

RELATIONSHIP AMONG DENTAL FLUOROSIS, INTELLECTUAL QUOTIENT AND ACADEMIC PERFORMANCE

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ABSTRACT: The objective of this study was to determine the association of dental fluorosis with alterations in cognitive assessment (IQ), average academic performance scores, and age-gender relationships in students from a population from the Dominican Republic, with endemic fluorosis. A cross-referenced study was carried out on 84 students from a public school located in an area with endemic fluorosis. An aggregate sampling design was used for the sample; those who complied with the inclusion criteria were selected through a simple random sampling model. Dental fluorosis was evaluated by grades according to Dean's index. Students participating in the study were given Raven's advanced progressive matrices test to determine IQ. The school academic average scores were supplied by the school administration. A moderate fluorosis level, obtained the highest case prevalence (45.2%). Almost 99% of the evaluated students, got intellectually lower results than the average score according to Raven's test. A noticeable discordance was evident among grades of IQ and average academic scores. The results showed that there was no statistically significant relationship between dental fluorosis and cognitive assessment. A secondary follow-up study is recommended with a larger population.

Key words: Cognitive alterations; Dental fluorosis: Endemic fluorosis; Fluorides; Intelligence test; Mottled enamel.

INTRODUCTION

The World Health Organization (WHO) recommends a fluoride (F) concentration of 0.7–1.2 ppm in drinking water for consumption to obtain a therapeutic anticariogenic effect and promote health in general, although it also allows for individual Country Standards to be set and Senegal has set a level of 0.6 ppm because of the high prevalence of dental fluorosis with 1.5 ppm.^{1,2} The prevalence of damage due to excess fluorine is not accurately known, but tens of millions of fluorosis cases are estimated.³ Dental fluorosis is a particular problem which occurs during the odontogenesis process and manifests as hypomineralization, and serious aesthetic and physiological changes.

Furthermore, in areas with endemic fluorosis, in a study performed on aborted human fetuses, it was found that F accumulation in cerebral tissue could cause the interruption of certain neurotransmitters and receptors in nervous cells while causing a reduction in the number of mitochondria, rugose endoplasmic reticulum, and free ribosomes in neurons in the cerebral cortex.⁴

Authors such as Grandjean⁵ have reported that fluorine excess during development may cause neurologic effects such as a reduced intelligence quotient and attention deficit hyperactivity disorder.⁶ Infants from areas with fluorosis had a five-fold greater probability of developing alterations in IQ, which could compromise their development and school performance due to a lower level of performance and learning limitations.⁷

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A recent study in the Azua province, Dominican Republic, described the analysis of water samples taken from water sources in the community of Barreras, with a fluoride concentration of 1.265 to 1.485 mg/L which surpasses concentrations stipulated by the American Dental Association (ADA) and WHO.⁸

The objective of this study was to analyze the relationship between dental fluorosis and cognitive assessment, by relating the Dean's fluorosis index, the IQ (Raven test), and the average academic performance scores of students living in an area with endemic fluorosis attending the public school of the community of Barreras, Azua, Dominican Republic.

MATERIAL AND METHODS

An epidemiologic study of a descriptive nature was carried out in order to evaluate the relationship between dental fluorosis (DF) levels, academic performance (AA), and intellectual quotient (IQ) of students from Barreras, a community with a high concentration of F (1.2–1.5 mg/L) in water, located in the Azua province of the Dominican Republic.

Through a file card for data collection drafted for this purpose, information was obtained on each student individually, participants were identified, and results were collected for different indicators such as gender, age, and average academic performance scores (A=90–100, B=80–89, C=70–79, and D=60–69). The school grade and place of residence were requested directly from the school institution. The same file card was validated and tested through a pilot test.

The inclusion criteria for participating in the study were: (i) age of 13–23 years; (ii) resident in the Azua province; (iii) enrolled in an educational institution; (iv) showing signs and/or symptoms of DF; (v) not being under orthodontic treatment; and (vi) having no history of neurologic and psychomotor conditions.

