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CORRELATION BETWEEN DENTAL FLUOROSIS AND GROUNDWATER CONSUMPTION IN CHILDREN AGED 8-15 YEARS IN THE KARST AREA BANYUMAS

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ABSTRACT

Background: dental fluorosis is a condition of tooth growth and development that causes spots and brittle teeth. The cause of dental fluorosis is chronic fluoride intoxication due to consumption of fluoridated water during the tooth development period. One type of water with a high fluoride content is groundwater in karst areas. Groundwater in Darmakradenan village containing 1,9 mg/L fluoride. The vast majority of the locals consume groundwater as drinking water. Aim: to determine the association between groundwater consumption and the incidence of dental fluorosis. Methods: an analytic-observational with a cross-sectional approach. The research population consisted of residents aged 8–15 years in Darmakradenan Village, Ajibarang District, and Banyumas Regency. Purposive sampling was implemented for selecting research participants, with a total of 90 participants who divided into two groups: consumed groundwater and refilled drinking water. The Dean's Index is used to examine the status of dental fluorosis. Analysis data used Chi-square test. Result: there was an association between groundwater consumption and dental fluorosis ($p < 0,05$, CC = 0,277). Conclusion: there is an association between groundwater consumption in karst areas and the incidence of dental fluorosis.

Keywords: Dental fluorosis, Fluoride, Groundwater, Karst area

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INTRODUCTION

Long-term exposure to excessive fluoride during tooth formation can induce dental fluorosis, a pathological condition of the teeth that results in spots and fragility on the

enamel surface. Dental fluorosis is a serious issue since it can impair a person's appearance, ability to speak, and capacity to chew food (Kemenkes RI, 2019). Children's self-esteem and overall quality of life can also be impacted by dental fluorosis. Dental fluorosis can occasionally result in a psychosocial load that affects social interactions and emotional disorders, particularly in school-age children (Montanher et al., 2024).

Based on Riskesdas 2018 (Kemenkes RI, 2019), the prevalence of dental fluorosis is quite low nationwide, at about 4.4%. However, this number does not accurately reflect situations in fluoride-endemic locations, particularly those with calcareous soil features. According to a number of studies, dental fluorosis is more common in regions with limestone bedrock, particularly those that depend on groundwater for drinking water (Ahmed et al., 2020; Rojonaworarit et al., 2021; Yani et al., 2021). Due to the dissolution of fluorite minerals (CaF_2) from sedimentary rocks, particularly in alkaline pH conditions and low calcium concentration, groundwater in calcareous locations has a significant potential to contain fluoride (WHO, 2017). Numerous health issues, including cancer, development abnormalities, and skeletal fluorosis, including dental fluorosis, have been linked to fluoride levels above the 1.5 mg/L threshold (WHO, 2006; Marwah, 2018). Residents of areas with calcareous soils run the danger of daily exposure to fluoride from water sources since these areas are more likely to produce groundwater with fluoride concentrations above the acceptable threshold (Inggas, 2025). The majority of earlier research has concentrated more on determining the fluoride content of groundwater and the incidence of fluorosis in particular regions, rather than directly contrasting the effects of drinking groundwater with safer replenishment water or other alternatives. Indeed, it is crucial to determine whether drinking replenished water helps prevent dental fluorosis, particularly in regions where the condition is endemic. This information is required to enable community water use improvements and policy initiatives.

One of the greatest limestone land areas in Ajibarang District, Banyumas, is Darmakradenan Village. There are villages on the limestone plain and limestone hills in Darmakradenan Village. People sip water from groundwater (BPS Banyumas Regency, 2021). Residents of Darmakradenan Village are susceptible to dental fluorosis due to the type of water they consume and the soil structure. This piqued researchers' attention in studying the connection between Darmakradenan Village's groundwater and replenishment water usage and dental fluorosis.

According to preliminary survey data, the majority of the village's population rely on the groundwater as their primary supply of drinking water, and it includes fluoride levels of approximately 1.8–2 mg/L. The study was limited to participants between the ages of 8 and 15 because the amelogenesis process of permanent teeth is complete by that age, and because dental fluorosis is most common in the 12–15 age range (Beltran-Aguilar et al., 2010; Marwah, 2018). Over half of respondents who drank groundwater had dental fluorosis symptoms, according to preliminary testing in the 8–12 age range. This number is significantly higher than the national prevalence. This study was carried out to determine whether groundwater consumption and the development of dental fluorosis in children residing in chalky areas, particularly Darmakradenan Village, are related, given the high occurrence. In addition to providing a scientific foundation for clean water regulations and public education in high-risk locations, this study is anticipated to close the information

gap regarding the comparison of dental fluorosis risks dependent on the kind of drinking water used.

