INTELLIGENCE QUOTIENTS OF 12–14 YEAR OLD SCHOOL CHILDREN IN A HIGH AND A LOW FLUORIDE VILLAGE IN INDIA

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SUMMARY: The aim of this preliminary study was to compare the intelligence quotient (IQ) scores of 12–14 year old school children living in a high fluoride (F) village with the IQ scores of a similar group of children in a low F village in the Davangere district, Karnataka, India. Sixty-five children from the one high school in the low F water village of Ajjihalli (F = 0.29 ppm) and 68 children from the one high school in the high F village of Holesirigere (F = 2.45 ppm) were selected by convenience sampling. Water F levels were estimated by the F ion selective electrode method. IQ scores were measured using Raven's Standard Progressive Matrices test. Chi-square and Z tests were used for statistical analysis of data. In the high F village of Holesirigere the mean IQ score of the 68 children was lower (86.3±12.8) than in the low F village of Ajjihalli, where the mean IQ score of 65 children was higher (88.8±15.3), but the difference was not statistically significant (p = 0.30) The number of children with IQ scores < 90 was 43/68 (63.2%) in high F Holesirigere and 31/65 (47.7%) in low F Ajjihalli, a difference that is nearly but not quite statistically significant (p = 0.06). The trend was toward lower IQ with high F water, even though these preliminary findings indicated that the F level in the drinking water was not significantly associated with IQ scores of 12–14 year old children in the high and low F villages.

Keywords: Davangere district; High fluoride village; Intelligence quotient; Karnataka state; India; Low fluoride village; School children.

INTRODUCTION

Among various biological effects associated with fluoride (F), disturbances of normal neurological functions of the central nervous system are of great concern. F can penetrate the foetal blood brain barrier and accumulate in cerebral tissue before birth, thereby affecting intelligence.[1] Human studies conducted in different parts of China have indicated an association between high levels of drinking water F and a lower IQ in children.[2] In India children in high F areas have been found to have low IQ, deaf mutism, genu valgum, and genu varum.[3]

With the existence of widespread endemic fluorosis in India, the possible adverse effect of elevated F in drinking water on the IQ level of children is a potentially serious public health problem. Davangere district in Karnataka state, India, is considered to be naturally fluoridated area according to studies conducted by the Rajeev Gandhi National Drinking Water Mission, New Delhi.[4] Hence it provides what would appear to be an ideal locale to investigate the relationship between F level in drinking water and IQ of children. Since a review of the scientific literature indicated a relative scarcity of such studies in this region of

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India, a preliminary study was conducted to compare IQ scores of 12–14 year old schoolchildren living in a high and a low F village in this part of India.

MATERIALS AND METHODS

The study was a cross-sectional comparison of the IQ scores of 12–14 year old school children living in the two villages Ajjihalli and Holesirigere in the Davanagere district of Karnataka, India. The plan of the study was reviewed and approved by the Institutional Ethical Committee. The selection of the two villages was based on difference in the level of F in the drinking water as reported by Chandrashekhar.[4] Both the villages had one high school each and had a common and stable public drinking water supply. The bore wells in the two villages were at least 12 years old according to the information supplied by the governing body of each village. The F content in drinking water was estimated by F ion Selective Electrode method. The low F village of Ajjihalli had a F level of 0.29 mg/L, and the high F village of Holesirigere had a F level of 2.45 mg/L.

As finally carried out, the study involved 133 children aged 12 to 14 years attending the government schools in the two villages. Permission was obtained from the school authorities and the parents to include the children in the study. The sampling methodology adopted was convenience sampling. Initially, 88 children in the low F village and 83 children in the high F village aged 12–14 years were available and screened for selection. Out of them, 65 children (33 males and 32 females) from the low F village Ajjihalli and 68 children (36 males and 32 females) from the high F village Holesirigere satisfied the criteria and were selected. Children who were continuous residents of the village since birth and children drinking water from the same public water supply were included in the study. All the children selected from each village were from the same high school. Children with a history of trauma or injury to the head, those affected by congenital or acquired neurological disorders, and psychological disorders, and, children who were absent on the day of survey were excluded from the study.

Data for each child's age, gender, duration of residency in the village, source of drinking water, and duration of using the water from that source were recorded on a specially designed form. The IQ of the children was measured using the Standard Progressive Matrices test (SPM) prepared by John C Raven.[5] Prior to administering the test, an explanation of the nature of the test and instructions were given to the children regarding the method of writing answers in the record form. The test was administered to each child in the study sample in groups of 20–23 in the school classroom under the supervision of the investigator. No chance for copying was allowed.

RESULTS

The test results were analyzed using chi-square test and 'Z' test. A p value of less than 0.05 was set for statistical significance. The mean IQ of children from high F village Holesirigere was slightly lower (86.3±12.8) when compared to the mean IQ of children from low F village Ajjihalli (88.8±15.3). But the difference between the means was not statistically significant ($Z = 1.03$, $p = 0.30$, NS) (Table 1).

Table 1. Distribution of IQ scores of 12–14 year old children in the low and high F villages

Village	No. of children	IQ 120–129 (superior)	IQ 110–119 (above average)	IQ 90–109 (average)	IQ 70–89 (below average)	IQ <70 (low)	Mean IQ (± SD)
Low F village (Ajjihalli)	65	1 (1.5%)	2 (3.1%)	31 (47.7%)	23 (35.4%)	8 (12.3%)	88.8 ± 15.3
High F village (Holesirigere)	68	0	2 (2.9%)	23 (33.8%)	38 (55.9%)	5 (7.4%)	86.3[a] ± 12.8

[a]Z = 1.03, p = 0.30 (not significant).

