

RESEARCH ARTICLE

ASSOCIATION BETWEEN FLUORIDE WATER AND INTELLIGENCE AMONG SCHOOL CHILDREN – NILE EAST LOCALITY -SUDAN (2015-2018)

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ABSTRACT

Long-term ingestion of large amounts of fluoride can lead to potentially severe skeletal problems and neurological consequences. This is an analytical cross sectional study conducted to evaluate the relationship between exposure to different drinking water fluoride levels and children's Intelligence Quotient (IQ) among school children in Nile East Locality-Sudan, convenient sampling strategy was utilized to include all the students aged 9–14 years presented on the day of examination from high and low fluoride areas. Sample of 197 school children from the two area were selected after fulfillment of inclusion criteria,(low fluoride area 89 and high fluoride area 108).Data collected by questionnaire and Raven's standard progressive matrices scale which was amended on Sudanese environment for assessment of Intelligence Quotient (IQ). Data was analyzed by using Statistical Packages for Social Sciences (SPSS) Appraisal of the Intelligence Quotient levels among the two groups (low and high-fluoride areas) showed a highly significant statistical association p value (0.001) the mean Intelligence Quotient in low fluoride area 95.02compering with high fluoride area 86.9. In comparison of the Intelligence Quotient scores of children in high and low area, only 1.1% of children were present in Grade 6 (definitely Excellent)in high fluoride area and 3.7% in low fluoride area. In addition, 5 (4.6%) in the low fluoride area in border line Intelligence Quotient in contrast to 17 (19.1%) in the high fluoride areas. Findings of the study concluded that the overall Intelligence Quotient levels in children's exposed to high fluoride level were significantly lower than the low fluoride areas and recommended that Further studies should be done to understand how toxic of fluoride can interfere with brain development.

Keywords: Drinking water, Developmental difficulties, Learning impairment, Childhood.

INTRODUCTION

Fluorine is the 13th most abundant naturally occurring element in the Earth's crust and is the lightest member of the halogens. It is the most electronegative and reactive of all elements, and is present as fluoride in drinking water. It occurs as fluoride naturally in soils and natural waters due to chemical weathering of some fluoride containing minerals (1). Around 200 million people of 29 countries in the world are severely affected due to fluoride pollution. Ingestion of fluoride beyond the World Health Organization recommended maximum permissible level (1.5 mg/l) is associated with dental and skeletal fluorosis and other toxic responses while lacking of fluoride intake is associated with dental caries (2). Fluoride is the chemical added to water that doesn't actually treat the water. Chlorine, for example, is added to kill bacteria so that we can drink the water without getting sick. Fluoride, by contrast, is added to prevent a disease (tooth decay) that is not caused by drinking water. Elevated concentration of naturally occurring fluoride (F) in drinking water and its health consequences are a worldwide problem. Many Asian and Latin American, countries have reported concentrations of F often exceeding the World Health Organization (WHO) guideline values of 1.5mg/L or their prevailing national standards (3).Drinking water is usually, but not always, the main source of fluoride (4). Even intelligence quotient (IQ) has been associated with exposure to fluoride (5). The negative effect of fluoride on children in the high fluoride area is mainly due to disruption of proper development in the womb due to the