A sample was established by using the formula for descriptive studies with a main variable of a qualitative nature. The study participants were 97 students; Due to the established criteria, a total of 84 students between 13 and 23 years old were evaluated.

Dental evaluation: The Dean's index⁹ was used to evaluate dental characteristics and differentiate the levels of DF, as follows:

Normal (code 0): a bright and smooth surface, habitual translucence, and pale beige color;

Questionable (code 1): a few white spots and normal diagnosis is not justified;

Very mild (code 2): DF affects 10% to 25% of the tooth surface with small opaque areas, irregular white color, and opacity of the cusps;

Mild (code 3): lines along the surface with wider white areas encompassing 25% to 50% of the surface;

Moderate (code 4): 100% of tooth surface affected by DF with the occurrence of brown spots and wear, but resistant to dental cavities; and

Severe (code 5): DF affects the entire tooth surface and hypoplasia is so noticeable that the tooth anatomic shape can be affected.

Intelligence assessment: IQ was evaluated by using Raven's matrices and shadows test¹⁰ which measures the abilities that comprise intelligence and normal brain function by generating percentile values. The Mexican version was used and it was validated for the population studied through a pilot test which was administered by the National University Pedro Henríquez Ureña's Department of Psychology. Tests were always applied by standardized psychologists. Specific classifications were made the following way:

Grade I (percentiles 99–80): very intelligent;

Grade II (79–66): intelligent;

Grade III+ (65–50): upper normal;

Grade III– (49–25): lower normal;

Grade IV (24–6): definitely below average; and

Grade V (5–0) intellectually impaired.^{11,12}

Ethical aspects: This study was approved by The National Bioethics Council of the Dominican Republic and it complied with ethical concepts in the Helsinki's declaration.¹³ To carry out the study on school grounds, signed permissions were obtained from the school district and the principal of the public school. Every subject was treated with respect, an informed consent was obtained from the parents or guardian, and an informed assent for minors, through which every aspect related to the study and confidentiality of information were made known. Likewise, the subject's well-being was always put above the interests of the research.

Statistical analysis: The data were analyzed with SPSS 14.0. A normality test was performed and if the p-value was less than 0.05, a non-parametric test was performed. If the p-value was greater than 0.05, the ANOVA and T-Student test were used.

RESULTS

Characteristics of the participants: A total of 84 students between 13 and 23 years old were evaluated. All the participants came from the same area, had a high exposure to endemic F, and fulfilled all the criteria. The characteristics of the participants and the variables collected according to the tests used are shown in Table 1.

Table 1. Characteristics of the study population according to the evaluated variables

Characteristic		Total (n=84)	%
Age (years)	≤16	45	53.50
	17–18	27	32.30
	≥19	12	14.20
Gender	Female	50	59.50
	Male	34	40.50
Academic performance (AA)	A (90–100)	13	15.50
	B (80–89)	47	55.95
	C (70–79)	24	28.57
	D (60–69)	0	0.00
Dean's fluorosis index	Normal (0)	1	1.20
	Questionable (1)	5	6.00
	Very mild (2)	13	15.50
	Mild (3)	15	17.85
	Moderate (4)	38	45.23
	Severe (5)	12	14.28
Intelligence quotient (IQ)	Grade I (99–80, very intelligent)	0	0.00
	Grade II (79–66, intelligent)	0	0.00
	Grade III+ (65–50, upper normal)	1	1.19
	Grade III– (49–25, lower normal)	55	65.50
	Grade IV (24–6, definitely below average)	27	32.14
	Grade V (5–0, intellectually impaired)	1	1.20

Analysis of dental fluorosis according to age and gender: There were no differences in DF when analyzed for different ages and gender.

Analysis of the IQ according to age and gender: According to Table 2, there were no differences in IQ between the different ages. The IQ was not different between males and females.

Table 2. IQ values by age and gender

Characteristic		N	Mean intelligence quotient (IQ)
Age (years)	≤16	45	39.20*
	17–18	27	46.60
	≥19	12	45.50
	Total	84	
Gender	Female	50	43.12*
	Male	34	41.59
	Total	84	

*No significant differences in IQ were present for the different age groups or according to gender.