In the high F village, the proportion of children with IQ below 90, i.e., below average IQ, was larger (43/68 or 63.2%) compared to the low F village (31/65 or 47.7%), but the difference was not quite statistically significant (χ^2 = 3.25, p = 0.06, NS) (Table 2).

Table 2. Number of children age 12–14 with IQ<90 and IQ≥90 in the low and high F villages

Village	Children with IQ<90 N (%)	Children with IQ≥90 N (%)
Low F village (Ajjihalli)	31 (47.7%)	34 (52.3%)
High F village (Holesirigere)	43 (63.2%)	25[a] (36.8%)

[a]χ^2 = 3.25, p = 0.06 (not significant).

DISCUSSION

As a preliminary study, the non-significant IQ differences reported between the high and the low F village should be viewed as tentative. Thus, although there was no statistically significant difference in the mean IQ scores of 133 children from the low and high F villages, it contrasts with the results of other studies, mostly in China and one from India, where significantly lower IQ scores correlate with higher F levels in the drinking water.[1,2,6-10] Though there was a trend in our study towards lower IQ in a greater number of children from high F village Holesirigere than in the low F village Ajjihalli, probably the small sample size of the present study failed to establish a statistically significant difference. The application of IQ tests to older children, i.e., at age 12–14, as opposed to younger, 6–8 year old children may thus result in smaller, non-significant differences in IQ scores in the older children.

A principal basis for reduced intelligence in children exposed to high levels of F is the ability of F to cross the blood brain barrier, producing biochemical and functional impairment of the nervous system during prenatal and development periods of infancy and childhood.[2] IQ, however, is known to be influenced by many factors including differences in biological susceptibility, environmental conditions, and measurement errors.[11] Variables like nutrition, prenatal care, breast feeding, stimulating environment, parental IQ, endemic iodine deficiency,[12] freedom from disease, physical trauma, good schooling, and maternal exposure to F during pregnancy play a large role in determining IQ development. F in drinking water is therefore just one among these several environmental factors affecting the IQ of children.

In the present study, with the exception of factors like exposure to school environment, and freedom from physical trauma, the possible effects of the above confounding factors including the parental education and socio-economic differences between the villages were not taken into consideration. Consequently, explaining the IQ of children solely according to the effects of exposure to high or low F water is not possible.

The SPM test by Raven used to measure IQ of children[5] is a ‘culture-fair’ test which is suitable to compare people with respect to their immediate capacities for observation and clear thinking.[5] Though SPM test was designed to cover the widest possible range of mental ability, several possible shortcomings of the test need to be considered. The scores represent relative intelligence, not absolute intelligence.[5] Intelligence is an encompassing term that includes attributes such as creativity, persistent curiosity, logical reasoning, problem-solving skill, critical thinking, and adaptation. These different aspects of intelligence are independent of one another.

The SPM test measures only observation, clear thinking, and logical reasoning and hence it is a poor indicator of other attributes of intelligence.[5] One cannot get a balanced picture of an individual from the IQ test since other categories of IQ are not considered.

Apart from the shortcomings of the IQ test itself, other factors like emotional tension, anxiety, and unfamiliarity with the testing process can also greatly affect test performances. Considering these factors and the fact that this was a preliminary study done on a small scale, further investigation to clarify the nature of the relationship between fluoride and intelligence are clearly desirable.

CONCLUSION

The findings of this preliminary study showed that F level in drinking water was not significantly associated with IQ level of 12–14 year old school children in a high and a low F village of the Davangere district, Karnataka, India. However, if systematically conducted large scale longitudinal studies prove that excess F in drinking water can adversely affect intelligence, then comprehensive measures should be taken to reduce the exposure to excess F among pregnant women and children in endemic F areas.

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REFERENCES

1 Zhao LB, Liang GH Liang, Zhang DN, W XR. Effect of a high fluoride water supply on children's intelligence. Fluoride 1996;29(4):190-2.
2 Xiang Q, 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.
3 Susheela AK, Bhatnagar M, Vig K, Mondal NK. Excess fluoride ingestion and thyroid hormone derangements in children living in Delhi, India. Fluoride 2005;38(2):98-108.
4 Chandrashekar J, Anuradhan KP. Prevalence of dental fluorosis in rural areas of Davangere, India. Int Dent J 2004;54(5):235-9.
5 Raven JC, Court JH, Raven J. Manual for Raven's Progressive Matrices and Vocabulary Scales. Section 3: Standard Progressive Matrices. London: HK Lewis and Co; 1977.
6 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);74-78.
7 Li XS, Zhi JL, Gao RO. Effect of fluoride exposure on intelligence in children. Fluoride 1995;28(4):189-92.
8 Seraj B, Shahrabi M, Falahzade. Effect of high fluoride concentration in drinking water on children's intelligence. J Dent Med 2007;19(2):80-6.
9 Trivedi MH, Verma RJ, Chinoy NJ. Effect of high fluoride water on intelligence of school children in India. Fluoride 2007;40(3):178-83.
10 Ren D, Li K, Lin D. A study of the intellectual ability of 8-14 year-old children in high fluoride, low iodine areas. Fluoride 2008;41(4):319-20.
11 Wikipedia, the free encyclopedia. Intelligence [article on the Internet]. San Francisco, CA, USA. [cited 2010 Nov 20]. Available from: http://en.wikipedia.org/wiki/Intelligence.
12 Wikipedia, the free encyclopedia. Intelligence Quotient [article on the Internet]. San Francisco, CA, USA. [cited 2010 Oct 21]. Available from http://en.wikipedia.org/wiki/Intelligence_Quotient.