mother's in-take of fluoride being passed to the fetus through the placenta, or childhood in a high fluoride environment. Either or both of these could lead to neuron damage, developmental difficulties, or neurotransmitter dysfunction (6). In children, the most reported effect is on cognitive capacities, particularly intelligence reduction. Children who live in a fluorosis area were found to have five times higher odds of developing low IQ than those who live in a nonfluorosis area or a slight fluorosis area (7). Due to the substantial role that neural health plays on the individual's quality of life, numerous studies have been conducted on the effect of excess fluoride on neurological development. Most of these investigations, which support the neurotoxic effect of fluoride, have been performed in animals, demonstrating generation of free radicals and alterations in the level of neuro-transmitters in the brain. These changes may interfere with normal development of the central nervous system (CNS) during the fetal and early childhood development. This period is the most critical phase in neurobehavioral development, in which the brain is sensitive to absent or increased levels of certain elements. Any cerebral impairment in this stage of the child's growth, leads to future cognitive and intellectual deficits (8). Also, the existing literature reports the neurological consequences associated with exposure to fluoride. In children, most reported effects are on the cognitive capacities, particularly intelligence reduction (9), (10), (11). As of September 2012, a total of 42 studies have investigated the relationship between F and human intelligence, and a total of 17 studies have investigated the relationship F and learning/computer storage in animals. Of these investigations, 36 of the 42 human studies have found that elevated F exposure is linked with reduced IQ, while 16 of the 17 animal

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studies have found that F exposure impairs the learning and retention capacity of animals. The human studies, which are based on IQ examinations of over 11,000 children, provide compelling evidence that F exposure during the early years of life can damage a child's developing brain. After reviewing 27 of the human IQ studies, a team of Harvard scientists concluded that fluoride's effect on the young brain should now be a "high research priority." (12). Other reviewers have reached similar conclusions, including the prestigious National Research Council (NRC), and scientists in the Neurotoxicology Division of the Environmental Protection Agency. Therefore, the present study was conducted to assess the effect of Fluoride in drinking water on the IQ of 9–14 years old, school going children, resident in high and low Fluoride areas in East Nile locality.

MATERIALS AND METHODS

Analytic cross sectional comparative study was conducted by measuring fluoride level in drinking water and its effect in IQ of school children in both study area (high fluoride area 4mg/l and low fluoride area 1mg/l), 197 students, 9 to 14 year-old (89 child in high fluoride area and 108 low fluoride area) were selected by convenient sampling. Inclusion criteria were included: Children were continuous residents in study area since birth, drinking water from same public water supply and attending same school, socioeconomic and cultural status and educational facilities are similar their only difference is the amount of fluoride in their drinking water. Exclusive criteria were included: Genetic or congenital acquired diseases related to nervous systems in past or present. Data collected via standard Raven's Progressive Matrices to assess IQ level, which is specific to this age group. Validity and reliability of the test are approved via some studies in Sudan (13),(14). (Norms for the Standard Progressive Matrices in Khartoum State). Raven's progressive matrices are multiple choice intelligence tests of abstract reasoning, originally developed in 1936. The booklet comprises five sets (A to E) of 12 items each (e.g., A1 through A12), with items within a set becoming increasingly difficult, requiring ever greater cognitive capacity to encode and analyze information. The Raven's test was designed to minimize the biases that language difference can create to measure intelligence. The scores from children's intelligence tests were measured by the Raven's test, that psychometric properties of its Sudanese version were assessed (2001 by Alkatib and Khalifa in 2011). This version has been used for IQ tests for Sudanese children. Their intellectual ability ranking was as follows:

IQ = 70 to 79 borderlines
 IQ = 80 to 89 below average
 IQ = 90 to 109 average
 IQ = 110 to 119 above average
 IQ = 120 to 129 excellent and
 IQ > 129 out of standing.

Also questionnaire used to assess demographical data for study population

Data collection Procedure

Initially, endemic fluoride areas were recognized according to the geological research of Government of Sudan in 2014 in the national laboratory (ESTAK) Prior to start of the study, list of

