EFFECT OF FLUORIDE EXPOSURE THROUGH DRINKING WATER ON THE ORAL HEALTH STATUS AND INTELLIGENCE PROFILE OF SCHOOL CHILDREN OF DISTRICT UNA, HIMACHAL PRADESH: AN INTERIM ANALYSIS

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ABSTRACT

BACKGROUND

This interim analysis of an ongoing project aims to study the association of fluoride levels with dental fluorosis and intelligence among children of 10-14 years of age in study area.

MATERIALS AND METHODS

The study was conducted in randomly selected 15 government high schools of District Una, Himachal Pradesh. The analysis of seven schools is being discussed with a sample size of 270. Dean's Fluorosis index was used to study fluorosis level and Intelligence test was conducted on students by using Raven's standard progressive matrices questionnaire.

Study Duration-Nine months.

RESULTS

Dental fluorosis was observed among 11.5% of students. It was higher among females (12.4%) as compared to males (10.6%). The intelligence level assessment of student showed that all of them were in the range of above average; about 83.3% of students were having grade III (Average) level of intelligence.

CONCLUSION

As the fluorosis level increased, the proportion of children with lower intelligence increased. Based on the findings, the chronic exposure to high levels of fluoride can be one of the factors that influence intellectual development.

KEYWORDS

Fluorosis, Intelligence Quotient, Adolescents.

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BACKGROUND

Fluorine is an important element in growth of teeth and prevents the enamel from dissolving under acidic conditions. Drinking water and sea food are good sources of Fluoride. Fluoride is beneficial to health if the concentration (CF) of the fluoride ion (F-) in drinking water is less than 1.5 mg/L. Ingestion of excess fluoride, most commonly in drinking-water, can cause fluorosis which affects the teeth and bones. Moderate amounts lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems. Paradoxically, low levels of fluoride intake helps to prevent dental caries. The control of drinking-water quality is therefore critical in preventing fluorosis. World Health Organization (WHO) has set the upper limit of fluoride

concentration in drinking water at 1.5 mg/L and in India the maximum permissible limit is 1 mg/L.¹

Known fluoride belts on land include: one that stretches from Syria through Jordan, Egypt, Libya, Algeria, Sudan and Kenya, and another that stretches from Turkey through Iraq, Iran, Afghanistan, India, northern Thailand and China. There are similar belts in the Americas and Japan. In these areas fluorosis has been reported.² The available data suggest that 15 States in India are endemic for fluorosis (fluoride level in drinking water >1.5 mg/L), and about 62 million people in India suffer from dental, skeletal and non-skeletal fluorosis. Out of these; 6 million are children below the age of 14 years.³

Introduction of systemic and topical fluorides into the prevention and control of dental caries denotes the most significant issue in dentistry. In the 1980s, it was established that fluoride controls caries mainly through its topical effect.⁴ A meta-analysis of 27 cross-sectional studies of children exposed to fluoride in drinking water, mainly from China, suggests an average IQ decrement of about seven points in children exposed to raised fluoride concentrations.⁵ There is paucity of literature published from the Indian subcontinent, which shows that fluoride exposure has an effect on the intellectual function of children. Data from previous studies could lend support to the hypothesis that

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interaction between fluoride, lead and arsenic could worsen the children's intelligence grade and thus indicate a need for further investigation.⁶

There is limited evidence on fluoride levels in water level across the country and so its association with dental fluorosis and intelligence of children. In addition, the fluoride levels in water bodies differ from region to region and are not uniform. Therefore, the present study aims to map the study area (District Una, Himachal Pradesh) into high and low fluoride area. Thereafter, the association of high and low fluoride levels with dental fluorosis and intelligence among children of 10-14 years of age will be studied in study area.

MATERIALS AND METHODS

District Una is in South western part of Himachal Pradesh and is situated in east of outer Shivaliks. It lies within North latitude 31°17'52" and 31°52'0" and East longitude 75°58'2" and 76°28'25". Una district is bounded by the river Beas on the north and the river Sutlej in the east. The population of district according to census 2011 was 5,21,057 where 10-14 years of age contributed to 10.3% of population.

