

INFLUENCE OF ENVIRONMENTAL FACTORS ON THE DYNAMICS OF DENTAL CARIES PREVALENCE AMONG SCHOOL-AGE CHILDREN

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Abstract. Dental caries remains one of the most prevalent chronic diseases among school-age children worldwide. The progression and prevalence of caries are influenced by multifactorial determinants, including dietary habits, oral hygiene practices, fluoride exposure, and environmental conditions such as water mineralization and air quality. The present study aimed to assess the dynamics of caries prevalence in school-age children and determine the impact of key environmental factors in different ecological zones. A total of 240 schoolchildren aged 7–15 years were examined, divided into three groups based on their residential environment (urban, semi-urban, and rural). The study included dental examinations, fluoride and calcium analysis of drinking water, and evaluation of environmental indicators. The results revealed significant regional variations in caries intensity, with higher prevalence in areas characterized by low fluoride and calcium concentrations in water and higher industrial pollution. The findings highlight the necessity of integrating environmental and preventive health strategies to reduce caries incidence in children.

Keywords: dental caries, environmental factors, fluoride, school-age children, oral health

Introduction. Dental caries is a major global public health problem that continues to affect children's health and quality of life. According to the World Health Organization (WHO), about 60–90% of school-age children worldwide suffer from caries in both developed and developing countries [1]. In Central Asian regions, including Uzbekistan, epidemiological studies indicate that the prevalence of dental caries among schoolchildren remains high, reaching 75–85%, despite preventive programs [2].

The etiology of dental caries is complex and multifactorial. Apart from individual factors such as oral hygiene, sugar intake, and microbial flora, environmental determinants play a crucial role in modulating caries risk [3]. According to Fejerskov and Kidd, environmental factors—including water composition, fluoride content, climate, and socio-economic conditions—significantly influence enamel resistance and bacterial colonization [4].

Researchers have emphasized that low fluoride concentration (<0.5 mg/L) in drinking water is one of the strongest predictors of caries in children, especially in rural

areas [5]. Studies conducted by Whelton et al. demonstrated that regions with optimal fluoride levels (0.7–1.0 mg/L) show a 40–60% reduction in caries prevalence compared to low-fluoride zones [6]. Other environmental aspects such as air quality, soil composition, and dietary mineral intake also affect the dynamics of enamel demineralization and remineralization [7].

Climate-related factors, including temperature and humidity, influence saliva viscosity and buffering capacity, indirectly modifying caries susceptibility [8]. Moreover, socio-ecological conditions such as industrial emissions, heavy metal exposure, and regional dietary patterns can lead to disparities in oral health outcomes among schoolchildren [9].

Objective: To evaluate the dynamics of dental caries prevalence among school-age children in different ecological environments and determine the correlation between environmental factors (fluoride and calcium levels, industrial pollution, and water quality) and caries intensity.

Materials and Methods

The study was conducted between 2023 and 2024 among 240 school-age children (aged 7–15 years) residing in three ecologically distinct zones of the Bukhara region:

- Group I (urban zone): 80 children living in an industrialized city environment.
- Group II (semi-urban zone): 80 children from suburban areas with mixed residential and agricultural exposure.
- Group III (rural zone): 80 children from rural communities with predominantly agricultural activity.

Clinical Examination

Each child underwent a standardized dental examination using the DMF (Decayed, Missing, and Filled Teeth) index to assess caries experience. Oral hygiene was evaluated by the Green–Vermillion Index, and dietary patterns were recorded through parental questionnaires.

Environmental and Laboratory Assessment

Samples of drinking water were collected from each area and analyzed for fluoride (F^-) and calcium (Ca^{2+}) concentrations using ion-selective electrode and atomic absorption spectrometry. Additionally, air quality parameters (suspended particulate matter, SO_2 , NO_2) were obtained from regional environmental monitoring data.