METHODS

Tools and Materials

Informed permission forms, stationery, and respondent data form sheets for filling out the data are among the instruments and supplies utilized in this study. A mouth mirror, sonde, tweezers, nierbeken, mask, gloves, cotton roll, 70% alcohol, and povidone iodine are among the equipment and supplies needed for a dental fluorosis examination.

Research Procedures

With reference number 095/KEPK/PE/VII/2023, the Health Research Ethics Commission of the Faculty of Medicine at Jenderal Soedirman University has granted ethical permission for this study. With a cross-sectional study design and an analytical observational technique, this research is quantitative (Notoatmodjo, 2018; Wang and Cheng, 2020). Children between the ages of 8 and 15 who had been residents of Darmakradenan Village since birth served as the study's subjects. Ninety persons in all responded, and they were split into two groups based on the kind of drinking water they had been using since they were young: groundwater (n=45) and replenished drinking water (n=45). Purposive sampling was the method used for subject sampling. The study excluded participants who had a history of preterm birth or who drank more than 750 milliliters of tea per day. A dentist used the Dean Index to do a dental fluorosis status examination. To prevent overdiagnosis or misclassification, which is essential for epidemiological validity in research, Patidar et al. (2021) underlined the need for differential diagnosis between fluorosis and non-fluoride opacity as well as the use of suitable clinical indices, such as the Dean Index. The two teeth with the most noticeable involvement were examined and evaluated in natural light. The lighter score is utilized as a representation if the severity of the two teeth differs.

Data Analysis

Software called SPSS version 25 was used to examine the data. The features of the respondents were described using univariate tests. The chi-square test was used to examine the connection between the dependent variable (incidence of dental fluorosis) and the independent variables (kind of drinking water intake). The degree of correlation between the variables was evaluated using the contingency coefficient (CC) test. At a 95% confidence level, a p value <0.05 was deemed statistically significant.

RESULTS AND DISCUSSION

Results

90 participants, ages 8 to 15, took part in the study; 45 of them were in the group that consumed groundwater, and the remaining 45 were in the group that consumed replenishment water.

Table 1. Distribution of Research Subjects by Gender.

Gender	Drink Groundwater		Drink Refilled Water		Total	
	Amount (Children)	Percentage (%)	Amount (Children)	Percentage (%)	Amount (Children)	Percentage (%)
Boys	28	62,2	23	51,1	51	56,7
Girls	17	37,8	22	48,9	39	43,3
Total	45	100	45	100	90	100

Table 2. Distribution of Research Subjects by Age.

Age (Year)	Drink Groundwater		Drink Refilled Water		Total	
	Amount (Children)	Percentage (%)	Amount (Children)	Percentage (%)	Amount (Children)	Percentage (%)
8-11	28	62,2	23	51,1	51	56,7
12-15	17	37,8	22	48,9	39	43,3
Total	45	100	45	100	90	100

Tables 1 and 2 show that men made up the bulk of research participants (56.7%). The majority of research participants (58.9%) were between the ages of 8 and 11.

Table 3. Dental Fluorosis Status of Subject Groups Consuming Groundwater in Darmakradenan Village, Ajibarang District, Banyumas Regency in 2023

Dental Fluorosis Status	Amount (Children)	Percentage (%)
Dental fluorosis	20	44,4
Non-dental fluorosis	25	55,6
Total	45	100

Tabel 4. Degree of Dental Fluorosis in Groundwater Group in Darmakradenan Village, Ajibarang District, Banyumas Regency in 2023

Degree of Dental Fluorosis	Amount (Children)	Percentage (%)
Normal	25	55,6
Questionable	5	11,1
Very mild	9	20
Mild	6	13,3
Moderate	0	0
Severe	0	0
Total	45	100

Table 5. Dental Fluorosis Status of Subject Groups Consuming Refilled Water in Darmakradenan Village, Ajibarang District, Banyumas Regency in 2023

Dental Fluorosis Status	Amount (Children)	Percentage (%)
Dental fluorosis	8	17,8
Non-dental fluorosis	37	82,2
Total	45	100

Table 6. Degree of Dental Fluorosis in Refilled Water Group in Darmakradenan Village, Ajibarang District, Banyumas Regency in 2023

Degree of Dental Fluorosis	Amount (Children)	Percentage (%)
Normal	37	82,2
Questionable	4	8,9
Very mild	4	8,9
Mild	0	0
Moderate	0	0
Severe	0	0
Total	45	100

Dental fluorosis symptoms were present in 52% of the groundwater-consuming group and only 24% of the replenished water group. The groundwater group had a more extensive distribution of symptoms and most occurrences of fluorosis were at very mild to moderate levels.