This is an interim analysis of an ongoing project which is being carried out in government high schools of district Una of Himachal Pradesh. There are total 42 high schools of district Una spreading over five blocks namely; Una, Amb, Haroli, Gagret, Dhundla. On an average, there are 40-50 school children of 10-14 years of age in each school and a total of 15 schools are being surveyed for the study purpose. In order to complete geographical coverage of study area, 3 schools were selected randomly (lottery method) from each of five blocks of the district (3x5=15). This interim analysis presents observations from seven schools in the period of nine months. Two schools selected from the two of the blocks and one each from the remaining three.

To detect 40.0% prevalence of malocclusion and 60.0% of prevalence of dental fluorosis, considering 1.5 relative risk⁷ at 95.0% confidence level and 80.0% study power, a sample size of 369 children is calculated. Based on 10.0% non-response, 405 children of age 10-14 years are being screened for oral hygiene, malocclusion and dental fluorosis. In order to keep reliable and relevant estimate, a sample size of 600 school children will be kept. These children are selected from all the government high schools based upon population proportion to size.

In the current analysis, data on 270 school children within the age group of 10-14 years from last six months (March through August 2016) studying at the selected government schools of study area were available. Prior consent was taken from all the school authorities and the parents of the children to conduct the survey. Those who did not consent to participate and children who are not enrolled in the school for the last 5-8 years were excluded from the analysis. Also, children who have a history of congenital or acquired neurological disorder or head injury were excluded from the analysis.

To assess the prevalence of fluorosis we used Dean's Fluorosis index.⁸ The dental checkup was performed by a dentist (Principal investigator) and his team which consisted of a medical social worker, and a health worker. The schools were mostly visited on Saturdays after taking appointment with the Principal as the students had more of free classes on this day of week. The four classes of the school (5th-8th) were

included in the study. On an average, all the government schools included in the survey had around 15-16 children in each of the above-mentioned classes. The dentist examined all the students of these classes to achieve a sample size of 40 in each school. One school was visited twice to complete the sample size. However, taking into account child absenteeism, exclusion criteria and not consenting to participate we reached to a sample size of 270.

Intelligence test was conducted on students by using Raven's standard progressive matrices questionnaire.⁹ The children's scores were converted to percentile and specific grades were allotted, based on the following criteria:

Grade I: Intellectually superior – If the score lies at or above the ninety-fifth percentile for that age group. Grade II: Definitely above average – If the score lies at or above the seventy-fifth percentile for that age group. Grade III: Intellectually average – If the score lies between the 25th and 75th percentile for that age group. Grade IV: Definitely below average in intellectual capacity – If the score lies at or below the 25th percentile for that age group. V: Intellectually impaired – If the score lies at or below the fifth percentile for that age group. The grades and intelligence are inversely related in the Raven's Standard Progressive Matrices.

Water sample was collected from the selected schools and tested for fluoride levels. The water sample was tested with the help of ion exchange method using specific F-electrode method. In the present study area, the source of the water supply is ground water which is lifted with pump and stored in large reservoirs. This method for water supply is implemented under the state government scheme "uthao peyjal pariyojna" (lift water scheme) to the entire district. The water sample was collected from the seven schools, from where the children were recruited. Chi square and standard error of difference of proportion is used to detect significant difference for proportion.

Ethical Clearance

Protocol has been reviewed and ethical clearance has been obtained from ethical committee of Dr. R. P. Govt. Medical College, Kangra at Tanda.

RESULTS

In the interim analysis, a total of 270 children were surveyed from seven schools along with collection of water sample for fluoride level. The water sample was collected from drinking water from where children were recruited. The place of water sample collected is shown in Table 1 indicating that the water sample collection was done from the same area at the inhabitant of the selected villages. (Table 1).

