INVESTIGATION OF INTELLIGENCE QUOTIENT IN 9–12-YEAR-OLD CHILDREN EXPOSED TO HIGH- AND LOW-DRINKING WATER FLUORIDE IN WEST AZERBAIJAN PROVINCE, IRAN

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SUMMARY: In order to investigate the relationship between fluoride (F) in drinking water and children's intelligence quotient (IQ), 39 9–12-year-old children in West Azerbaijan, were selected and their IQ measured using the Iranian version of the RB Cattell test. The study cases were 19 children living in a high-drinking water F region (3.94 mg F/L), and the control group was 20 children in a low-drinking water F region (0.25 mg F/L). The results showed that, the mean IQ of children living in the high-drinking water F region was lower (81.21±16.17) than that of children in the low-drinking water F region (104.25±20.73, p=0.0004). There is a significant linear trend for children in the high-drinking water F region to have a lower IQ (p=0.0067).

Keywords: Fluoride in drinking water; Intelligence Quotient; Iran; RB Cattell test; West Azerbaijan, Iran.

INTRODUCTION

For most individuals, the source of greatest exposure to fluoride (F), a recognized developmental neurotoxin,[1] is drinking water with other exposure sources including food, dental products, and pesticides.[2] The World Health Organization has set a guideline value for the upper limit of F in drinking water of 1.5 mg/L.[3] F is not an essential trace element and is not required for the development of healthy teeth and bones. In humans, effects on thyroid function were associated with F exposures of 0.05–0.13 mg/kg bw/day when iodine intake was adequate and 0.01–0.03 mg/kg bw/day when iodine intake was inadequate.[4] Many studies show that exposure to high levels of F in water may decrease IQ scores in children.[5-10] Animal investigations have shown that exposure to high levels of F in drinking water results in structural and functional damages to nervous system.[11-13] In some regions of Iran the concentration of F in drinking water exceeds the upper limit of 1.5 mg/L. Several recent Iranian investigations have been done on the levels and effects of F in water, food, tea, and air.[14-21] In the present study, the effect on the Intelligence Quotient (IQ) of children in two similar rural communities of Azerbaijan Province in Iran drinking water with high and low levels of F was investigated.

MATERIAL AND METHODS

The two rural areas studied had very similar population, educational, economic, social, cultural, and general demographic characteristics but differed in the concentration of F in drinking water. For the determination of F concentration,

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water samples were collected from drinking water supplies (wells and springs) in the two study regions.

The F levels in the water samples were determined by SPADNS (sulfo phenyl azo dihydroxy naphthalene disulfonic acid) colorimetric method in the chemistry laboratory in the Department of Environmental Health Engineering in Tehran University of Medical Sciences.

The location of the two regions is shown in Figure 1.