Table 7. Chi Square Analysis Results of the Relationship between Drinking Water Type and Dental Fluorosis Incidence in Darmakradenan Village, Ajibarang District, Banyumas Regency in 2023

Drinking Water Type	Status of Dental Fluorosis						*p*	*CC*
	Dental Fluorosis		Non-Dental Fluorosis		Total			
	Amount (Children)	Percentage (%)	Amount (Children)	Percentage (%)	Amount (Children)	Percentage (%)		
Groundwater	20	44,4	25	55,6	45	100	0,006	0,277
Refilled Water	8	17,8	37	88,2	45	100		
Total	28	31,1	62	68,9	100	100		

The incidence of dental fluorosis was significantly correlated with groundwater use, according to chi-square analysis ($p < 0.05$). The weak to moderate link was suggested by the contingency coefficient (CC) value of 0.277.

Discussion

According to this study, the prevalence of dental fluorosis in children in Darmakradenan Village between the ages of 8 and 15 is significantly correlated with groundwater consumption. These findings support the hypothesis that excessive fluoride exposure, particularly from high-fluoride drinking water, can harm tooth enamel structure during the amelogenesis phase. Flouride levels in the groundwater of Darmakradenan Village were determined to be between 1.8 and 2 mg/L, exceeding the WHO criterion of 1.5 mg/L (Kemenkes RI, 2019). According to the World Health Organization (WHO), skeletal and dental fluorosis can result from prolonged exposure to drinking water with high amounts of fluoride (WHO, 2006). Compared to the national average, the prevalence of dental fluorosis among respondents in the groundwater drinking group was significantly higher at 52%. According to Rojonaworarit et al. (2021), who discovered a high frequency of fluorosis in Thailand's rural areas with high groundwater fluoride content, this indicates

that dental fluorosis is endemic in Darmakradenan Village. In a fluoride-endemic region of Haryana, India, a study by Shyam et al. (2021) on 2,200 children aged 11 to 14 years revealed a very high prevalence of dental fluorosis, reaching 96.6%, with mild to moderate cases accounting for the bulk of cases. In a community research conducted in the chalky state of Karnataka, India, Prasad et al. (2023) similarly discovered that 46% of children aged 6 to 12 had dental fluorosis, with mild cases accounting for 37.9%, moderate cases for 7.8%, and severe cases for 0.3%. This supports the conclusion that regions with high fluoride concentrations are consistently associated with a high incidence of fluorosis, particularly for those in elementary school through early adolescence.

Communities that use groundwater with a fluoride level of more than 1.5 mg/L also had a significant frequency of fluorosis, according to a study by Ahmed et al. in the Thar region of Pakistan. Similar research by Al Warawreh et al. (2020) in Jordan and Okoye et al. (2019) in Nigeria also demonstrated a link between the degree of fluorosis and high fluoride levels in drinking water. From a pathophysiological perspective, elevated fluoride levels impact ameloblast activity in enamel development. According to Rubio et al. (2017), prolonged exposure results in white or brownish patches and increased porosity in the enamel. According to the age-group distribution of dental fluorosis, children between the ages of 8 and 11—the last age group in which permanent teeth form account for the majority of instances. This is consistent with the Do et al. (2020) findings. that the latter stage of amelogenesis is when fluorosis incidence peaks.

Although the fluoride level in the refill water was only 1 mg/L, a small number of fluorosis cases were also discovered in this group. Other factors that may have contributed to this include the use of fluoride toothpaste, tea consumption (which contains natural fluoride), and the mother's nutritional history during pregnancy (Achmad et al., 2021). This study group's mild to moderate fluorosis manifested as brown discolouration, non-transparent enamel, and sporadic white patches. The Dean Index classification, which separates fluorosis into five levels questionable, very light, mild, moderate, and severe is consistent with this image (Marwah, 2018).

The use of exclusion methods in samples with premature births and excessive tea consumption is a form of internal control to reduce bias, but this study has limitations, such as not controlling for all risk factors, such as a history of medication or systemic diseases that affect fluoride metabolism, such as celiac disease or rickets (Nor, 2017). These results highlight the necessity of educating the people about the dangers of excessive fluoride levels and the significance of monitoring the quality of drinking water in limestone areas. Encouragement of the use of refilled drinking water with optimal fluoride levels and the provision of basic household water treatment facilities, such as defluoridation techniques using activated charcoal or bone char techniques, are practical solutions for people living in limestone soil areas. According to research by Jalil and Sham (2020), cross-agency cooperation and health education initiatives can raise public knowledge about fluoridated water. To more thoroughly evaluate the cause-and-effect connection, more longitudinal study is required (Hung et al., 2023).

CONCLUSION

The frequency of dental fluorosis in children aged 8 to 15 in Darmakradenan Village was shown to be significantly correlated with groundwater intake in calcareous soil

areas. Thus, the use of groundwater as a drinking water source requires additional attention, particularly for youngsters while their teeth are growing.

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