Dental fluorosis was observed among 11.5% of students. Its prevalence was found to be 10.6% in males and 12.4% among females. The severity for dental fluorosis was assessed and so far no single case of severe dental fluorosis was observed. Very mild-to-moderate dental fluorosis was observed in 4.7% and 6.2% had questionable status. (Table 2).

The intelligence level assessment of student showed that all of them were in the range of grade II to grade III, about 83.3% of students were having grade III level of intelligence. The

distribution for intelligence level was observed to be statistically different in both males and females. (Table 3).

Cross tabulation for intelligence and fluorosis level was done and none of the children with grade I and grade V level of intelligence was observed. (Table 4). Neither was there any subject with severe fluorosis level. So, they are excluded from the table 4. Grade II intelligence was compared against grade III and IV level separately. Fluorosis free category included 88.7% children with average intelligence. Majority of children were having grade III level of intelligence; it was observed as a dominant category across normal (94.6%) to very mild level (60.0%) of fluorosis as compared to grade II intelligence level. The difference was statistically significant across all levels of fluorosis. Below average intelligence was observed to be higher among very mild fluorosis level (66.7%) as compared to above average level. Among the below average intelligent group, higher proportion was observed among normal fluorosis group (62.5%). No significant difference was observed between grade IV and II level of intelligence with level of fluorosis among children.

Serial. No	Place	Fluoride Content (ppm)
1	Saloh	0.57
2	Haroli	0.42
3	Lalhri	0.40
4	Mehtpur	0.68
5	KutharKalan	0.63
6	Gagret	0.41
7	Batoli	0.52

Table 1. Fluoride Content of Water Sample collected from Selected Government Schools

Fluorosis Parameter	Male N (%)	Female N (%)	All N (%)	p value
Normal (0)	126(89.3)	113(87.5)	239(88.5)	0.65
Questionable (0.5)	8(5.6)	9(6.9)	17(6.2)	0.66
Very mild (1)	4(2.8)	5(3.8)	9(3.3)	0.63
Mild (2)	2(1.4)	1(0.7)	3(1.1)	0.61
Moderate (3)	1(0.7)	1(0.7)	2 (0.3)	0.95
Severe (4)	0(0)	0(0)	0(0)	NA
Total	141 (100)	129 (100)	270 (100)	

Table 2. Severity of Dental Fluorosis in the Examined School Children

Parameter	Male N (%)	Female N (%)	All (%)	p value
Grade 1	0 (0)	0 (0)	0(0)	-
Grade 2	12 (8.5)	9 (6.9)	21 (7.7)	0.63
Grade 3	118 (83.6)	107 (82.9)	225 (83.3)	0.87
Grade 4	11 (7.8)	13 (10)	24 (8.8)	0.64
Grade 5	0 (0)	0 (0)	0 (0)	-
Total	141 (100.0)	129 (100.0)	270 (100.0)	

Table 3. Intelligence Assessment in Examined School Children

Fluorosis Level	Intelligence Level					
	Grade II N (%)	Grade III N (%)	P-value	Grade II N (%)	Grade IV N (%)	p-value
Normal	12(5.4)	212(94.6)	0.00	12(44.4)	15(55.6)	0.71
Questionable	5(38.4)	8(61.6)	0.00	5(55.6)	4(44.4)	0.54
Very mild	2(40.0)	3(60.0)	0.01	2(33.3)	4(66.7)	0.48
Mild	1(50.0)	1(50.0)	0.02	1(50.0)	1(50.0)	0.92
Moderate	1(50.0)	1(50.0)	0.02	1(100)	0	0.28
Total	21 (8.5)	225 (91.5)		21 (46.7)	24 (53.3)	

Table 4. Distribution of Intelligence Level among levels of Fluorosis of School Children

DISCUSSION

In the present study, the proportion of students with questionable fluorosis parameter is 6.2%, very mild and mild dental fluorosis as per Dean's index was 3.3% and 1.1% respectively. This estimate in our study is very less as compared to other studies done in other states of India. A higher prevalence of 91.2% was reported from the Punjab,¹⁰ 61-66.7% from Birbhum, West Bengal¹¹, 71% from Nalgonda in south¹² and 45.7% from Rajasthan.¹³ The present study did not show severe fluorosis in any of the students and only 0.2% of students had moderate fluorosis.

