EFFECT OF FLUORIDE EXPOSURE ON INTELLIGENCE IN CHILDREN

X S Li,[a] J L Zhi,[b] and R O Gao[c]
Guizhou, China

SUMMARY: The intelligence was measured of 907 children aged 8-13 years living in areas which differed in the amount of fluoride present in the environment. The *Intelligence Quotient* (IQ) of children living in areas with a medium or severe prevalence of fluorosis was lower than that of children living in areas with only slight fluorosis or no fluorosis. The development of intelligence appeared to be adversely affected by fluoride in the areas with a medium or severe prevalence of fluorosis but to a minor extent only in areas with only a slight prevalence of fluorosis. A high fluoride intake was associated with a lower intelligence. No correlation was found between age and intelligence in the areas with a medium and severe prevalence of fluorosis. The effect of exposure to a high level of fluoride on intelligence may occur at an early stage of development of the embryo and infant when the differentiation of brain nerve cells is occurring and development is most rapid.

Keywords: Child; China; Fluoride; Fluorosis; Intelligence; Intelligence testing.

Introduction

With the study in recent years of endemic fluorosis, attention has been given to the effect of fluoride on intelligence in children.[1-2] In the present study children living in areas with differing prevalences of fluorosis received intelligence testing.

Materials and Methods

The survey was carried out in November and December 1991 in the Anshu and Zhijin counties in Guizhou Province. The prevalence of fluorosis due to soot from coal burning varied from being absent to being present to a slight, medium or severe degree. In the medium and severe fluorosis areas, it was customary for coal to be used as a domestic fuel for cooking, heating and drying grain whereas in the areas without or only slight fluorosis there was no custom of drying grain by the use of coal. The standards of material and cultural life for the children were similar in all four areas. The survey areas have no iodine deficiency disease.

The children surveyed were of Han nationality and numbered 907 with ages from 8-13 years. Children whose intelligence had been affected by congenital or acquired diseases not related to fluoride were excluded.

Intelligence was measured using the *China Rui Wen's Scaler for Rural Areas*.[3] In each area, 20-24 children were examined, by a special examiner, in each age group with the groups being separated by intervals of six months in age.

[a] Guizhou Provincial Sanitary and Anti-Epidemic Station, Guiyang City, 550001, China. [b] Anshun Prefecture Sanitary and Anti-Epidemic Station. [c] Zhijin County Sanitary and Anti-Epidemic Station.

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The significance of the various levels in the Intelligence Quotient (IQ) were: <70 low; 70-79 borderline; 80-89 lower medium; 90-109 medium; 110-119 upper medium; 120-129 excellent; >129 special excellence.

The dental fluorosis index using the method of Dean and the urinary fluoride concentrations for the children from the four different areas are shown in Table 1.

Table 1. Dental fluorosis prevalence, dental fluorosis index and urinary fluoride concentration for children from areas with no fluorosis and slight, medium and severe prevalences of fluorosis

	Non-fluorosis area	Slight fluorois area	Medium fluorosis area	Severe fluorosis area
Dental fluorosis index	<0.4	0.8	2.5	3.2
Urinary F mg/L	1.02	1.81	2.01	2.69

Results

The numbers of children examined in each area and their mean IQs are shown in Table 2.

The distribution of the IQ scores is shown in Table 3.

As shown in Table 3, more children with IQs of <70 and 70-79 and fewer children with IQs of 90-109 and 110-119 were present in the medium and severe fluorosis areas than in the slight fluorosis and non-fluorosis areas. No children with IQs of 120-129 and >129 were found in the medium and severe fluorosis areas.

In Table 4 the IQs of children of different ages from areas with differing prevalences of fluorosis are shown.

A comparison of the IQs of boys and girls is shown in Table 5.

Discussion

The results of the survey show that the intelligence, as measured by the mean IQ, of children aged 8-13 years living in areas with a medium or severe prevalence of fluorosis was lower than that of children living in areas with a slight prevalence of fluorosis or no fluorosis. Similarly more children with a low or borderline IQ were present in the medium and severe fluorosis areas. That a high fluoride environment can adversely affect the development of intelligence in children is in agreement with the findings of Guo *et al.*[1] No significant difference in intelligence was present between children in the slight fluorosis and the non-fluorosis areas. The lowering of intelligence in the moderate and severe fluorosis areas indicates that the central nervous systems of the children in those areas are adversely affected by fluoride.