all area in the Khartoum was obtained. Information about fluoride level in drinking water was obtained from the documented records of Water Management Works Khartoum. Nile East locality was selected, After that Area were categorized into low and high fluoride areas for the purpose of the study. The information on the list of Primary schools in albasher block 1 and albasher block 2 was obtained from the district education officer of the locality. Two governmental school from both area having same medium of education were selected. The intelligence quotient (IQ) measured in the children of both areas by Using IQ test Raven's standard Progressive Matrices (RSPM). Research team applied the test collectively to the examinees who were in the sample of the study and began preparing the appropriate number of paper and test sheet and ensure the existence of pencil with each pupil after that, each student was seated on a comfortable seat with table and allowed enough space between the seats of examinees to facilitate the process of monitoring performance and supervision and avoid problem of fraud (cheating). The examiner began distributing the answer papers and asked the examinees to fill the personal data. Then the examiner distributed the test sheets and asked them not to open pamphlets before they were allowed. After the examiner confirmed that all examinees had been prepared to perform the test, he began to explain how to write the answer to the answer sheet and this was done through the collective answer to question one in the first group, the examiner then confirmed that all the examinees had already recorded the answer in the right place in the answer sheet. The examiner then gave the examinees the opportunity to question and continued to explain and explain until everyone understood, the examiner asked the examinees to continue to solve the rest test questions in the same way until the end of the test sheet, with reminders that is no specific answer time. After about three minutes the examiner and supervisors passed to ensure that the examinees don't fail to fill out the personal data in the manner of recording the answer in the answer sheet, after that the examiner and supervisors stopped providing any assistance and after about half an hour, the examiner asked the examinees to left each of the test paper and inside it the answer sheet as assign that he has completed the test and finish the answer, and then the examiner and supervisors received the test booklet and the answer paper in, then the examinees went. Data were analyzed by SPSS software; t test and chi square. The finding presented as means and standard deviation. $P < 0.05$ was considered as statistically significant.

Ethical considerations

The ethical approval for the study was sought from the committee of Alzaim Alazhare University. Formal permission letter was submitted to the Nile East Locality, An official permission was obtained from the District Educational officer Nile East Locality, Written permission was sought from the school offices. The parents of children included in this study was informed about the objective and the need of this study and verbal informed consent was obtained from each parent. Privacy was protected, data was collected in private place and Information yield from present study is kept confidential. only responsible team (candidate and supervisor) have access to it. The questionnaire contained the definition of the child but it was converted to code so that we maintain the confidentiality of the data, this code is known only by the candidate and supervisor.

RESULTS

Based on fluoride concentration level in drinking water two areas were assigned into - low, and high fluoride (1 mg/d 4mg/respectively). Total number of Childers is 197. The distribution of male and female children among areas, in low fluoride concentration area, 41.7% of the study participants were males and 58.3% were females and in high fluoride concentration area, 49.4% were males and 50.6% were females. Most of the parents were illiterate or read up till primary level. The mean IQ level of study participants based on fluoride concentration in the area with low fluoride concentration in drinking water (95.02) compared to areas with high fluoride concentration (86.92), a highly significant statistical association was found p value (0.001). Table (2) shows the IQ grades of the children in areas with low and high fluoride concentration in drinking water. In high fluoride areas, percentage of children with low average IQ, (grade VII, VI,V) was (66.2%) compared to low fluoride areas (33.5%), student in average, grade (IV, III) in high fluoride areas(31.7%) compared to low fluoride areas (63.9%). excellent(grade II,I) in high fluoride areas(1.1%) compared to low fluoride areas (4.6%) and the difference was statistically significant (P < 0.001).

Table 1. Comparison of the mean IQ scores of children in low and high fluoride area

Study area	Number of population	Mean	Std. Deviation	P. value
Square1 (fluoride 4 mg/dl)	89	86.92	11.72	0.001
Square2 (fluoride 1 mg/dl)	108	95.02	12.16	

Table 2. Distribution of IQ scores for children in the high and low fluoride area

IQ score	Address		Total	P value
	Square1 (fluoride 4 mg/dl)	Square1 (fluoride 1 mg/dl)		
low	6 (6.7%)	2 (1.9%)	8 (4.1%)	0.001
Border line	17 (19.1%)	5 (4.6%)	22 (11.2%)	
Below average	36 (40.4%)	27 (25.0%)	63 (32.0%)	
Average	26 (29.2%)	61 (56.5%)	87 (44.2%)	
Above average	3 (3.4%)	8 (7.4%)	11 (5.6%)	
Excellent	1 (1.1%)	4 (3.7%)	5 (2.5%)	
Out standing	0 (0%)	1 (0.9%)	1 (0.5%)	
Total	89 (100.0%)	108 (100.0%)	197 (100.0%)	