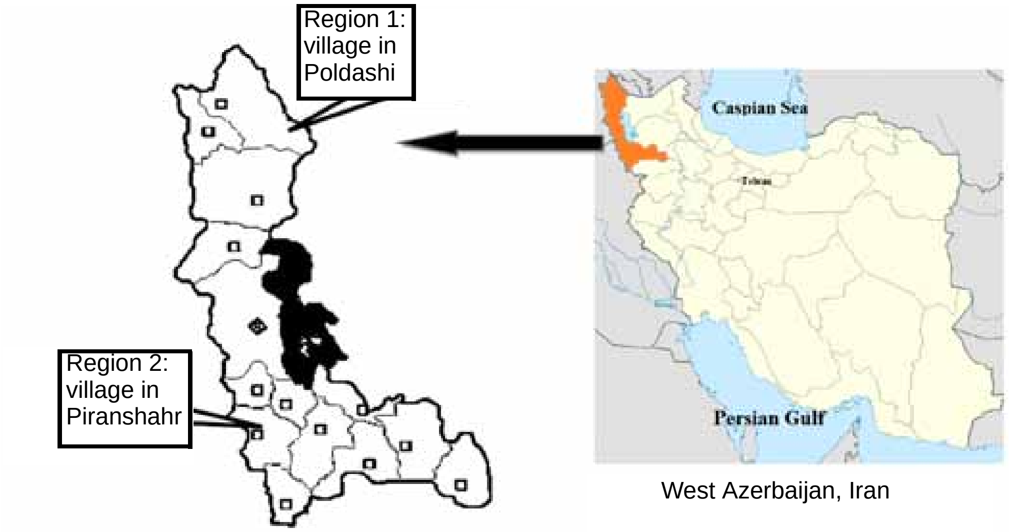

Figure 1. Location of the two study regions in Poldashi and Piranshahr, West Azerbaijan, Iran.

The sample comprised 39 male children, aged 9–12 years, residing in two villages of west Azerbaijan province in Iran. By a random sampling method, 19 children were selected from the high-F region with 3.94 mg/L of F in the drinking water and 20 children were chosen from the low-F region with a drinking water F level of 0.25 mg/L. Questionnaires were completed by the parents to measure potential confounding factors involving educational, economic, social, cultural, and general demographic characteristics. Children with mental retardation, neurological disorders, and congenital or acquired diseases of the nervous system were excluded.

IQ measurement: After the consultation with the Psychometric Laboratory in the Faculty of Psychology and Educational Sciences, University of Tehran, the Iranian version of the Raymond B Cattell test (RB Cattell, scale 2-A for children age 8–13 years) was chosen to measure IQ. The test included 46 questions in 4 parts; 12 in part 1, 14 in part 2, 12 in part 3, and 8 in part 4. The questionnaires were completed by the children after receiving instructions from a teacher and an examiner. The IQ scores were classified in seven categories: <70 retarded (low); 70–79 borderline (below average); 80–89 dull normal (low average); 90–109 normal (average); 110–119 bright normal (high average); 120–129 superior (good); and >129 very superior (excellent). The children's IQs were calculated and the data analyzed with SPSS version 16 software (mean±SD) and GraphPad InStat™, version 3.10 (unpaired t test and chi-squared testing).

RESULTS

The IQ of the 19 children in the high-F region was lower (mean±SD: 81.21±16.17), than that of the 20 children in the low-F region (mean±SD: 104.25±20.73, p=0.0004, Table 1).

Table 1. Comparison of the mean IQ scores of the children in the low- and high-fluoride regions. (Region in West Azebaijan province: LFR=low-fluoride region; HFR=high-fluoride region)

Region	Drinking water F (mg/L)	No. of children	Mean age (years)	IQ level		
				Mean±SD	SE of mean	95% CI
LFR	0.25	20	10.89	104.25±20.73	4.64	94.55–113.95
HFR	3.94	19	10.47	81.21±16.17*	3.71	73.42–89.00

Compared to the low-fluoride region: *p=0.0004 (Unpaired t test, t=3.856 with 37 degrees of freedom; The t test assumes that the data comes from populations with equal SDs; The Kolmogorov and Smirnov assumption test suggests that the difference between the two SDs is not significant; F=1.644, p=0.2974).

In the high-F region, 57.8% had scores indicating mental retardation (IQ <70) or borderline intelligence (IQ 70–79), while this figure was only 10% in the low–F region (Table 2).

Table 2. Distribution of the mean IQ scores of the children in the low- and high-fluoride regions

IQ classification		Low-fluoride region		High-fluoride region	
		Number	Percent	Number	Percent
IQ <70	retarded (low)	1	5%	3[*,†]	15.8%
IQ 70-79	borderline (below average)	1	5%	8[*,†]	42%
IQ 80-89	dull normal (low average)	2	10%	2[*,†]	10.5%
IQ 90-109	normal (average)	7	35%	4[*,†]	21.1%
IQ 110-119	bright normal (high average)	2	10%	1[*,†]	5.3%
IQ 120-129	superior (good)	4	20%	1[*,†]	5.3%
IQ >129	very superior (excellent)	3	15%	0[*,†]	0%

IQ<70–89, IQ90–109, and IQ110–>129 groups compared to the low-fluoride region: *p=0.0067 (Chi-squared test for independence, Chi-squared=10.018 with 2 degrees of freedom; The variables of IQ and fluoride status are significantly associated); †p=0.0019 (Chi-squared test for trend, Chi-squared for trend=9.644 with 1 degree of freedom; There is a significant linear trend for children in the high-fluoride region to have a lower IQ).