Association between DF and IQ: As shown in Table 3, the IQ values for the different degrees of DF were not different (ANOVA, $p > 0.05$).

Table 3. IQ in different level of fluorosis

Dean's fluorosis index	N (total=84)	Mean intelligence quotient (IQ, mean±SD)
Normal (0)	1	29.00*
Questionable (1)	5	29.8±8.9
Very mild (2)	13	23.9±10.8
Mild (3)	15	31.9±10.9
Moderate (4)	38	28.0±11.1
Severe (5)	12	29.8±11.7

*No significant differences in IQ were present for the groups with different degrees of dental fluorosis according to Dean's fluorosis index.

Association between IQ and academic performance (AA): There were no differences in the academic performance of the groups with different levels of IQ (ANOVA $p > 0.05$, Table 4).

Table 4. Academic performance in different IQ levels

IQ	N (total=84)	Academic performance (AA) (mean±SD)
Grade III+ (65–50, upper normal)	55	83.07±6.79*
Grade III– (49–25, lower normal)	1	98.00
Grade IV (24–6, definitely below average)	27	83.26±5.60
Grade V (5–0, intellectually impaired)	1	86.00

*No significant differences in academic performance (AA) were present for the different IQ groups.

DISCUSSION

The Barreras community, in Azua, is an area with endemic fluorosis where many residents have shown signs of dental fluorosis for years but to them the abnormal coloration of their teeth was considered to be something which was normal. This is the second study in the Azua province to evaluate the dental fluorosis in the population and the first one to also consider the cognitive aspects.⁸

The age with the highest prevalence of DF was less than or equal to 16 years old, with no difference between the genders; both genders presented with a high prevalence of moderate fluorosis. These results differ from the study carried out by Contreras and Martín in 2017,⁸ who concluded that, in this same community, females and students between 16 and 22 years old were more affected. In regards to gender, another study by Yang et al, in 2008,¹⁴ also had results that differed from those of the present study. Yang et al. found that. males accounted for more than 72% of their sample with DF.¹⁴

Not all the previous studies classified DF according to its severity. Similar to our study, Choi et al., 2014¹⁵ in China, showed that 60% of the subjects had moderate or severe DF, while Khan et al. in 2015,¹⁶ in India, reported that 76.3% of their population was free from fluorosis.

Unlike the results obtained in the present study, Yang et al,¹⁴ reported that only 16.7% had IQ in the low categories. Poureslami et al. in 2011,⁶ showed in 120 boys and girls, between 7 and 9 years old, that the entire sample had an average IQ, among which 30% had low fluorosis and 25.4% had high fluorosis. Among this population, no case had a very high IQ.

In the relationship between IQ and DF, the mild DF group had the highest mean IQ with a mean of 31.9 (III–, lower normal), while the very mild DF group had the lowest mean IQ with a mean of 23.9 (IV, below average). There was no statistically significant difference among the values for the mean IQ in the various DF groups. Yu et al. in 2018,¹⁷ verified that intelligence decreased by 51% in children with a higher

urinary F and concluded that there was an association between chronic exposure to F, dental health, and lower intelligence. Aravind et al,¹¹ showed a decrease in IQ levels with no gender difference. In one of the cities they studied the drinking water fluoride was 1.5 ppm F, a level similar to that in the present study of 1.2–1.5 ppm.

Bashash et al,¹⁸ reported that there was an indisputable significant difference in the results on cognitive functions of children exposed to hyper fluorosis and that the vulnerable time when toxicity occurred was during pregnancy with the fetus *in utero*. Furthermore, Shivaprakash et al,⁴ showed that IQ scores of 66.2, 66.3, and 66.4 IQ were present in cases with mild, moderate, and severe fluorosis, respectively. Based on these values, they concluded that there was no significant difference between IQ and DF.

Finally, in the present study, the correlation of AA and IQ showed a noticeable discordance between both variables. No other studies were found that considered the variable of AA, so it is recommended that academic performance be considered in future studies.

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