DISCUSSION

This study was conducted with an afford to assess the relation between exposures to different drinking water fluoride levels and children's intelligence quotient (IQ) among 9-14 year old school going children of Nile East Locality-Sudan Total number of students is 197 student, numbers of male 89 and female 108 student. The present study revealed a positive relation of IQ with fluoride in drinking water. Many literatures conducted (15), (16), (17), (18), have shown that exposure to high levels of fluoride in drinking water associate with deficits towards children's intelligence. These results were mainly illustrated by comparing mean IQ scores in different exposure groups that were selected based on fluoride concentrations in drinking water. This designates that early and long-term

contact to excess F (fluoride) causes deficits in memory attention, which was contrary to the results of (19),(20),(21). who concluded that F level in drinking water was not significantly associated with IQ levels of 12-14 years old school children in a high and low F village of Davangere, Karnataka, India. However, on other side, studies on human fetuses have already shown that developing brain is the ripest targets for disruption by fluoride poisoning. Given that, at early stages of life, i.e. before the age of 6 years, the human brain is in its fastest stage of development, and that around seven and eight basic structural development is completed, therefore, the brain is most vulnerable to damage from excess F intake before this age (22). The functional and biochemical harm to the nervous system during the prenatal and development periods of infancy and childhood because fluoride can cross the blood brain barrier leading to lack of IQ in children exposed to high levels of fluoride is mainly; however, it is also due to factors involving variation in biological susceptibility, environmental conditions, and measurement errors. (20). Also, it can pass through the placenta to the fetus (7), (23). 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 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. 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. (24). In addition with subsequent continuous exposure to fluoride during childhood, it may have adverse effects on the developing brain, thereby causing decreased intelligence in children (7). The biomechanism of the action of fluoride in reducing intelligence is still not clear. However, there is evidence that it may involve the alteration of the membrane lipid and cause a reduction in the cholinesterase activity in the brain. This may lead to altered utilization of acetylcholine, affecting the transmission of nerve impulses in the brain tissue. (25), (26). NaF has been found to alter the levels of dopamine, serotonin, 5-hydroxyindoleacetic acid, homovanille acid, norepinephrine, and epinephrine, in the hippocampus and neocortex regions of the rat brain. demonstrated changes in neurotransmitters and their receptors in the fetal brain from the endemic fluorosis area (27). Thyroid hormones play an important role in the development of the brain. In a study, Susheela et al. found that elevated fluoride uptake may cause iodine deficiency in fluorotic individuals, even when they reside in non-iodine deficient areas (28). This study showed that the proportion of the children ranked in the ranges of average, above average and excellent were higher in low- fluoride area than the students in the same ranks in high fluoride area, These results are similar to the studies done by Poureslami *et al.* 2011 In addition, The proportion of the children ranked in the ranges of below average and borderline were higher in high fluoride area than those in low- fluoride area, and These results are similar to the studies done (29). These findings support the idea of the influence of high fluoride on the intellectual ability.

Conclusion

The data from this current study can support the hypothesis that excess F in drinking water has a neurological toxic effect.

Therefore, a close observation of the fluoride levels in local water supplies of areas with recorded endemic fluorosis and implementing preventive public health measures to reduce the fluoride exposure levels seem necessary; because intelligence of child is not of concern just to the parents or teachers, but to the individual child itself to carry-on a life of quality and productivity.

Recommendation

- Suggestion new research to understand how toxic of fluoride can interfere with brain development and how best to prevent long-term dysfunctions and deficits.
- Promote policy development aimed at protecting vulnerable populations against Chemicals those are toxic to the brain.

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