Forty-five percent of the children in the low-F region scored as being of normal or bright normal intelligence compared to only 26.4% in the high-F area of West Azerbaijan. Fifteen percent of the students in the low-F region were in the very superior category (IQ>129) while none of the children in the high-F region were so classified. The data indicated that living in a high-F region was associated with a lower IQ (p=0.0067, Table 2 and Figure 2).

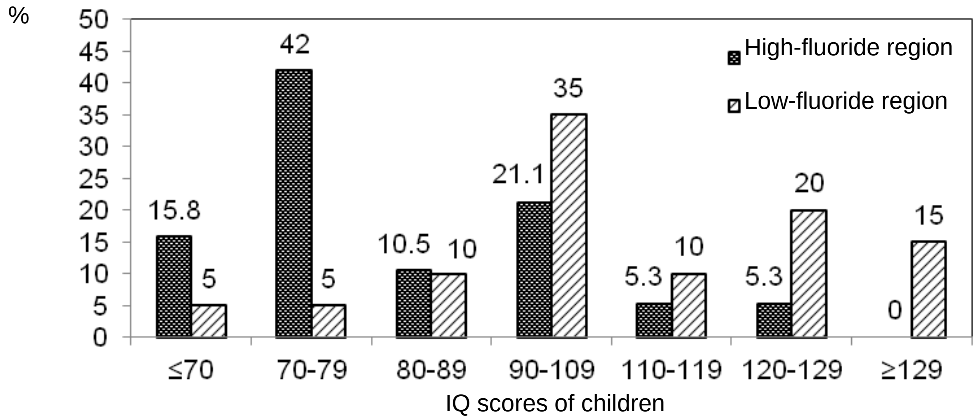

Figure 2. The percentage distribution of IQ in children in the high- and low-fluoride regions.

No significant differences were found in the potential confounding factors of educational, economic, social, cultural, and general demographic characteristics between the high- and low-F regions.

DISCUSSION

The study found that children residing in a region with a high drinking water F level had lower IQs compared to children living in a low drinking water F region (p<0.001). The differences could not be attributed to confounding educational, economic, social, cultural, and general demographic factors.

In similar research, Liu et al.[22] found that children living in a high-F region had a significantly greater incidence of borderline and lower IQs than children living in a low-F region (p<0.01). Similarly, Chen et al.[7] observed a significantly lower average IQ score in children living in high-F region compared to children living in a low-F region. Seraj et al.[23] showed that when children lived in regions with higher than normal water F concentrations they had lower IQs. Consistent with these studies, we found the percentages of students in the retarded, borderline and dull normal categories were higher in the high-F region than in children in the low-F region. Thus, children's intelligence may be affected by high water F levels.

One mechanism for the adverse effect of F on brain development is the ability of F to interfere with the activity of the thyroid gland.[24,25] Exposure to high doses of F may also result in dental fluorosis, skeletal fluorosis, increased rates of bone fractures, decreased birth rates, and increased rates of urolithiasis (kidney stones).[25] When ingested during pregnancy, F can affect the human fetus, by passing through the placenta and entering the organs and tissues of the fetus.[26]

Because F has the potential to be toxic to many organ systems, further toxicity studies need to be done. If the F concentration in a community's water supply is significantly above the permissible level of 1.5 mg/L, it is essential to evaluate the situation and control the drinking water F level. Using a hybrid sorbent resin is one of the options that is effective for removing F from drinking water.[27]

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