Because no correlation was found between age and IQ for children in the medium and severe fluorosis areas, it appears that the influence of a high fluoride environment on the development of intelligence may occur early in development such as during the stages of embryonic life or infancy when the differentiation and

Table 2. Numbers of children examined and their mean IQs in areas differing in the prevalence of fluorosis

	Non-fluorosis area	Slight fluorosis area	Medium fluorosis area	Severe fluorosis area
Number of children examined	226	227	224	230
IQ (mean±SD)	89.9±10.4*	89.7±12.7	79.7±12.7**	80.3±12.9***

* comparing the non-fluorosis and slight fluorosis areas $t = 0.110$, $p > 0.05$.
** comparing the medium and severe fluorosis areas $t = 0.367$, $p > 0.05$.
*** comparing the severe and medium fluorosis areas, and the slight and non-fluorosis areas $t = 5.922$, $p < 0.01$.

Table 3. The distribution of child IQ scores from areas of differing fluorosis prevalence

Fluorosis status of area	IQ <70	IQ 70-79	IQ 80-89	IQ 90-109	IQ 110-119	IQ 120-129	IQ >129
Non	2.6%	9.7%	37.1%	46.8%	3.9%	0.8%	0
Slight	3.1%	15.9%	29.1%	47.1%	3.1%	1.3%	<0.4
Medium	25.4%	23.7%	29.9%	20.5%	0.4%	0	0
Severe	20.9%	26.6%	26.9%	25.2%	0.4%	0	0

Table 4. IQs of children of different ages from areas differing in the prevalence of fluorosis

	IQ (mean±SD) of children from areas in which the fluorosis prevalence was:			
Age in years[b]	non-fluorosis[c]	slight	medium[d]	severe
8.0 - 8.49	86.1±11.4	90.7 ± 9.7	78.9±13.9	83.8±14.4
8.5 - 8.99	88.9±13.9	87.2±20.2	79.8±10.0	80.2±15.1
9.0 - 9.49[a]	91.1±11.2	92.6±11.1	78.7±14.6	82.1±14.1
9.5 - 9.99	86.3±11.3	88.7±12.6	75.8±15.6	81.9±15.2
10.0-10.49[a]	88.4 ± 8.6	92.0±13.9	81.1±13.5	82.9 ± 9.0
10.5-10.99[a]	90.6 ± 9.1	91.7±12.6	75.5 ± 9.2	79.6±10.5
11.0-11.49[a]	92.2±13.1	86.7 ± 9.8	77.3±11.8	75.9±12.3
11.5-11.99[a]	91.7 ± 9.5	90.1±13.4	78.4±13.5	79.6±13.5
12.0-12.49	87.4 ± 5.9	86.8±10.4	85.9±12.8	76.9±14.3
12.5-12.99[a]	93.2 ± 5.7	86.6±10.2	85.5 ± 9.5	77.1±12.6
13.0-13.49[a]	93.8 ± 9.5	94.3±12.7	85.5±10.6	83.1±10.4

[a] comparing non-fluorosis and slight fluorosis areas, and medium and severe fluorosis areas $t = 1.945$-4.81, $p < 0.05$. For other age groups comparisons were not significant.
[b] comparing the IQ for one age group with that for other age groups in the same area, no significant differences were found $t = 0.03$-1.70, $p > 0.05$. No trend was found indicating that the IQ became lower as the time spent in a high fluorosis area increased.
[c] comparing non-fluorosis and slight fluorosis areas, no significant difference was found.
[d] comparing the medium and severe fluorosis areas, no significant difference was found.

Table 5. The IQs of boys and girls aged 8-13 from areas of differing fluorosis prevalence

	IQ (mean±SD) of children living in areas in which the prevalence of fluorosis was:			
	non-fluorosis	slight	medium	severe
Boys *	89.3±0.82 (n=148)	89.8±1.10 (n=139)	81.2±1.07 (n=132)	80.6±1.06 (n=151)
Girls	91.0±1.26 (n=78)	89.4±1.30 (n=88)	77.6±1.33 (n=92)	79.8±1.44 (n=79)

*comparing boys and girls in each of the areas differing in fluorosis prevalence p>0.5 (Standards established for the test show no significant difference between the sexes[4])

growth of the nervous system is most rapid. A higher concentration of fluoride has been found in embryonic brain tissue obtained from termination of pregnancy operations in areas where fluorosis due to coal burning was prevalent.[5-6] Stereological and ultramicroscopic study of this tissue showed the differentiation of brain nerve cells was poor, and brain development was delayed. This suggests that developing brain tissues are sensitive to the toxic effects of fluoride.

The findings in the present study suggest that in areas with a medium or severe prevalence of fluorosis, active and comprehensive measures should be taken to reduce the fluoride intake for the population, especially in pregnant women and infants. Avoiding a high intake of fluoride is seen to be a important factor in determining the quality of health enjoyed by communities.

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