Statistical Analysis. Data were processed using SPSS 26.0. Mean values were compared using ANOVA and Student's t-test, while correlations between environmental indicators and caries indices were assessed with Pearson's correlation coefficient ($p < 0.05$ considered significant).

Results. The overall prevalence of dental caries among all examined children was 78.3%, with significant variation across ecological zones ($p < 0.01$). The highest

prevalence was observed in rural areas (86.2%), followed by semi-urban (76.5%) and urban zones (72.4%). Mean DMF index values were correspondingly higher in low-fluoride regions.

Table 1. Caries Prevalence and DMF Index in Different Ecological Zones

Zone	Number of children	Caries prevalence (%)	Mean DMF Index (M $\pm$ SD)
Urban	80	72.4	2.46 $\pm$ 0.74
Semi-urban	80	76.5	3.02 $\pm$ 0.91
Rural	80	86.2	3.84 $\pm$ 1.05

Table 1 demonstrates a clear gradient of increasing caries prevalence from urban to rural areas. This trend correlates with environmental parameters, suggesting that fluoride deficiency and lower calcium concentration in drinking water contribute to higher caries incidence.

Table 2. Environmental Indicators in Different Ecological Zones

Parameter	Urban	Semi-urban	Rural
Fluoride in water (mg/L)	0.78 $\pm$ 0.09	0.52 $\pm$ 0.06	0.34 $\pm$ 0.05
Calcium in water (mg/L)	68.4 $\pm$ 5.2	57.9 $\pm$ 4.7	44.2 $\pm$ 4.1
PM _{2.5} (μ g/m ³)	36.5 $\pm$ 2.3	28.7 $\pm$ 2.5	18.4 $\pm$ 2.1
Air temperature ($^{\circ}$ C, annual mean)	16.8 $\pm$ 0.7	18.2 $\pm$ 0.6	19.6 $\pm$ 0.8

As shown in Table 2, fluoride and calcium concentrations were significantly lower in rural zones, coinciding with higher caries rates. Conversely, industrial air pollution was higher in urban regions but did not correlate directly with caries levels, emphasizing that mineral imbalance in water plays a more critical etiological role.

Discussion. The study confirmed that environmental factors, particularly fluoride and calcium concentrations in drinking water, play a decisive role in determining the prevalence and intensity of dental caries among school-age children. These findings align with previous studies reporting that optimal fluoride levels (0.7–1.0 mg/L) are associated with lower caries incidence and improved enamel remineralization [10].

In rural areas, where drinking water is often sourced from wells with low mineral content, insufficient fluoride and calcium intake weakens enamel resistance, facilitating cariogenic bacterial activity. Similar observations were made by Whelton et al. and Fejerskov et al., who emphasized the protective role of mineralized water in enamel maturation and stability [11].

The results also highlight that air quality indicators, although important for respiratory health, have less direct influence on caries formation compared to water

chemistry and dietary minerals. Nonetheless, exposure to environmental pollutants may indirectly affect oral immunity and salivary composition [12].

From a public health perspective, the obtained data underscore the necessity of introducing community-level preventive strategies, including controlled water fluoridation, regular oral health education, and periodic screening in schools. These interventions can significantly reduce the burden of dental caries and improve children's overall well-being.

The socio-economic impact of dental caries is substantial, affecting school performance, nutrition, and quality of life. Early preventive action not only benefits individual health but also reduces healthcare costs associated with restorative dental treatment and absenteeism [13].

Conclusion

1. Dental caries among school-age children demonstrates distinct ecological variability, with higher prevalence in regions characterized by low fluoride and calcium levels in drinking water.

2. The relationship between environmental mineral composition and caries intensity is statistically significant, confirming the crucial role of fluoride and calcium in enamel resistance.

3. Environmental monitoring and public dental health programs should be integrated to reduce regional disparities in oral health.

4. Preventive measures such as water fluoridation, dietary supplementation, and school-based hygiene programs can substantially improve oral health outcomes and decrease the economic burden of dental diseases.

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