The prevalence among girls was more (12.4%) than boys (10.6%). Among girls, questionable parameter in 6.9%, very mild 3.8%, mild 0.7%, and severe form was noted to be nil whereas among boys, questionable 5.6%, very mild 2.8%, mild 1.4%, and severe form was again not presented by them. Moreover, this is consistent with the results of other studies conducted in Kerala, where higher prevalence was reported among girls.¹⁴ On the contrary, another study conducted among children of Tamil Nadu and Nalgonda, prevalence was reported more among boys than girls.^{12,15}

Majority of the children were in intellectually average intelligence group (grade III: 83.3%). Higher proportion of boys belonged to intellectually above average and average intelligence group as compared to girls; however, the difference was not significant. In psychology books also, gender is mentioned as a nonrelated factor to IQ. Similar results were reported by Xiang et al from China¹⁶ and Khan et al from Lucknow, ¹⁷ India. However, majority of children from Lucknow were above average intelligence (45.7%)¹⁷; however, this was conducted on relatively lower age group (6-13 years). Another similar study from Iran showed around 28% of average intelligence children (7-9 years) and 9% above average and no significant difference between male and females.¹⁸ An observation of decreasing IQ with increasing age has been discussed by Xiang et al, but reason is still not clear. Possibly, the total intake of fluoride/kg body weight per day or lifetime was the main cause, also adolescence is a sensitive period for the effect of fluoride on children's intelligence development.¹⁶ The reason for relatively lower proportion of IQ level in our study area could be due to its rural background, low socioeconomic status and nutritional status. However, these confounders have not been accounted for in this interim analysis. They will be accounted for in the final report.

In the current analysis, we compared normal and below normal intelligence with above normal across the various fluorosis levels. As the fluorosis level increased, the proportion of children with lower intelligence increased. Xiang et al also found a significant inverse concentration-response relationship between the fluoride level in drinking water and the IQ of children.¹⁶ Khan et al observed that majority of the fluorosis free children (76.3%) had an IQ grade 2,¹⁷ whereas our study reported 88.7% grade 3 children in the same group. Khan et al., also reported that with increase in the grade of fluorosis, a trend of increase in the IQ grade (decrease in intellectual capacity) was observed indicating a strong correlation between fluorosis grade.¹⁷ Saxena et al and Shivaprakash et al in their study have also demonstrated that intellectual capacity of children decreases with increase in the fluorosis grade.^{6, 19} Data from previous studies support to the hypothesis that interaction between fluoride, lead, and arsenic could worsen the children's intelligence grades,²⁰ and thus, indicate a need for further investigation. Guan et al demonstrated that the contents of phospholipids and ubiquinone are altered in the brain of rats affected by chronic fluorosis, and therefore changes in membrane lipids could be a cause of this disorder.²¹ A principal ground for reduced intelligence in human children exposed to high levels of fluoride is its ability to cross the blood brain barrier, producing biochemical and functional impairment of the nervous system during prenatal and development periods of early childhood and childhood. IQ, however, is known to be influenced by many factors, including differences in biological susceptibility, environmental conditions, and measurement errors.²² Our study area lies in the foothills of Dhauladhar ranges, which are endemic for hypothyroidism. In a low iodine area, impairment of intelligence could occur through the development of hypothyroidism or clinical/subclinical cretinism.

CONCLUSION

Data from this interim analysis supports that children exposed to fluoride are at risk for impaired development of intelligence. After the complete data is analysed the true association will be available.

Recommendations

Millions of children around the world are exposed to high concentration of fluoride in water, and are therefore, potentially at risk. An urgent attention is needed to protect the upcoming generation.

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