children and the theoretical standard

Type	n	Mean±SD	Distribution (%)							Significance of average IQ
			<69	70-79	80-89	90-109	110-119	120-129	>130	
Endemic	720	92.07±17.12	10.38	11.67	17.78	42.50	11.94	4.72	0.56	
Theoretical		100.00±15.00	2.20	6.70	16.10	50.00	16.10	6.72	2.20	p<0.01

Comparison of the IQ distribution of children with or without dental fluorosis among children living in areas with endemic fluoride poisoning: Among children from the endemic area, 419 were suffering from dental fluorosis, and 301 were disease-free. The average IQ of the dental fluorosis sufferers is clearly lower than

that of non-sufferers, and this difference is extremely significant. The rate of fluorosis sufferers with "low" IQ is elevated as compared with the non-sufferers, but this result is not significant. The general results indicate that, within a fluorosis endemic area, the intellectual ability of children suffering from dental fluorosis is diminished when compared with non-sufferers (Table 3).

Table 3. Comparison of IQ distribution for sufferers and non-sufferers of dental fluorosis in three endemic regions

Region/Type	n	Mean ±SD	Distribution (%)							Significance of average IQ
			<69	70-79	80-89	90-109	110-119	120-129	>130	
Guyang/										
Sufferers	164	86.29±13.33	10.98	18.29	23.78	45.73	1.22	0.00	0.56	p>0.01
Non-sufferers	141	93.16±15.00	10.64	7.09	22.70	36.88	17.73	3.55	1.42	
Damao/										
Sufferers	255	90.20±16.23	13.73	12.16	15.29	48.63	7.84	2.35	0.00	p<0.01
Non-sufferers	160	100.00±18.66	6.63	8.75	11.25	34.38	24.38	14.38	1.25	
Both/										
Sufferers	419	88.67±15.26	11.69	15.51	18.62	47.49	5.25	1.43	0.00	p<0.01
Non-sufferers	301	96.79±18.43	9.63	6.31	16.61	35.55	21.26	9.30	1.33	

Comparison of IQ distribution by gender within the region of endemic fluoride poisoning: Among the 720 subjects living in the endemic area, 382 were boys and 338 were girls, with average IQs of 92.24 and 91.87, respectively; the slight difference between girls and boys is not significant. With regard to the number of "low" IQ children, there were slightly more girls than boys, but this result too was not significant, demonstrating that the damage to intellectual ability caused by fluoride poisoning shows no particular gender bias.

Table 4. Comparison of IQ distribution by gender within endemic region

Gender	n	Mean±SD	Distribution (%)							Significance of average IQ
			<69	70-79	80-89	90-109	110-119	120-129	>130	
Male	382	92.24±16.88	9.69	11.52	18.32	42.93	13.09	3.40	1.05	
Female	338	91.87±17.42	12.13	12.12	17.46	41.72	10.36	6.21	0.00	p>0.05
Total	720	92.07±17.12	10.83	11.57	17.78	42.50	11.94	4.72	0.56	

ANALYSIS AND DISCUSSION

The general view of intellectual ability is that it results from two factors. The first component is innate intelligence derived from some combination of neurological function and brain structure and having little or nothing to do with environment or cultural background, for instance abilities such as general perception, short-term memory, mental agility, attention, reaction time, etc. The other factor is acquired intelligence relating to the accumulation of knowledge, education, experience, etc. Examples of this include information, vocabulary, understanding, linguistic and computational ability, etc. The test used in this study, the Raven IQ test, is intended to test basic, innate factors in the child's overall intellectual competence, and as such it is a measure of the normal development of neural function within the cerebral cortex. The critical phase in brain development happens during early childhood or the fetal stage. It is at this time that brains cells

are dividing rapidly, with dendrite branching, axonal sprouting, synapses connecting, and the myelin sheath forming. It is during this phase that the brain and indeed the entire nervous system are most susceptible to a lack or an excess of various elements. Fluoride poisoning caused by geochemical factors has an indisputable negative influence on human intellectual development.

Fluoride is one of the elements that, in trace amounts, is regarded as necessary for human life. However, people who live permanently in areas that have high fluoride drinking water will have an excessive intake, leading to a change in the consistency of tooth enamel, disrupting the crystalline structure of bone, and inhibiting the normal function of enzymes. The major clinical manifestations are dental and skeletal fluorosis. There are various reports on the intellectual effects of chronic fluoride poisoning in large populations, but the mechanisms involved are still not entirely clear. A study by He Wei et al.[1] suggests that changes in nitric oxide synthase (NOS) positive neurons in the cortex might be a primary factor in the damage to rat brain function caused by fluoride poisoning. Another report demonstrates that damage to brain tissue from excess fluoride leads to a lack of choline neurotransmitters in the central cortex and a decline in memory and learning ability.[2] In our study, we found that the average IQ of children in a fluoride endemic area was somewhat lower than the control, but the result was not statistically significant ($p>0.05$). The percentage of children with "low" IQs, however, was higher as compared to the control, and this was very significant statistically. The decrease in the average IQ of the children from the fluoride endemic area as compared with the theoretical standard was 7.94 points, and the number of "low" IQ subjects was 8% higher than expected; both results are statistically significant.

The observed negative influence of fluoride could be a result of two different exposures: first, the mother's burden of fluoride passing through the placenta during pregnancy, affecting the normal development of the fetus; and the other, an excess uptake of fluoride due to a childhood spent in a high fluoride environment. Particularly, the fluoride from excess intake during the period up until the age of 8 can influence the child's intellectual ability and neurological development to various degrees. The most obvious harm caused by excess fluoride is dental fluorosis. Our study showed that, within the endemic fluoride area, the average IQ of children suffering from dental fluorosis is clearly lower than those that show no signs of the disease, and this result is very significant ($p <0.01$). This IQ difference of 8.12 points suggests that children suffering from dental fluorosis might be particularly sensitive to excess fluoride, and that the manifestation of this effect is not limited to the typical symptoms of fluorosis, but, more seriously, can disrupt intellectual development.

REFERENCES

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